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Ct Findings In Abdominopelvic Vascular Compression Syndromes

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Abstract
Abdominopelvic vascular compression syndromes (AVCS) comprise a group of uncommon conditions caused by extrinsic compression of vessels or hollow viscera by adjacent anatomical structures. These include nutcracker syndrome, superior mesenteric artery syndrome, median arcuate ligament syndrome, and May–Thurner syndrome. Contrast-enhanced computed tomography (CT) is central to diagnosis, enabling visualization of direct vessel narrowing, secondary changes such as collateral formation, and precise quantitative measurements. Advanced techniques, including multiphasic CT angiography, dual-energy CT, respiratory phase imaging, and 3D reconstructions, enhance detection and surgical planning. Accurate interpretation requires correlation with clinical presentation to distinguish true pathological compression from incidental anatomical variants. This review synthesizes current literature on CT findings in AVCS, detailing characteristic signs, diagnostic measurement thresholds, indirect indicators, and the role of advanced imaging strategies. Awareness of CT features and potential pitfalls can improve diagnostic confidence, facilitate timely treatment, and potentially prevent complications.
Keywords: *Abdominopelvic vascular compression, Computed tomography angiography, Nutcracker syndrome, Superior mesenteric artery syndrome, Median arcuate ligament syndrome*

INTRODUCTION

Abdominopelvic vascular compression syndromes (AVCS) encompass a spectrum of uncommon disorders where blood vessels—or adjacent hollow organs—become compressed by nearby anatomical structures. These include classic vascular compression conditions like median arcuate ligament syndrome (MALS), nutcracker syndrome (NCS), May–Thurner syndrome (MTS), and visceral compressions such as superior mesenteric artery syndrome (SMAS) [1]. Though rare, AVCS are increasingly identified incidentally during imaging for unrelated indications [2].

Clinically, AVCS often manifest with nonspecific symptoms—such as postprandial abdominal pain, nausea, vomiting, weight loss, or flank discomfort—but may also result in serious complications including ischemia, venous thrombosis, hematuria, or gastrointestinal obstruction [1,3]. Because of the overlapping and subtle presentations, timely recognition hinges on high-quality imaging evaluation [1,3].

Contrast-enhanced computed tomography (CT), particularly with angiographic phases and advanced multiplanar reconstructions, has become the preferred noninvasive modality for assessing AVCS. Its high spatial resolution enables clear visualization of anatomical relationships and hallmark morphologic features—such as the "hooked" narrowing of the celiac trunk in MALS, the “beak sign” at the compressed left renal vein in NCS, reduced aortomesenteric angle and distance in SMAS, and focal left common iliac vein compression beneath the right common iliac artery in MTS [1,2,4]. The widespread availability of CT and its ability to depict both vascular and adjacent organ findings reinforces its diagnostic utility [2,5].

Several recent pictorial and narrative reviews underscore CT’s pivotal role. Cardoso and colleagues highlighted typical imaging patterns of AVCS, emphasizing CT’s precision in revealing vessel anatomy, compression mechanisms, and guiding clinical management to prevent complications [4]. Nadim et al. provided a comprehensive head-to-toe overview of vascular compression syndromes, illustrating how CT uncovers both incidental anatomic predispositions and clinically significant compressions [5]. Gozzo et al. detailed CT findings across AVCS variants, reinforcing the importance of dynamic imaging in cases with position-dependent symptoms [1]. A unique case report by Shah et al. (2025) illustrated the rare coexistence of MALS and NCS in a single patient, where CT elegantly demonstrated celiac artery compression, compensatory SMA dilation, and resultant left renal vein compression causing varicocele [6].

Accurate CT interpretation requires familiarity with both pathognomonic imaging signs and potential anatomical mimics. It also demands clinical correlation to distinguish incidental anatomical variants from true symptomatic syndromes [1,4]. As imaging technology evolves—such as with dynamic expiratoryinspiratory CT and advanced reconstructions—CT remains central to the diagnosis, management, and surgical planning of AVCS [6]. The aim of this review is to provide a comprehensive narrative overview of the computed tomography (CT) findings in abdominopelvic vascular compression syndromes, emphasizing characteristic imaging signs, quantitative diagnostic parameters, and advanced reconstruction techniques. By synthesizing recent literature, this paper seeks to enhance radiologists' recognition of these uncommon but clinically significant entities, differentiate pathological compression from anatomical variants, and highlight CT's role in guiding diagnosis, treatment planning, and prevention of complications.

Direct Vascular Compression Signs on CT

Direct vascular compression signs are the primary CT features in abdominopelvic vascular compression syndromes (AVCS). They represent focal narrowing of a vessel at a predictable anatomical location due to extrinsic compression by adjacent structures. On CT angiography, these signs are best appreciated on thin-section axial images supplemented with multiplanar reformations (MPR) and, when indicated, maximum intensity projection (MIP) or three-dimensional volume rendering [7,8].

