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Assessing Different Imaging Modalities for the Diagnosis of May-Thurner Syndrome: A Review

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Abstract: *May-Thurner Syndrome(MTS) is a type of venous compression syndrome typically characterized by the compression of left common iliac vein by the overlying right common iliac artery and the fifth lumbar vertebra causing venous obstruction, venous insufficiency, and left lower extremity deep vein thrombosis. The diagnosis is based on clinical presentations and imaging. This review article gives a brief summary on different imaging modalities that are used to diagnose MTS. The initial diagnostic workup is the doppler ultrasound which can easily detect lower extremity deep vein thrombosis (DVT)but doesn't give clear information about the venous abnormalities or any anatomic changes in the pelvic area. Both Computed Tomography (CT) venography and Magnetic Resonance (MR) venography can give a clear picture of the veins in the abdomen and the pelvis and can assess any extrinsic compression, degree of stenosis, and underlying thrombosis. Unlike CT venography, MR venography has minimum risk of ionizing radiation exposure and can be used to detect venous flow direction helping in detecting the hemodynamic consequences; it can also be used without contrast agent in allergic and renal failure patients. Catheter directed contrast venography is the gold standard for the diagnosis of MTS; distinguishing acute or chronic thrombus, detecting collaterals, associated venous obstruction, and degree of stenosis. Intravascular ultrasound is evolving as the dynamic tool which identifies early intimal changes and precisely measures venous narrowing. Endovascular treatment with balloon angioplasty or stenting can also be planned in a single setting when diagnosing suspected MTS with contrast venography or intravascular ultrasound.*

Key Words: *May-Thurner Syndrome - doppler ultrasound - ct venography - mr venography - contrast venography - intravascular ultrasound*

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I. Introduction

May-Thurner Syndrome (MTS), also known as Iliac Vein Compression Syndrome, Iliocaval Compression Syndrome or Cockett's Syndrome, wasfirst described by May and Thurner in 1957. It is characterized by compression of left common iliac vein (LCIV) by right common iliac artery (RCIA)on the anterior side and by the fifth lumbar vertebral body on the posterior side (Fig.1).[1] The continuous chronic pulsations of the right common iliac artery contribute to the spur formation along the wall of left common iliac vein and overtime lead to accumulation of elastin and collagen with intimal proliferation.[2] The anterior-posteriordiameter of LCIV becomes narrow and the transverse diameter widens. This leads to stasis of venous return within the lower extremity vein. Compression of left common iliac vein in combination with other risk factors (such as dehydration, surgery, immobilization, genetic factors, etc.) increases the risk of venous hypertension, stenosis, obstruction and deep vein thrombosis (DVT).[1,3] Due to the development of collateral veins, draining the blood into the inferior vena cava bypassing the narrowed left common iliac vein, patients can remain asymptomatic.The true incidence of MTS is unknown and despite its high prevalence MTS is diagnosed in only 2-5% of patients evaluated for chronic venous insufficiency. The incidence is 18-49% in patients presented with left lower extremity DVT.[4,5,6] Left lower extremity DVT is 3-8 times more likely to occur than right-sided DVT.[1] Female to male ratio of MTS is at least 2:1. Females present at a younger age and have increased risk of pulmonary embolism compared to men.[6]Although the most common May-Thurner anatomic variant is the LCIV compression by RCIA and the 5th lumbar vertebra, several other variations of MTS like

right-sided disease, involvement of other anatomic structures such as distended bladder, a penile prosthesis reservoir, endometriosis, common iliac artery aneurysm, internal iliac artery aneurysm, etc. were also reported in the literature.[7]

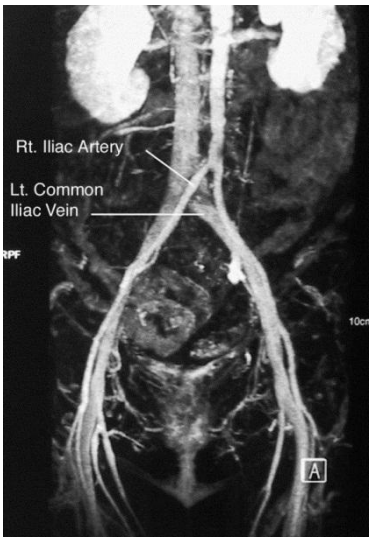

Fig.1: Magnetic resonance venography showing typical May-Thurner Syndrome (left common iliac vein compressed by right common iliac artery).

