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VOLUMETRIC ANALYSIS OF VERTEBRAL HEMANGIOMAS: A RETROSPECTIVE STUDY *

*VERTEBRAL HEMANJİOMLARIN VOLÜM ANALİZİ: RETROSPEKTİF ÇALIŞMA**

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SUMMARY

Purpose: This study was carried out to analyze volumes and localization of vertebral hemangiomas in T12-L5 levels on MRI in patients with low back pain.

Methods: Thoracic-lumbar MR images were examined retrospectively in a total of 150 patients. Hemangiomas observed in vertebral bodies on sagittal vertebral sections were assessed and data were evaluated to get ratios regarding sex, vertebra and vertebral body localizations. Volumetric estimates were performed in the sagittal plane images were calculated using Cavalieri principle.

Results: Hemangiomas were observed in a total of 24 patients (16 %) of whom 22 were females. Two patients had two hemangiomas in different vertebral bodies. Localizations of the hemangiomas were as follows: 6 (23.08 %), 6 (23.08 %), 3 (11.54 %), 6 (23.08 %), 3 (11.54 %), and 2 (7.69 %) in T12-L5 vertebral bodies, respectively. Only 1 (3.84 %) hemangioma was in central part. The remaining 7 (26.92 %) and 18 (69.23 %) of hemangiomas were in anterior and posterior halves, respectively. The mean volumes of vertebral hemangiomas were 0.780 ± 0.165, 1.018 ± 0.210, 0.527 ± 0.079, 2.282 ± 1.333, 3.417 ± 1.598, 0.910 ± 0.070 cm3 for T12-L5 vertebral levels, respectively. Total mean volume of vertebral hemangiomas was found 1.484 ± 0.393 cm^3.

Conclusions: Certain volumetric discrepancies in radiological features exist in vertebral hemangiomas. This study suggests the importance of localization, feature and volume of the vertebral hemangiomas to understand the clinical symptoms and patient history better.

Key word: Benign spinal tumors, hemanjioma, MRI, volume of the tumor

Level of Evidence: Retrospective clinical study, Level III.

ÖZET

Amaç: Bu çalışmanın amacı, bel ağrısı olan hastaların MRG görüntülerinde T12-L5 seviyelerinde vertebral hemanjiomların lokalizasyonunu ve hacmini analize etmektir.

Metod: 150 hastanın torako-lomber MR görüntüleri geriye dönük olarak incelendi. Sagital vertebra görüntülerinde vertebra korpusunda hemanjiom tespit edilenler incelendi ve cinsiyet, vertebra ve vertebra korpus lokalizasyonuna göre bulgular değerlendirildi. Volümetrik değerlendirme sagittal planda gerçekleştirildi ve Cavalieri prensiplerine göre hesaplandı.

Sonuçlar: 22'si kadın olmak üzere toplam 24 hastada hemanjiom tespit edildi. İki hastanın değişik vertebra korpusunda iki adet hemanjiomu mevcuttu. Hemanjiomların T12-L5 vertebra korpuslarında lokalizasyonu sırasıyla: 6 (% 23,08), 6 (% 23,08), 3 (% 11,54), 6 (% 23,08), 3 (% 11,54), ve 2 (% 7,69) idi. Sadece 1 (% 3,84) hemanjiom orta bölümdeydi. Kalanların 7 (% 26,92)'si ve 18 (% 69,23)'i sırasıyla ön ve arka yarıdaydı. Vertebral hemanjiomların ortalama hacimleri T12-L5 vertebra seviyelerinde sırasıyla 0.780±0.165, 1.018 ± 0.210, 0.527 ± 0.079, 2.282 ± 1.333, 3.417 ± 1.598, 0.910 ± 0.070 cm3' dü. Vertebral hemanjiomların total ortalama hacmi ise 1.484 ± 0.393cm^3 bulundu.

Sonuç: Vertebral hemanjiomların radyolojik özelliklerinde belirli hacimsel farklılık vardır. Bu çalışma, klinik semptomları ve hasta özgeçmişini daha iyi anlamak için hemanjiomların lokalizasyonu, özellikleri ve hacminin önemini belirtmektedir.

Anahtar kelimeler: Benign omurga tümörü, hemanjiom, MRG, tümör hacmi

Kanıt Düzeyi: Retrospective klinik çalışma, Level III

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INTRODUCTION:

Osseous hemangiomas are benign developmental vascular lesions of bone, usually of dysembryogenetic origin or a hamartomatous lesion. They are common in the spinal column and calvaria and less frequently affect long bones. Vertebral hemangiomas (VHs) account for 28 % of all skeletal hemangiomas, with the thoracic spine being the most common location (12,16).