Characteristic patterns include the "beak sign" in nutcracker syndrome, reflecting abrupt tapering of the left renal vein between the superior mesenteric artery (SMA) and aorta [7]. In median arcuate ligament syndrome (MALS), CT typically shows focal narrowing of the celiac artery origin with a "hooked" configuration on sagittal images, often accompanied by post-stenotic dilatation [8,9]. Superior mesenteric artery syndrome (SMAS) demonstrates abrupt duodenal narrowing between the SMA and aorta, best seen on sagittal MPR, along with measurement of the aortomesenteric angle and distance [10]. May–Thurner syndrome (MTS) shows focal compression of the left common iliac vein by the overlying right common iliac artery against the lumbar vertebral body, with or without pre-stenotic dilatation [11].

For accurate diagnosis, correlation with quantitative criteria—such as degree of stenosis, luminal diameter ratios, or aortomesenteric angle measurements—is essential [7,10]. In arterial compression, the narrowing is usually smooth and free of wall irregularities, helping to distinguish it from atherosclerotic stenosis [9]. In venous compression, delayed phase imaging may reveal collateral veins, which reinforces the diagnosis [11].

Table 1: Summary of Direct CT Signs in Major AVCS

Syndrome	Compressed Vessel	Compression Site	Characteristic CT Sign	Quantitative Criteria
Nutcracker Syndrome (NCS)	Left renal vein	Between SMA and aorta	"Beak sign"	Hilar-to-compressed segment diameter ratio >4.9 [7]
Superior Mesenteric Artery Syndrome (SMAS)	Third part of duodenum	Between SMA and aorta	Abrupt duodenal narrowing	Aortomesenteric angle <22°, distance <8 mm [10]
Median Arcuate Ligament Syndrome (MALS)	Celiac artery	At diaphragmatic crura	"Hooked" narrowing ± post-stenotic dilatation	Degree of stenosis >50% [8,9]
May–Thurner Syndrome (MTS)	Left common iliac vein	Between right common iliac artery and vertebral body	Focal narrowing ± pre-stenotic dilatation	Cross-sectional area reduction >70% [11]
Gonadal Vein Compression	Gonadal vein	Retroperitoneal or pelvic course	Smooth tapering	No standardized cut-off [12]

Indirect and Secondary CT Findings

Indirect or secondary CT findings play a crucial role in reinforcing the diagnosis of abdominopelvic vascular compression syndromes (AVCS). These findings reflect hemodynamic alterations due to sustained compression—often manifesting as venous engorgement, collateral vessel formation, post-stenotic dilation, or proximal organ distension.

- In **Nutcracker Syndrome (NCS)**, CT may show dilation of the left renal vein proximal to compression, along with prominent gonadal vein dilation and pelvic varices—markers of venous hypertension and pelvic congestion [13,14].
- For **May–Thurner Syndrome (MTS)**, CT frequently reveals pelvic or thigh collateral veins and pre-stenotic dilatation of the left common iliac vein, particularly in chronic compression cases [15,16].
- In **Median Arcuate Ligament Syndrome (MALS)**, collateral enlargement—especially in the pancreaticoduodenal arcade—and post-stenotic dilation of the celiac trunk are commonly observed [17].
- In **Superior Mesenteric Artery Syndrome (SMAS)**, CT often shows marked dilation of the proximal duodenum and stomach, retained fluids or contents, and in chronic cases, signs of mesenteric fat loss—indicating ongoing obstructive physiology [10].

Awareness of these indirect signs enhances diagnostic confidence, distinguishing pathology from incidental anatomical variants, and guiding appropriate clinical management.

Table 2: Summary of Indirect and Secondary CT Findings in Major AVCS

Syndrome	Indirect CT Findings	Clinical Significance
Nutcracker Syndrome (NCS)	Proximal LRV dilation, gonadal vein and pelvic collateral dilatation	Supports diagnosis and symptomatic pelvic congestion [14]
May–Thurner Syndrome (MTS)	Pre-stenotic iliac vein dilatation, pelvic/thigh venous collaterals	Denotes hemodynamically significant obstruction [16]
Median Arcuate Ligament Syndrome (MALS)	Post-stenotic celiac artery dilation, prominent pancreaticoduodenal collaterals	Indicates chronic stenosis with collateral flow [17]
Superior Mesenteric Artery Syndrome (SMAS)	Dilated stomach/proximal duodenum, retained content, mesenteric fat loss	Reflects chronic obstruction and nutritional compromise [10]

Quantitative CT Measurements and Ratios

Quantitative CT measurements play a key role in confirming the diagnosis of abdominopelvic vascular compression syndromes (AVCS). These objective parameters help differentiate true pathological compression from normal anatomical variation and provide reproducible criteria for both diagnosis and follow-up. They are best obtained on thin-section multiplanar reformations from contrast-enhanced CT angiography.