II. Clinical Presentation

MTS patients are mostly asymptomatic. The clinical presentations of MTS vary, which are divided into three stages. In stage 1, patients are asymptomatic with left iliac vein compression as a common finding on imaging, stage 2 is the formation of intraluminal spur and intimal changes in the vein wall, and stage 3 is unilateral left lower extremity DVT**.** Acute presentations include sudden onset of left leg swelling, pain, and DVT,with or without identifiablerisk factors (such as surgery, prolonged immobility, pregnancy, lengthy travel, etc.) present to exacerbate the event**.**[1,8] Acute MTS rarely presents with systemic pulmonary embolism because the narrowing of LCIV can offer protection by trapping the large emboli.[9] A study by Chan K.T. et.al. suggests that ilio-caval compression of ≥70% could reduce the risk of pulmonary embolism by 80%.[10] Chronic changes of MTS are due to long-term venous hypertension and characterized by venous insufficiency, varicose veins, skin changes (hyperpigmentation), lipodermatosclerosis, telangiectasias, phlebitis, venous claudication, and venous ulcerations.[1,3,11]Rarely, patients also present with pulmonary embolism, stroke, or myocardial infarction secondary to emboli.[1]

III. Diagnosis

A detailed history and physical examination is inadequate for the diagnosis of MTS.Younger patients should also be evaluated for thrombophilia to ascertain the risk factors for DVT, a study by Kolbel et al. suggests that 67% of patients with ilio-femoral DVT or MTS can have thrombophilia.[12] Different imaging modalities are used to detect the presence of MTS anatomy and confirm the diagnosis.The non-invasive tests used are Doppler Ultrasound, Computed Tomography (CT) and Magnetic Resonance Venography (MRV) while the invasive tests used are catheter directed contrastvenography (Digital Subtraction Angiography-DSA) and Intravascular Ultrasound (IVUS).

Doppler Ultrasound

The initial radiologic test of choice in patients presenting with unilateral left leg edema or pain is the doppler ultrasound as it is non-invasive, quick, cost-effective, and has high sensitivity and specificity to diagnose lower extremity DVT, a common result ofMTS.[13]The findings may include an abnormal doppler flow in the lower extremity below the compression (substantial increase in flow velocity) or the absence of variation of flow within the common femoral vein with respect to respiratory variation. These findings suggest an isolated iliac vein stenosis.[14]Ultrasound has its limitations in visualizing the basic anatomy of May-Thurner Syndrome.Direct examination of the iliac veins above the inguinal canal and identification of the pathology,like the presence of intraluminal spurs within the compressed left common iliac vein, is very difficult due to its deep seated location in the pelvic region and the overlying bowel gas, especially in obese patients.[1,15,16]However, there has been a case reported by Oğuzkurt et al.[14] where MTS was suspected by the doppler examination of the iliofemoral veins.In many acute emergency cases, doppler ultrasound of the lower extremity fails to examine the

iliac vein segments and shows no DVT thus missing the diagnosis of MTS frequently even in symptomatic patients.[3]This imaging modality is useful in determining the patency of veins but a negative result does not rule out the possibility of MTS and therefore other imaging tests should be considered to establish a diagnosis.