VHs are relatively common benign vascular tumors of the spinal column. The prevalence of VHs is common and has been differently reported from 10 to 27 % based on autopsy series, plain X-rays and magnetic resonance imaging (MRI) reviews (3,6,12,19). They are most often asymptomatic and found incidentally during imaging studies and are commonly discovered in the routine evaluation of back pain. Only 0.9-1.2 % of all VHs is symptomatic (6,9,12,13,15). They generally present with pain and in fewer than half of the cases may present with neurological symptoms such as radiculopathy, myelopathy and paralysis.

Also they may need to differentiate from other lesions such as metastases, multiple myeloma, lymphoma, Paget disease and blood dyscrasia (4,8,22). Women are affected more often than men and young adults are more commonly symptomatic than the elderly.

Hormonal stimulus during pregnancy may stimulate the VHs growth. The majority of the VHs are located in the thoracic spine with comparatively fewer lesions in the lumbar and cervical regions. Multiple-level involvement occurs in up to 30 % of cases. While these lesions can arise in patients over a wide age range, VHs are usually detected in patients in the fourth and fifth decades of life (6,8,12,).

Conventional spinal radiographic findings are characteristic, consisting of either regular vertical linear striations (corduroy cloth or jail bar) or "honeycombed" pattern in vertebral body. In computed tomography (CT), VHs demonstrate prominence of the vertical coarse trabeculation with an intervening stroma of soft-tissue or fat attenuation dots (polka-dot pattern) in transverse image sections.

In magnetic resonance (MR) images, increased mottled signal on T1- and T2-weighted images (mottled appearance or salt/pepper appearance) are characteristic (6,8,12,16).

VHs are usual benign course. They can cause neurological symptoms by multiple etiologies, including epidural expansion of tumor tissue, expansion of bony elements, expansion of feeding vessels, epidural hemorrhage or rarely by compression fracture of the vertebra (4,8,22). One of the causes of the spinal cord compression depends on the extraosseous soft tissue extension into the paravertebral and/or epidural space (19). Level of the vertebra, localization of VHs in the vertebral body (i.e. anterior, central and posterior) and volume of VHs are important role in symptoms. Thus localization and volume of VHs are clinically important.

In this study, we investigated VHs and their localizations and morphometry in thoraco-lumbar vertebral bodies on MR images in patients with low back pain, retrospectively. We think that this is the first study on volumetric measurements of VHs in the literature.

MATERIALS AND METHODS:

Thoracic-lumbar MR images were examined retrospectively in a total of 150 patients (48 males, 102 females) with low back pain. Mean age, weight, and height and body mass index (BMI) in the cases were 43.04 ± 2.190 year, 73.28 ± 2.018 kg, 162 ± 1.234 cm, and 35.00 ± 0.826 respectively.

MRI samples were obtained from Department of Neurosurgery, Pendik State Hospital, Istanbul. MRI examinations were carried out with a 1.5 Tesla device (Philips Intera, Philips Medical Systems, Amsterdam, The Netherlands) using T1 and T2 weighted sagittal and transverse plane with 3 mm sections imaging. Hemangiomas observed in T12-L5 vertebral bodies were assessed and data were evaluated to get ratios regarding sex, vertebra and vertebral body localizations.

Localizations of the hemangiomas in vertebral bodies:

In order to classify the localizations of the hemangiomas in vertebral bodies, two vertical lines were drawn over the vertebral body image area in sagittal plane so that the body image area would be divided into three equal parts.

Volumes of vertebral hemangiomas:

Volumetric estimates were performed in the sagittal plane images which were printed on films in rectangular frames of 83x55 mm length. Volumes of the hemangiomas were calculated using Cavalieri principle, one of the stereologic methods, as described previously (5,14). A square grid system with d= 2.5 mm between test points, i.e. representing an area of 6.25 mm^2 109 per point, were used to estimate surface area of the slices of sagittal section planes. The films were then placed on a light bow and hemangiomas were identified with the guidance of scanogram of the section series. The transparent square grid test system was randomly superimposed on the entire image frame (Figure-1). Points hitting the surface area of hemangiomas were manually counted for volume estimation using the formula given below:

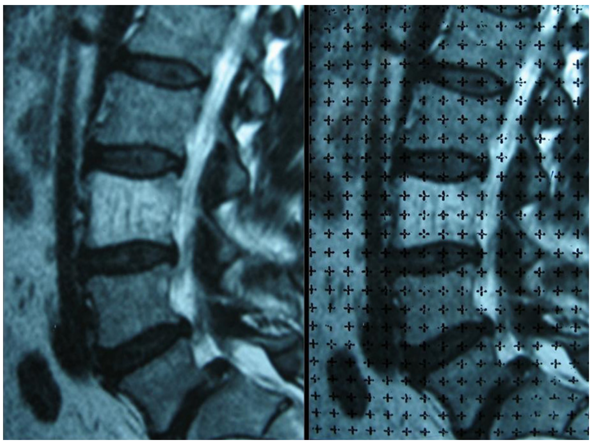

Figure-1. MRI scans of specimen without the point counting grid, a. and with the grid superimposed b. on the sagittal plane.

