THE SUPERIOR MESENTERIC ARTERY ANATOMICAL FEATURES THAT CAUSE VASCULAR COMPRESSION SYNDROMES

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ABSTRACT

Objective. To evaluate prevalence rate of superior mesenteric artery (SMA) syndrome in CT imaging research carried out in The Hospital of Lithuanian University of Health Sciences Kauno klinikos Department of Radiology.
Materials and methods. Evaluation of 330 patients of abdomen CTs. Advantage Workstation 4.2P (GE HealthCare) was used for multiplanar reconstruction. Statistical analysis was performed with SPSS v. 23.0.
Results and conclusions. Superior mesenteric artery syndrome risk factors were identified: small aortomesenteric angle and decreased aortomesenteric distance with prevalence of 18,2% and 14,3% of cases, respectively. At least one risk factor was prevalent in 25,6%, both in 6,7% of patients. Low origin of SMA was observed in 6,7% cases. Compression of the left renal vein between the SMA and aorta in 24,0% cases: 7,0% of them had radiology signs compatible with Nutcracker syndrome. Identified lower than 10 mm cut-off value with 73% sensitivity and 81% specificity of the distance between SMA and abdominal aorta at the level of left renal vein.

***Keywords*:** vascular compression syndrome, superior mesenteric artery, left renal vein

INTRODUCTION

Because abdominal cavity organs are arranged in confined anatomic space, various anatomical structures can compress blood vessels, or arteries of harder consistency can compress internal organs. When symptomatic, such compressions are referred as " vascular compression syndrome" (VCS), since they all involve either the compression of vascular structures or the compression of hollow viscera by vascular structures [1].

Physicians of various specialties can come across this syndrome, but often due to vague, nonspecific, and obscure symptoms, correct diagnoses maybe delayed or even missed. Although the prevalence rate of VCS in population is less than 1 pct, it is important to be able to recognize and properly examine patients if the syndrome can be suspected. Literature mentions various types of VCS [1, 2]. In this article we are going to discuss two of them: superior mesenteric artery (SMA) and nutcracker syndromes.

SMA syndrome occurs when the third part of the duodenum is compressed between SMA and the abdominal aorta (AA). At the vertebral L1-L2 level SMA branches from abdominal aorta and travels in an anterior/inferior direction making an angle with abdominal aorta (SMA angle). Right here, in the level of L3 vertebral between SMA and AA occurs the third (inferior/horizontal) part of the duodenum. Duodenum is almost entirely retroperitoneal and surrounded by retroperitoneal fat, which helps to maintain big SMA angle and distance between SMA and AA. According to literature data, normal SMA angle is between 28°– 65°, and distance between SMA and AA is 10 to 35 mm [3-6]. These measurements can decrease because of rapid and severe weight loss, resulting in a loss of retroperitoneal fat, for example in cases of cancer, eating disorders or malabsorbtion [7, 8]. Also after undergoing corrective surgery for scoliosis, in whom lengthening of the spine may increase tension on the SMA and thus decrease SMA angle and aortomesenteric distance [9, 10]. Risk may increase because of anatomical variance such as low origin of the SMA [8, 11].

Syndrome resembles upper-gastrointestinal-tract obstruction symptoms: heaviness after eating, nausea, vomiting, weight loss. An important feature in classical syndrome case - symptoms are partially relieved when lying flat in the face down or on the left lateral position [3, 7, 8]. Diagnosis must be reached by exclusion of other gastrointestinal-tract obstruction causes performing esophagogastroduodenoscopy and imaging methods. In nonoccurrence of other disorders related to symptoms, CT angiography, which is gold standard diagnostic test for SMA, is performed. In arterial contrast phase images are reconstructed for clear visual evaluation of SMA angle and distance between SMA and AA (fig. 1). It is important to note that the radiologic findings of these symptoms alone are not sufficient to make the diagnosis of SMA syndrome, unless clinical symptoms are also present [1].