Computed Tomography (CT)

Computed tomography with intravenous contrast (CT venography/CTV) is a non-invasive imaging modality whichis used to evaluate the iliac veins in the abdomen and pelvis. It provides prompt, precise, and reliable assessment of the suspected venous compression and can detect collateral pathways. Otherextrinsic compressions of the iliac vein (hematoma, malignancy, etc.) can be ruled out. It gives information about surrounding anatomy, vascular architecture, the degree of stenosis, and defines the underlying thrombosis (Fig.2)**.**[11,16,17]A normal CT result with traditional 10-mm cuts does not necessarily rule out MTS as the small iliac spurs may not be visualized or the fibrosis can hide the underlying anatomy. CT findings using narrower cuts of 3mm to 5mm might be enough to visualize the details like the presence of iliac spurs and other intraluminal changes.[16]Chung et al.[18] used spiral CT venography in 44 patients presenting with lower extremity DVT, 27 of which were diagnosed with MTS. In a study by Oguzkurt et al.,[19] transverse plane CT was used in 10 patients with initial diagnosis of DVT based on clinical presentations and doppler ultrasound. Compression of left CIV by the right CIA was confirmed in all the patients. In another study by Liu et al.,[20] transverse plane CT confirmed the compression of the iliac vein by the overlying right common iliac artery. Many other studies suggested high specificity (89%-100%) and sensitivity (94%-100%) of CTV in the investigation of lower extremity DVT and pulmonary embolism.However, CTV also has its limitations including poor attenuation of the deep veins and large volume of contrast medium is required which is contraindicated in pregnant patients and patients with impaired renal function.[16,20,21]The image resolution may also be limited in the pelvic region due to the presence of bony artifacts.[9]

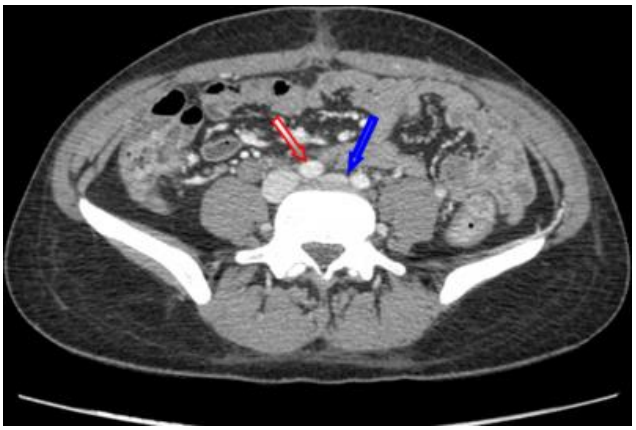

Fig.2: Pelvic CT scan showing compression of the left common iliac vein (blue arrow) by right common iliac artery (red arrow).

Magnetic Resonance Venography (MRV)

Magnetic Resonance Venography is another non-invasive, sensitive tool suitable for evaluation of the compression of iliac vein and confirming the diagnosis of MTS. MRI with MRV has been widely used recently to assess the venous compression syndromes. It can easily depict the compression area or obstruction and accurately estimate the degree of collateral flow, thus, assisting in the diagnosis of MTS (Fig.3).[22] Like CT, MRV can also identify all the pelvic structures, anatomic abnormalities, presence of venous spurs and intraluminal changes.[3,16]The advantages of MRV over CT are that the risk of exposure to the ionizing radiation is minimized and its flow-sensitive sequences allow evaluation of venous flow directionality, in turn predicting the hemodynamic importance of compressive lesions.[1]Studies suggest that MR venography can be performed without the use of contrast agent making it ideal for patients who have contrast allergies or renal insufficiencies. An advanced blood pool contrast agent "gadofosveset trisodium" (gadolinium-based contrast agent) increased the resolution, sensitivity, and specificity compared to non-enhanced MRV and showed no cases of nephrogenic systemic fibrosis.[1,15]In a study by Wolpert et al., 9 out of 24 (37.5%) patients presenting with left lower extremity edema and pain were suspected of MT anatomy initially by ultrasound and MTS was confirmedin all the 9 patients with MR venography. After initial assessment by ultrasound, MRV can be the procedure of choice for MTS diagnosis. The main limitation of MRV in MTS diagnosis is that it can sometimes present confusing images as there is nonlaminar flow in the vascular regions above the bifurcations.[23]McDermott et al. suggestedthat by using repeated single MRV study, the compressed left common iliac vein was unstable over time on the same patients due to positioning of patient or volume status. Therefore,single MRV may not be

enough to confirm the diagnosis and may require further tests.[24]Besides, these studies are expensive, time consuming, and difficult to execute on ill patients.