In **Nutcracker Syndrome (NCS)**, the hilar-to-compressed segment diameter ratio of the left renal vein is a widely used parameter; a ratio greater than 4.9 is considered highly specific, while a ratio greater than 2.25 is highly sensitive for the diagnosis [14]. Measurement of the aortomesenteric angle (AMA) and aortomesenteric distance (AMD) also aids in diagnosis, as NCS often coexists with SMA-related narrowing [18].

In **Superior Mesenteric Artery Syndrome (SMAS)**, an AMA less than 22° and an AMD less than 8 mm are considered diagnostic, with sensitivity and specificity exceeding 90% in symptomatic patients [10].

In **Median Arcuate Ligament Syndrome (MALS)**, CT can quantify the degree of celiac artery luminal narrowing, with stenosis greater than 50%—particularly if dynamic and respiratory-dependent—being clinically relevant [8].

For **May–Thurner Syndrome (MTS)**, a cross-sectional area reduction of the left common iliac vein greater than 70% compared with an adjacent normal segment, or a diameter ratio of compressed to proximal segment less than 0.5, supports the diagnosis [11].

These quantitative metrics, when combined with direct and indirect CT findings, increase diagnostic confidence, facilitate multidisciplinary discussion, and help in surgical or endovascular planning.

Table 3: Quantitative CT Measurement Criteria in AVCS

Syndrome	Quantitative CT Criteria	Diagnostic Thresholds	Clinical Utility
Nutcracker Syndrome (NCS)	Hilar-to-compressed LRV diameter ratio	>4.9 (specific), >2.25 (sensitive) [14]	Confirms significant compression

SMA Syndrome (SMAS)	Aortomesenteric angle (AMA), Aortomesenteric distance (AMD)	AMA <22°, AMD <8 mm [10]	Correlates with duodenal obstruction
Median Arcuate Ligament Syndrome (MALS)	Celiac artery stenosis percentage	>50% narrowing [8]	Guides surgical release decisions
May–Thurner Syndrome (MTS)	LCV area reduction or diameter ratio	>70% area reduction or <0.5 ratio [11]	Predicts venous hypertension risk

Table 4: Advanced CT Techniques in AVCS Evaluation

Technique	Application	Diagnostic Advantage
Multiphasic CTA	All AVCS types	Differentiates arterial vs venous compression phases, detects collaterals [19]
Respiratory-phase imaging	MALS	Differentiates dynamic from fixed stenosis [20]
Dual-energy CT (DECT)	Arterial & venous AVCS	Enhanced contrast conspicuity, perfusion assessment [21]
4D CTA	Complex AVCS	Flow dynamics and collateral visualization [22]
ECG-gated CTA	Arterial AVCS	Reduces motion artefact in proximal vessels [23]
3D VR/MIP	All AVCS	Surgical and endovascular planning [24]

CONCLUSION

Computed tomography remains the cornerstone for diagnosing abdominopelvic vascular compression syndromes, providing comprehensive anatomical assessment, quantitative evaluation, and pre-interventional planning. Recognition of direct and indirect CT signs, combined with established measurement thresholds, improves diagnostic accuracy. Advanced CT techniques further refine visualization and help differentiate true compression from anatomical variants. Integrating imaging findings with clinical context is essential to guide appropriate management, whether conservative, surgical, or endovascular. Enhanced awareness among radiologists can lead to earlier detection, better patient outcomes, and reduced morbidity associated with delayed diagnosis.