Firstly SMA syndrome is treated symptomatically. The main conservative long term treatment method is weight gain, to increase the SMA angle [8]. If these methods are ineffective, the possibility of surgery is considered. First choice surgical option includes laparoscopic duodenojejunostomy [12, 13].

Nutcracker syndrome (NS) first time was mentioned in 1937, when authors described the position of the left renal vein (LRV) between SMA and the aorta as being similar to that of a nut between the jaws of a nutcracker [14]. Most typically LRV is compressed between SMA and the aorta and is known as anterior nutcracker. In atypical cases retroaortic or circumaortic renal vein may be compressed between the aorta and the vertebral body, which is called posterior nutcracker. As in the case of SMA compression this anatomical variance of syndrome is not always associated with clinical symptoms. In rare cases when symptoms occur, this condition is called NS. NS origin is analogous to and may occur simultaneously with SMA syndrome [15, 16].

Clinical manifestation of the nutcracker syndrome includes left flank pain, haematuria, orthostatic proteinuria. Severity of symptoms can vary - gross haematuria can result in anemia. Because of pelvic venous congestion, chronic pelvic pain, dysuria, dysmenorea can occur in women and left side varicocele in men [19-22]. NS is very rarely the cause of haematuria, so at first it is necessary to exclude other diseases. Usually NS is diagnosed by performing CT angiography in venous phase. In reconstructed images SMA angle and distance between SMA, the aorta and dilated LRV and pelvic vein is evaluated (fig. 2 and 3). Ultrasonography can help to evaluate peak systolic velocity (PSV) in LRV compression point and renal hilum. The ratio of the PSV between the two measured points is called velocity rate. The optimum cut-off values must be equal or greater than 4.7 (sensitivity 100%, specificity 90%) for NS diagnosis [23]. Still the most informative diagnostic test for nutcracker syndrome remains retrograde venography. Test allows to determine the renocaval pressure gradient, the dilated gonadal and other pelvic veins. Clinical NS diagnosis should be made when observations of LRV compression at multidetector CT or MR imaging with characteristic clinical symptoms are present. The absence of symptoms merely represents the nutcracker phenomenon, not nutcracker syndrome [1].

The main goal in conservative treatment is weight gain. Surgical option is considered, if very severe clinical symptoms occur. To alleviate LRV outflow obstruction and hypertension numerous surgical approaches can be used: LRV transposition to the more inferior vena cava (IVC), LRV bypass surgery, external venous stent placement, renal autotransplantation to the iliac fossa [15, 21,24].

To draw attention to these quite rare syndromes, we performed retrospective analysis of prevalence rate of SMA anatomical features causing VCS, in CT imaging research carried out in The Hospital of Lithuanian University of Health Sciences Kauno klinikos Department of Radiology.

OBJECTIVE: To evaluate the prevalence rate of SMA anatomical features causing VCS, in CT imaging research carried out in The Hospital of Lithuanian University of Health Sciences Kauno klinikos Department of Radiology.

MATERIALS AND METHODS

Retrospective analysis of abdominal CT scans. The study sample consisted of patients who had undergone abdominal CT scan examinations in January - March, 2016 in the department of Radiology in The Hospital of Lithuanian University of Health Sciences Kauno klinikos. 330 patients reconstructed abdominal CT scans were evaluated (N=330), men 157 (47,6%) and women 173 (52,4%). Average age 60,2 ± 15,0.