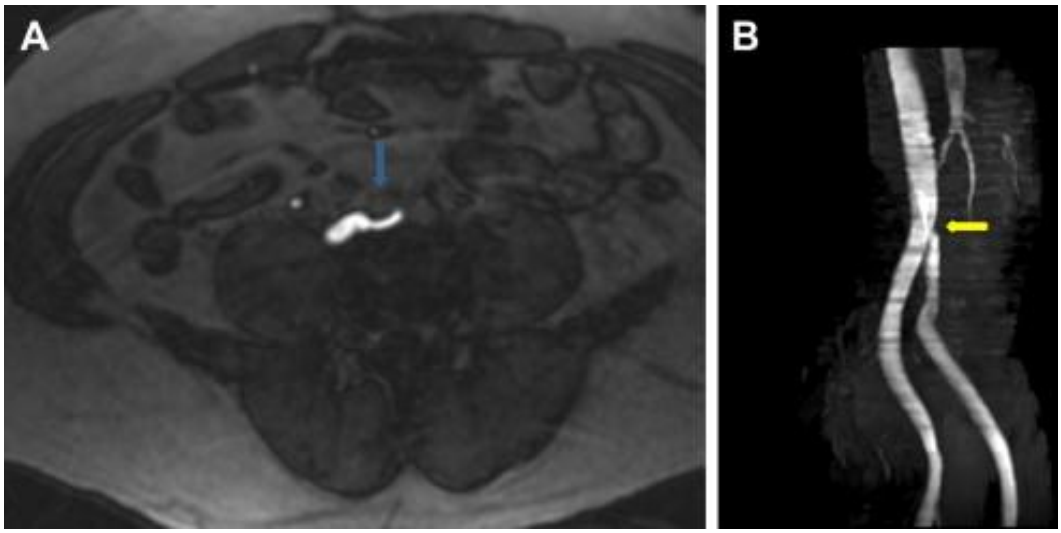

Fig.3: Axial(A) and sagittal(B) plane magnetic resonance venography illustrating extrinsic compression of the left iliac vein by the right iliac artery.

Contrast Venography

The gold standard for the diagnosis of May-Thurner Syndrome is the catheter directed contrast venography. This invasive procedure can locate the position and nature of the thrombus (acute or chronic), associated venous obstruction, degree of stenosis or occlusion, presence of venous collaterals, and also assist in finding the venous abnormalities of the femoral veins like duplication of femoral vein (usually bilateral in distribution and can occur in 12% of patients)(Fig.4a,4b)**.**[11,12,16]The standard method is injecting contrast agent through dorsum of the foot but more volume of contrast agent is required to fully visualize the iliac veins in the pelvis hence it is injected in either popliteal or femoral vein for better visualization of the iliac vein.[16,25]The hemodynamic evaluation of MTS can be done through pressure gradient measurements within the compressed vein. The pressure difference of more than 2mmHg at rest and more than 3mmHg during exercise is considered significant for the stenosis.[11,16]This invasive technique is useful in planning endovascular treatment interventions at the time of venography itself, such as thrombolysis, balloon angioplasty, or stent placement.[1]Though considered gold standard, this procedure has some disadvantages. It is invasive, expensive, time consuming, can cause post-stenting DVT or contrast allergies, and difficult to execute in extensive iliofemoral DVT patients.