REFERENCES

1. Gozzo C, Giambelluca D, Cannella R, Caruana G, Jukna A, Picone D, Midiri M, Salvaggio G. CT imaging findings of abdominopelvic vascular compression syndromes: what the radiologist needs to know. Insights Imaging. 2020;11:48. p. 1–14. https://doi.org/10.1186/s13244-020-00852-z
2. Fong JK, Poh AC, Tan AG, Taneja R. Imaging findings and clinical features of abdominal vascular compression syndromes. AJR Am J Roentgenol. 2014;203:29–36. https://doi.org/10.2214/AJR.13.11598
3. Liu Y, et al. Ultrasound characteristics of abdominal vascular compression syndromes. Front Cardiovasc Med. 2023;10:1282597. p. 1–10. https://doi.org/10.3389/fcvm.2023.1282597
4. Cardoso DL, et al. Abdominal vascular compression syndromes: a pictorial review. Eur J Radiol. 2025;189:112169. https://doi.org/10.1016/j.ejrad.2025.112169
5. Nadim B, Alizada S, Gupta S, Steigner ML, Menard MT, Aghayev A. Under pressure: a head-to-toe review of vascular compression syndromes. Clin Radiol. 2024;79:722–735. https://doi.org/10.1016/j.crad.2024.07.006
6. Shah S, Patel N, Spitzer L. Median arcuate ligament syndrome causing nutcracker syndrome and left-sided varicocele. Cureus. 2025;17:e83177. p. 1–6. https://doi.org/10.7759/cureus.83177
7. Takebayashi S, Ueki Y, Ikeda N, Shindo S, Ohta H, Naiki T. Nutcracker phenomenon demonstrated by multislice computed tomography. Abdom Imaging. 2009;34:757–761. https://doi.org/10.1007/s00261-008-9443-4
8. Horton KM, Talamini MA, Fishman EK. Median arcuate ligament syndrome: evaluation with CT angiography. Radiographics. 2005;25:1177–1182. https://doi.org/10.1148/rg.255055001
9. Heo SH, Kim YW, Shin SS, Lim HS, Seon HJ, Jung SI, Jeong YY. Imaging features of vascular compression syndromes. Radiographics. 2014;34:117–137. https://doi.org/10.1148/rg.341125010
10. Unal B, Aktas A, Kemal G, Bilgili Y, Güliter S, Daphan C, Aydinuraz K. Superior mesenteric artery syndrome: CT and ultrasonography findings. Diagn Interv Radiol. 2005;11:90–95. https://dirjournal.org/en/superior-mesenteric-artery-syndrome-131481
11. Kibbe MR, Ujiki M, Goodwin AL, Eskandari M, Yao J, Matsumura J. Iliac vein compression in an asymptomatic patient population. J Vasc Surg. 2004;39:937–943. https://doi.org/10.1016/j.jvs.2003.12.032
12. Cassidy FH, Ishioka KM, McMahon CJ, Chu P, Sakamoto K, Lee KS, Chung R, McAninch JW, Boulay R, Coakley FV. MR angiography of pelvic congestion syndrome: diagnosis and treatment implications. AJR Am J Roentgenol. 2008;191:183–187. https://doi.org/10.2214/AJR.07.3284

13. Takebayashi S, Ueki T, Ikeda N, Fujikawa A. Diagnosis of the nutcracker syndrome with color Doppler sonography: correlation with flow patterns on retrograde left renal venography. AJR Am J Roentgenol. 1999;172(1):39–43. doi:10.2214/ajr.172.1.9888735
14. Kim SH, Cho SW, Kim HD, Chung JW, Park JH, Han MC. Nutcracker syndrome: diagnosis with Doppler US and MR imaging. Radiology. 1996;198(1):93–97. doi:10.1148/radiology.198.1.8539406
15. Mehra S, Choudhary M. Iliac vein compression—the May–Thurner syndrome diagnosed by CT angiography. J Clin Diagn Res. 2020;14(5):TD01–TD03.
16. Naveen D, et al. A case series of May–Thurner syndrome: CT both diagnostic and therapeutic guidance. Int J Anat Radiol Surg. 2024;13(1):RS01–RS03.
17. Lamba R, Tanner D, Sekhon S, McGahan J, Corwin M, Lall C. Multidetector CT of vascular compression syndromes in the abdomen and pelvis. Radiographics. 2014;34(1):93–115. doi:10.1148/rg.341125010
18. Kurklinsky AK, Rooke TW. Nutcracker phenomenon and nutcracker syndrome. Mayo Clin Proc. 2010;85(6):552-559. doi:10.4065/mcp.2009.0586
19. Young VA, Obi C, Oladini LK, Josephs SC, Hofmann LV. Venous Compressive Disorders. Techniques in Vascular and Interventional Radiology. 2024 Jun 1;27(2):100964.
20. Malik DA, Thomas T, Zafar M, Naqvi SA, Kaur S, Liaquat RR, Akan D. A Case of Chronic Mesenteric Ischemia Due to Celiac and Mesenteric Artery Thrombosis. Cureus. 2023 Aug 28;15(8).
21. Rajiah PS, Kambadakone A, Ananthakrishnan L, Sutphin P, Kalva SP. Vascular applications of dual-energy computed tomography. Radiologic Clinics. 2023 Nov 1;61(6):1011-29.
22. Krishnamurthy R, Bahouth SM, Muthupillai R. 4D contrast-enhanced MR angiography with the keyhole technique in children: technique and clinical applications. Radiographics. 2016 Mar;36(2):523-37.
23. Heuschmid M, Kuettner A, Schroeder S, Trabold T, Feyer A, Seemann MD, Kuzo R, Claussen CD, Kopp AF. ECG-gated 16-MDCT of the coronary arteries: assessment of image quality and accuracy in detecting stenoses. American journal of roentgenology. 2005 May;184(5):1413-9.
24. Fishman EK, Ney DR, Heath DG, Corl FM, Horton KM, Johnson PT. Volume rendering versus maximum intensity projection in CT angiography: what works best, when, and why. Radiographics. 2006 May;26(3):905-22.