CT imaging tests were performed using "GE Light Speed VCT 64" multidetector computed tomography on the patients lying on their back with hands raised above their heads. We performed non-contrast and contrast scan in craniocaudal direction using non-ionic intravenous contrast agents. Using automatic syringe we injected 100 - 120 ml contrast material at the 3 ml per second velocity. CT imaging was performed after 30 and 55s after contrast injection. We evaluated 330 patients' abdominal CT using Advantage Workstation 4.2P for multiplanar reconstruction. We evaluated these anatomical peculiarities: SMA angle, distance between SMA and abdominal aorta at the level of the duodenum and LRV . We measured the height were SMA branches from AA near vertebral cortex level, and evaluated hemodynamic changes characteristic for NS - LRV prestenotic dilatation, renal and pelvic varicose veins. CT scans were not analyzed in cases where it was not possible to examine and evaluate investigated structures. For data analysis we used descriptive statistics, means were presented with standard deviation. A nonparametric Mann-Whitney test was used to compare the means of the quantitative variables for the two independent groups. ROC (Received Operating Characteristic) analysis was used to determine the sensitivity and specificity of the study, and diagnostic value. The results are considered statistically significant if p < 0,05.

RESULTS

Average SMA angle - 47,5 ± 4,6°. Less than 28° angle, which is risk factor for SMA syndrome, was found in 60 (18,2%) subjects, bigger - 270 (81,8%). Average distance between SMA and AA was 20,50 ± 1,15 mm. Less than 10 mm distance is risk factor for SMA syndrome and was found in 47 (14,3%), bigger than 10 mm - 281 (85,7%) cases. In 2 (0,6%) subjects duodenum was in front of SMA. At least one risk factor was found in 84 (25,6%) patients, two - 22 (6,7%). There were no correlation between SMA angle and the distance to AA (r = 0,48, p = 0,01). Men average SMA angle is bigger than women (52,9 ± 21,5° ir 42,6 ± 19,4°, p = 0,01). Men average distance between SMA and AA was larger than women (42,6 ± 19,4 mm ir 18 ± 10 mm, p = 0,01). Height were SMA cuts off from AA: in 187 (56,7%) subjects branching occurs at L1 vertebral body level, 79 (23,9%) - at the level of the L1/L2 intervertebral disc, 39 (11,8%) - at Th12/L1 level, 22 (6,7%) - lower than the L1/L2 intervertebral disc, 3 (0,9%) - higher than Th12/L1 intervertebral disc level (diagram 1). LRV compresion was found in 79 (24,0%) subjects. 23 (7,0%) had radiological signs/indications characteristic of NS - LRV prestenotic dilatation, renal and pelvic varicose veins (diagram 2). Insignificant LRV prestenotic dilation was present in 56 (17,0%) subjects. The NS was not evaluated in 16 (4,8%) subjects because of their anatomical features (LRV was positioned behind AA). Average distance between SMA and AA at LRV was 15,4 ± 1,0 mm.

Using ROC curve analysis AUC = 0,801, we determined critical distance between SMA and AA at LRV which is smaller than 10 mm, with 73% sensitivity and 81% specificity.

DISCUSSION

There are limited literature data about VCS and the amount of research subjects in published studies is quite small. According to many authors the normal distance between SMS and AA is 10-35 mm, and <8-10 mm is considered as SMA risk factor. On the other hand, data about SMA angle size as risk factor are ambiguous. Many sources refer to <25° or <22° angle, but we in our study used newer data which point out <28° angle [3-7]. Italian researches performed untrasonography on 950 patients and found significantly reduced SMA angle (<25°) in 3,05% (N=29) cases. 22 patients also had reduced distance between SMA and AA - from 2 to 8 mm. CT examinations gave overlapping results [25]. These results differ from our analysis - we found 18,2 % reduced SMA angle and 14,3% reduced distance between SMA and AA, respectively. The distinction may be caused by selecting different research methods (untrasonography and CT) and bigger SMA angle margins. N. D. Marret and co-authors specify SMA angle values for 8 SMA syndrome patients between 9° and 18° (average/mean 12°) in their research paper [7]. G. A. Agrawal and co-authors who analyzed 4 SMA syndrome cases found similar results - average SMA angle in CT reconstruction was 13,5° and distance between SMA and AA - 4,4 mm [3].

We did not found literature data about prevalence rate of LRV compression or NS radiological characteristics but discovered information about the meanings of such attributes. According to W. J. Fu and co-authors research of NS patients data, average distance between SMA and AA was 3 mm, while control group data - 10-14 mm [17]. Arima M. and co-authors in the group of patients found smaller than 16° SMA angle [18].