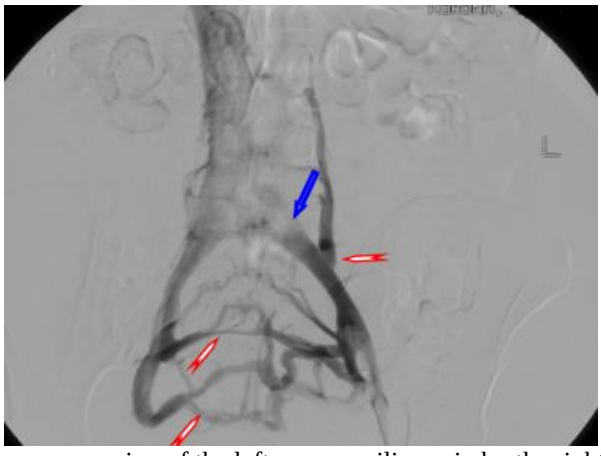

Fig.4a: Venogram revealing compression of the left common iliac vein by the right common iliac artery (blue arrow) and also showing collateral veins (red arrows).

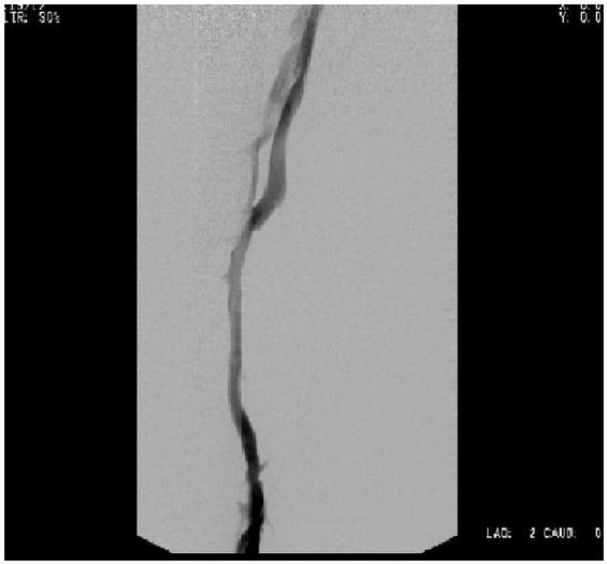

Fig.4b: Duplication of the femoral vein demonstrated by venogram

Intravascular Ultrasound (IVUS)

Intravascular ultrasound (IVUS) is evolving as the most delicate and dynamic tool to determine the degree of stenosis, morphology, and dimensions of the vessels. This imaging modality helps not only in the diagnosis but also in the treatment of MTS. The specific area of the lumen and the diameters can be measured without the use of contrast.[3]The IVUS transducer can precisely determine the left common iliac vein size, any intimal changes like venous spurs in chronic cases, characterization of the residual thrombus and degree of external compression (Fig.5). In a study by Ahmed et al.,[26] IVUS was well correlated with venography and was more perfect in describing the cause of venous narrowing. In a retrospective study conducted by Forauer et al.,[27] IVUS confirmed the diagnosisof all the 16 patients enrolled, helped in deciding endovascular treatment in about 50% of patients and also assisted in the selection of the stent and its placement. Generally, IVUS is a useful imaging modality in the diagnosis of MTS which has disadvantages of being an invasive procedure and does not give extra-vascular information.

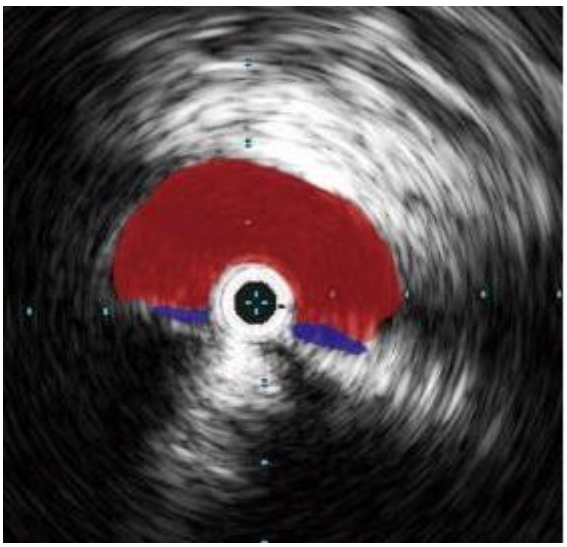

Fig.5: Intravascular ultrasound showing obliteration of the lumen of the left common iliac vein (blue) by the overlying right common iliac artery (red).

Imaging Modality	Advantages	Disadvantages
Doppler Ultrasound	Sensitive and specific for lower extremity DVT Quick , portable and non-invasive Less expensive	Difficult to examine veins in the abdomen and pelvis Difficult to assess the iliac vein compression Operator dependent

	No risk of radiation	
CT Venography	Highly sensitive and specific Non-invasive Illustrates extravascular compressions	Exposure to radiation Requires large volume of contrast Contrast agent complications Presence of bony artifacts limits the resolution
MR Venography	Non-ionizing radiation Clear resolution Safe gadolinium-based contrast agents Can also be used without contrast Can evaluate hemodynamic significance of the venous compression	Not always available Expensive Imaging artifacts due to metallic implants in the pelvis Contraindicated for patients with metallic implants and pacemakers
Catheter Venography	Diagnosis and treatment in the same setting Pressure gradient can be measured through the compression Can illustrates the presence of collaterals Can evaluate hemodynamic significance	Invasive procedure Expensive Contrast allergies or post-stenting DVT Does not provide extravascular information
Intravascular Ultrasound	Sensitive test to define the degree of stenosis Can measure the vein specifications without using contrast Endovascular treatment	Invasive Does not provide extravascular information

IV. Treatment

Assessment of initial treatment is based on the presence or absence of DVT. In the absence of DVT, MT anatomy patients are managed conservatively by compression stockings. When acute DVT is present, the standard therapy is compression with anticoagulation therapy and catheter-directed thrombolysis.[1,3]Anticoagulation therapy alone is not effective in the management of MTS as long as the underlying pathology persists. Presently, endovascular intervention of MTS has been quite effective than other highly invasive treatments like surgical venous reconstructions. The main aim of the endovascular treatment of MTS is resolving of thrombus (acute or subacute), recanalization of stenotic or occluded segments and balloon angioplasty and stent placement to sustain the iliac vein patency.[11]In symptomatic patients with considerable compression and a positive thrombophilia result, endovascular treatment should be considered.[28]In 1995, Berger et al.[29] placed the first stent in a patient with thrombotic MTS. Later, many studies have validated its efficiency. Stented patients had considerably higher patency compared to the patients who were treated only with thrombolysis or thrombectomy.Stent placements can relieve symptoms in the majority of the patients by reestablishing the blood flow through the iliac vein to the inferior vena cava.[30]After subsequent studies, the Society of Interventional Radiology and the Society of Vascular Surgery guidelines suggested iliac venous stenting for the external iliac vein compression.[3]Anticoagulants and compression stockings are still advised even after stent placement to prevent occlusion of the stent and DVT recurrence.[1,5]Surgical management is indicated when endovascular intervention fails. It involves removal of thrombus and vein repair, artery relocation and venous bypass graft placement.[11]

V. Conclusion

The most commonly overlooked cause of DVT is MTS,especially in young patients.In order to avoid further complications of intimal changes leading to multiple DVTs and post-thrombotic syndrome, a thorough diagnostic approach and definitive result is important in MTS patients. Though the initial imaging modality is doppler ultrasound because of its easy availability and quick results, CT and MRI with venography are more advanced in specifying the underlying anatomy. With more developments in MR venography and the use of blood pool contrast agents, visual details and hemodynamic significance have improved a lot. The extensively used invasive contrast venography and IVUS are superior toolsnot only in confirming the diagnosis but also to execute therapeutic endovascular interventions in the same setting. At present, there are no specific guidelines or diagnostic criteria to diagnose MTS and more studies are needed to specify a comprehensive diagnostic protocol.