Figure 1. Patient R. K. Abdominal CT scan examination using intravenous contrast agents. Sagittal view of SMA (red arrow) and compressed duodenum (blue arrow).

SMA syndrome and NS are more prevalent in women than men patients [3, 7, 8, 19-22]. Our research data shows that the distance between SMA and AA and the average SMA angle were smaller in women than men, which could indicate relatively higher risk of these syndromes.

As the use of CT increases, symptoms of vascular compression syndrome (VCS) are sometimes detected in the patients for research on a completely different basis. In these cases, when characteristic clinical symptoms are not present, the situation is described as radiological signs of vascular compression or radiological syndrome. It is important to keep in mind that when a patient is undergoing a CT scan of abdominal pain and we cannot identify any obvious changes, there is always a need to think about VCS.

CONCLUSIONS

1. The prevalence rate of SMA syndrome risk factors indentified: SMA angle less than 28° - 18,2 %, distance between SMA and AA less than 10 mm - 14,3 %, Low SMA branching position from the abdominal aorta - 6,7 % patients.
2. 7,0 % of patients had radiology signs compatible with NS.
3. Identified lower than 10 mm. cut-off value with 73 % sensitivity and 81 % specificity of the distance between SMA and abdominal aorta at the level of left renal vein.

Figure 2. Patient R. K. Abdominal CT scan examination using intravenous contrast agents. Axial view of SMA (red arrow) and dilated LRV (blue arrow).

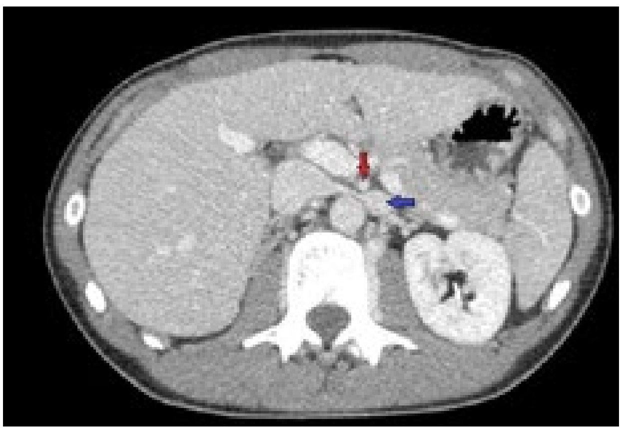


Figure 3. Patient R. K. Abdominal CT scan examination using intravenous contrast agents. Axial view of dilated pelvic veins indicated by red arrows.

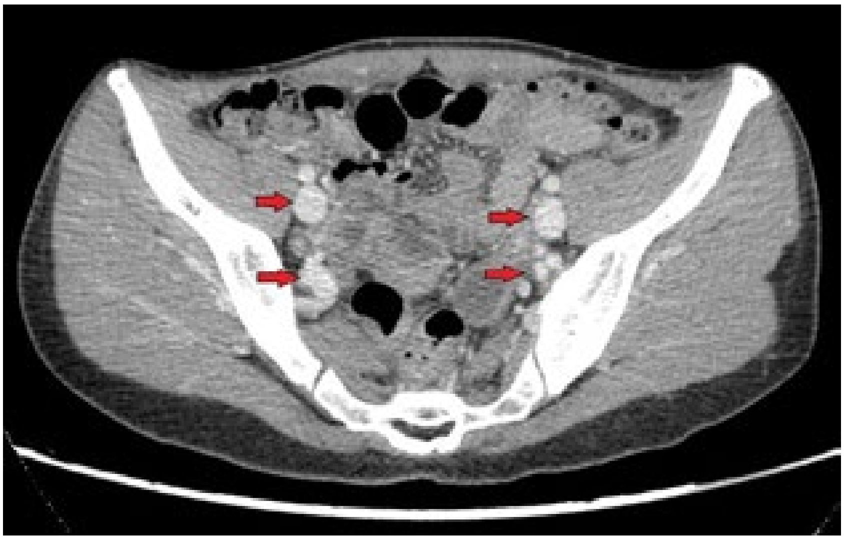


Figure 4. The prevalence rate of SMA syndrome risk factors.