References

[1]. Zucker EJ, Ganguli S, Ghoshhajra BB, Gupta R, Prabhakar AM. Imaging of venous compression syndromes. CardiovascDiagnTher 2016;6(6):519-532. doi: 10.21037/cdt.2016.11.19
[2]. May R, Thurner J. The cause of the predominantly sinistral occurrence of thrombosis of the pelvic veins. Angiology. 1957;8:419–27. doi: 10.1177/000331975700800505
[3]. Knuttinen MG, Naidu S, Oklu R, Kriegshauser S, Eversman W, Rotellini L, Thorpe PE. MayThurner: diagnosis and endovascular management. CardiovascDiagnTher 2017;7(Suppl 3):S159-S164. doi: 10.21037/ cdt.2017.10.14
[4]. Nazzal M, El-Fedaly M, Kazan V, Qu W, Renno AW, Al-Natour M, et al. Incidence and clinical significance of iliac vein compression. Vascular. 2015;23:337–43. doi: 10.1177/1708538114551194.
[5]. Kalu S., Shah P., Natarajan A., Nwankwo N., Mustafa U., Hussain N. May-Thurner syndrome: a case report and review of the literature. *Case Reports in Vascular Medicine*. 2013;2013:5. doi: 10.1155/2013/740182.740182

[6]. Kaltenmeier CT, Erben Y, Indes J, et al. Systematic review of May-Thurner syndrome with emphasis on gender differences. J VascSurg Venous LymphatDisord. 2018;6(3):399-407.e4
[7]. Kibbe MR , Ujiki M , Goodwin AL , Eskandari M , Yao J , Matsumura J . Iliac vein compression in an asymptomatic patient population. J Vasc. Surg. 2004;39:937–43 .
[8]. Sameer Gupta, TaslimaBhuiyan, Amit R Shah, Ross T Lyon, Aksim Rivera, et al. May–Thurner Syndrome: A Case Based Review. J Heart Circ. 2014;1(1):17000101. Doi:http://dx.doi.org/10.19104/jhc.2014.101
[9]. Donatella N, Marcello BU, Gaetano V, Massimo P, Massimo M, Giancarlo B. What the young physician should know about may-Thurner syndrome. In: Translational Medicine @ UniSa 12 (août); 2015. p. 19–28.
[10]. Chan KT, Popat RA, Sze DY, Kuo WT, Kothary N, Louie JD,et al. Common iliac vein stenosis and risk of symptomatic pulmonary embolism: an inverse correlation. J VascIntervRadiol 2011;22:133-41.
[11]. Chamarthy, M. R., Sutphin, P., Anderson, M., Reddick, M., Kalva, S. P. Evolving Concepts in the Diagnosis and Management of May–Thurner Syndrome. J ClinIntervRadiol ISVIR (2017); 01(01), 023-030. doi:10.1055/s-0036-1597954
[12]. Rajachandran, M, Schainfeld, R. Diagnosis and treatment of May-Thurner syndrome. Vascular Disease Management. 2014;11(11):E265–73.
[13]. Boc A, Boc V, Kozak M. May-Thurner syndrome: old acquaintance, new perspective: Case report. Wien KlinWochenschr. 2017;129(9-10):362-365.
[14]. Oğuzkurt L, Ozkan U, Tercan F, Koç Z. Ultrasonographic diagnosis of iliac vein compression (May-Thurner) syndrome. DiagnIntervRadiol. 2007;13(3):152-5.
[15]. Brazeau NF, Harvey HB, Pinto EG, Deipolyi A, Hesketh RL, Oklu R. May-Thurner syndrome: diagnosis andmanagement. Vasa 2013;42(2):96–105.
[16]. Brinegar KN, Sheth RA, Khademhosseini A, Bautista J, Oklu R. Iliac vein compression syndrome: Clinical, imaging and pathologic findings. World J Radiol. 2015;7(11):375-81.
[17]. A.Y. Mousa, A.F. AbuRahma, May-Thurner syndrome: Update and Review, Ann. Vasc. Surg. 27 (2013) 984–995, http://dx.doi.org/10.1016/j.avsg.2013.05.001.
[18]. Chung JW, Yoon CJ, Jung SI, Kim HC, Lee W, Kim YI, et al. Acute iliofemoral deep vein thrombosis: evaluation of underlying anatomic abnormalities by spiral CT venography. J VascIntervRadiol 2004;15(3):249-56.
[19]. Oguzkurt L, Tercan F, Pourbagher MA, Kizilkilic O, Turkoz R, Boyvat F. Computed tomography findings in 10 cases of iliac vein compression (May-Thurner) syndrome. Eur J Radiol. 2005;55(3):421-5. http://dx.doi.org/10.1016/j.ejrad.2004.11.002. PMid:16129251
[20]. Liu Z, Gao N, Shen L, Yang J, Zhu Y, Li Z, et al. Endovascular treatment for symptomatic iliac vein compression syndrome: a prospective consecutive series of 48 patients. Ann Vasc Surg. 2014;28(3):695-704.
[21]. Shi W-Y, Wang L-W, Wang S-J, Yin X-D, Gu J-P. Combined Direct and Indirect CT Venography (Combined CTV) in Detecting Lower Extremity Deep Vein Thrombosis. Zhu. M, ed. Medicine. 2016;95(11):e3010. doi:10.1097/MD.0000000000003010.
[22]. Gurel K, Gurel S, Karavas E, Buharalıoglu Y, Daglar B. Direct contrast-enhanced MR venography in the diagnosis of May-Thurner syndrome. Eur J Radiol. 2011;80(2):533-6.
[23]. Wolpert LM, Rahmani O, Stein B, Gallagher JJ, Drezner AD. Magnetic resonance venography in the diagnosis and management of May-Thurner syndrome. Vasc Endovascular Surg 2002;36(1):51–7.
[24]. McDermott S, Oliveira G, Ergül E, Brazeau N, Wicky S, Oklu R. May-Thurner syndrome: can it be diagnosed by a single MR Venography study? DiagnIntervRadiol (Ankara, Turkey). 2013;19(1):44–8. https://doi.org/10.4261/1305-3825.DIR.5939-12.1.
[25]. N.D. Shebel, C.C. Whalen, Diagnosis and management of iliac vein compression syndrome, J. Vasc. Nurs. 23 (2005) 10–17, http://dx.doi.org/10.1016/j.jvn.2004.12.001 quiz 18-19.
[26]. Ahmed HK, Hagspiel KD. Intravascular Ultrasonographic findings in May-Thurner Syndrome (iliac vein compression syndrome). J Ultrasound Med.2001;20(3):251–6.
[27]. Forauer AR, Gemmete JJ, Dasika NL, Cho KJ, Williams DM. Intravascular ultrasound in the diagnosis and treatment of iliac vein compression (May-Thurner) syndrome. J VascIntervRadiol 2002;13(5):523–7.
[28]. Portero T.A., García, J.U., Raso, A.G., Sillero, M.P.L. Endovascular Treatment of Deep Vein Thrombosis Associated with May-Thurner Syndrome: A Case Series. American Journal of Medical Case Reports, 4(5), (2016) 180-185.
[29]. Berger A, Jaffe JW, York TN. Iliac compression syndrome treated with stent placement. J VascSurg 1995;21(3):510–14.
[30]. W.-Y. Shi, J.-P. Gu, C.-J. Liu, X. He, W.-S. Lou, Endovascular treatment for iliac vein compression syndrome with or without lower extremity deep vein thrombosis: a retrospective study on mid-term in-stent patency from a single center, Eur. J.Radiol. 85 (2016) 7–14, http://dx.doi.org/10.1016/j.ejrad.2015.10.021.

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