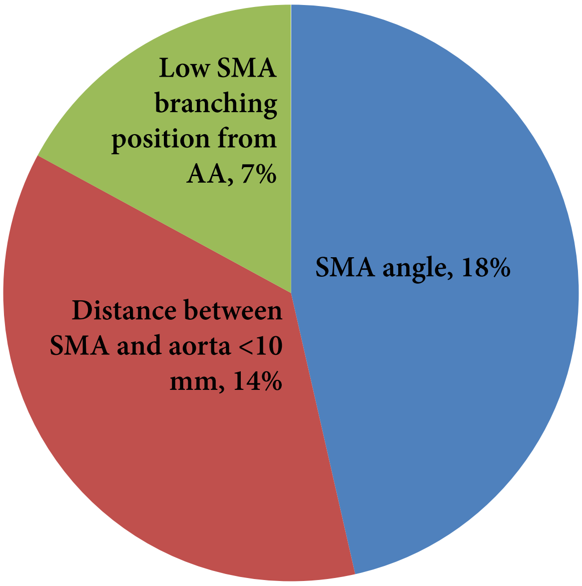
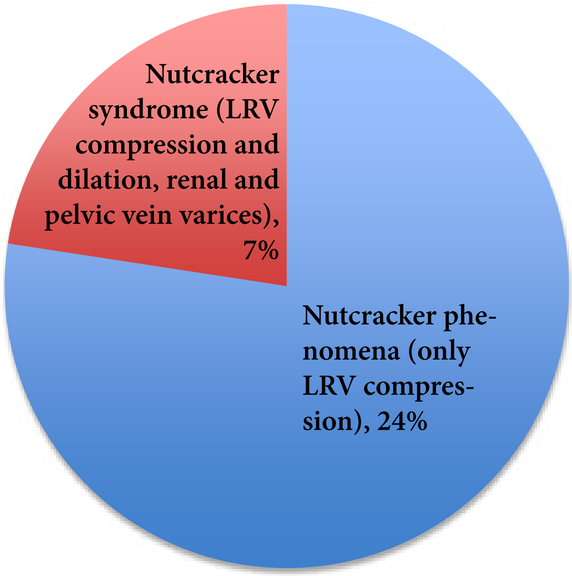


Figure 5. The prevalence rate of NS risk factors.



REFERENCES

1. Ramit Lamba, MBBS, MD, Dawn T. Tanner, MD, Simran Sekhon, MBBS, John P. McGahan, MD, Michael T. Corwin, MD, Chandana G. Lall, MD. Multidetector CT of Vascular Compression Syndromes in the Abdomen and Pelvis. RadioGraphics 2014; 34:93–115

2. Between a Rock and a Hard Place: Clinical and Imaging Features of Vascu¬lar Compression Syndromes Ruth Eliahou, MD, Jacob Sosna, MD, Allan I. Bloom, MD. RadioGraphics 2012; 32(1):E33–E49

3. Agrawal GA, Johnson PT, Fishman EK. Multidetector row CT of superior mesenteric artery syndrome.J Clin Gastroenterol 2007;41(1):62–65.

4. Konen E, Amitai M, Apter S, Garniek A, Gayer G, Nass S et al. CT angiography of superior mesenteric artery syndrome. AJR Am J Roentgenol 1998;171(5):1279–1281.

5. Gustafsson L, Falk A, Lukes PJ, Gamklou R. Diagnosis and treatment of superior mesenteric artery syndrome. Br J Surg 1984;71(7):499–501.

6. Mansberger AR Jr, Hearn JB, Byers RM, Fleisig N, Buxton RW. Vascular compression of the duodenum:emphasis on accurate diagnosis. Am J Surg 1968;115(1):89–96.

7. Merrett N.D., Wilson R.B., Cosman P, Biankin A.V.Superior mesenteric artery syndrome: diagnosis and treatment strategies. J Gastrointest Surg 2009;13(2):287–292.

8. Welsch T, Büchler MW, Kienle P. Recalling superior mesenteric artery syndrome. Dig Surg 2007; 24(3):149–156.

9. Sapkas G, O'Brien JP. Vascular compression of the duodenum (cast syndrome) associated with the treatment of spinal deformities: a report of six cases. Arch Orthop Trauma Surg 1981;98(1):7–11.

10. Griffiths GJ, Whitehouse GH. Radiological features of vascular compression of the duodenum occurring as a complication of the treatment of scoliosis (the cast syndrome). Clin Radiol 1978;29(1):77–83.

11. Strong EK. Mechanics of arteriomesenteric duodenal obstruction and direct surgical attack upon etiology. Ann Surg 1958;148(5):725–730.

12. Mandarry M, Zhao L, Zhang C, Wei Z: A comprehensive review of superior mesenteric artery syndrome. Eur Surg 2010;42:229-236.

13. Wyten R, Kelty CJ, Falk GL. Laparoscopic duodenojejunostomy for the treatment of superior mesenteric artery (SMA) syndrome: case series. J Laparoendosc Adv Surg Tech A 2010;20(2):173–176.

14. Grant JCB. A method of anatomy: descriptive and deductive. 3rd ed. Baltimore, Md: Williams & Wilkins, 1944.

15. Menard MT. Nutcracker syndrome: when should it be treated and how? Perspect Vasc Surg Endovasc Ther 2009;21(2):117–124.

16. Kurklinsky AK, Rooke TW. Nutcracker phenomenon and nutcracker syndrome. Mayo Clin Pct 2010;85(6):552–559.

17. Fu WJ, Hong BF, Xiao YY, et al. Diagnosis of the nutcracker phenomenon by multislice helical computed tomography angiography. Chin Med J (Engl) 2004;117(12):1873–1875.

18. Arima M, Hosokawa S, Ogino T, Ihara H, Terakawa T, Ikoma F. Ultrasonographically demonstrated nutcracker phenomenon: alternative to angiography. Int Urol Nephrol 1990;22(1):3–6.

19. De Schepper A. "Nutcracker" phenomenon of the renal vein and venous pathology of the left kidney. J Belge Radiol 1972;55(5):507–511.

20. Scultetus AH, Villavicencio JL, Gillespie DL. The nutcracker syndrome: its role in the pelvic venous disorders. J Vasc Surg 2001;34(5):812–819.

21. Rudloff U, Holmes RJ, Prem JT, Faust GR, Moldwin R, Siegel D. Mesoaortic compression of the left renal vein (nutcracker syndrome): case reports and review of the literature. Ann Vasc Surg 2006;20(1):120–129.

22. Kim SH, Cho SW, Kim HD, Chung JW, Park JH, Han MC. Nutcracker syndrome: diagnosis with Doppler US. Radiology 1996;198(1):93–97.

23. Cheon JE, Kim WS, Kim IO, et al. Nutcracker syndrome in children with gross haematuria: Doppler sonographic evaluation of the left renal vein. Pediatr Radiol 2006;36(7):682–686.

24. Reed NR, Kalra M, Bower TC, Vrtiska TJ, Ricotta JJ 2nd, Gloviczki P. Left renal vein transposition for nutcracker syndrome. J Vasc Surg 2009;49(2):386–393; discussion 393–394.

25. Neri, s., Signorelli, s. S., Mondati, e., Pulvirenti, d., Campanile, e., di Pino, l. et al. Ultrasound imaging in diagnosis of superior mesenteric artery syndrome. (2005) Journal of Internal Medicine, 257: 346–351. doi:10.1111/j.1365-2796.2005.01456.