$V= t \times [(SU \times d)/SL]2\ 115 \times \Sigma P$

According to the formula above, t is the thickness of section, SU is the scale unit (the real length of the scale marked on the MR images), d is the distance between two points in the point grid, SL is the scale length (the actual measure of the scale on MR images) and P is the number of points counted. All data were entered to a previously-prepared Microsoft Excel spreadsheet for automatic calculation of both the results of the above formula and the statistical evaluation parameters including the nugget variance and the coefficient of error (CE).

Statistical analyses:

They were performed on a personal computer using SPSS for Windows software. Results were shown as mean ± SEM (standard error of means). Correlation analysis among the volumes of the hemangiomas, ages, and BMIs was performed using Pearson correlation test. $p<0.05$ was considered statistically significant.

RESULTS:

Hemangiomas were observed in a total of 24 patients (16%) of whom 22 were females in T12-L5 vertebral bodies.

Localizations of the VHs:

While two patients had two VHs in different vertebral bodies, the rest of the patients had only one VH in one vertebral body (totally 26 hemangiomas). Localizations of the VHs were as follows: 6 (23.08 %), 6 (23.08 %), 3 (11.54 %), 6 (23.08 %), 3 (11.54 %), and 2 (7.69 %) in T12-L5 respectively (Figure-2).

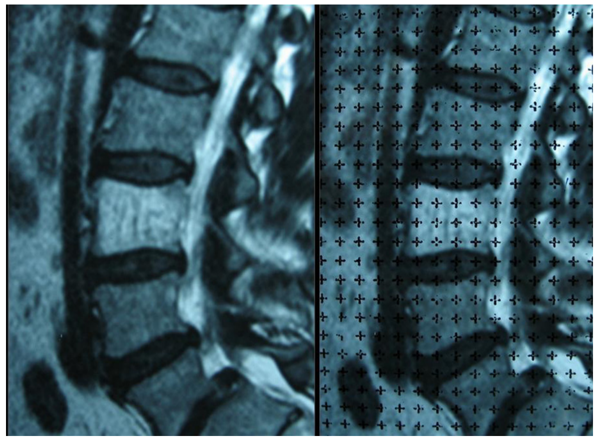

Figure-2. Localizations of the hemangiomas between T12 and L5 vertebral body. Result was showed as percentage.

Localizations of the VHs in vertebral bodies:

Localizations of the hemangiomas in vertebral bodies were classified as being in central part, anterior half and posterior half. Seven (26.92 %) of the hemangiomas were in the anterior part, 18 (69.23 %) of them were in the posterior part but only one (3.84 %) hemangioma was found to be in the central part of the vertebral body (Figure-3).

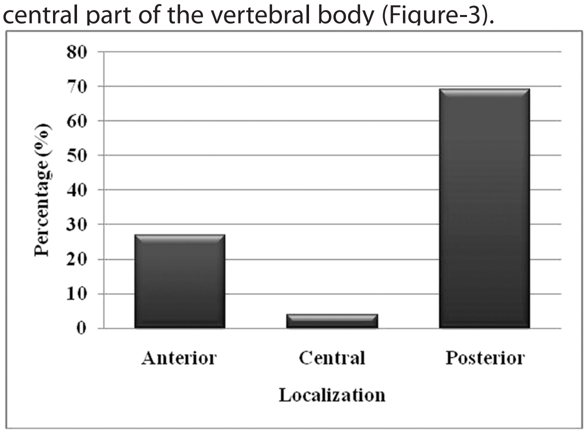

Figure-3. Localizations of the hemangiomas in vertebral body. Result was showed as percentage. A: Anterior part, C: Central part and P: posterior part of vertebra in sagittal plane.

Volumes of VHs:

The mean volumes of VHs were 0.780 ± 0.165, 1.018 ± 0.210, 0.527 ± 0.079, 2.282 ± 1.333, 3.417 ± 1.598, 0.910 ± 0.070 cm^3 for T12-L5 levels, respectively. Total mean volume of VHs was found 1.484 ± 0.393 (minimum 0.350, maximum 8.780 cm3) (Table-1).

Table-1. The mean volumes of vertebral hemangiomas in T12-L5 vertebras. Data were shown mean ± SEM.

Level	Number of case	Volume of hemangiomas	Minimum volume	Maximum volume
T12	6	0.780 ± 0.165	0.430	1.440
L1	6	1.018 ± 0.210	0.350	1.500
L2	3	0.527 ± 0.079	0.370	0.620
L3	6	2.282 ± 1.333	0.430	8.780
L4	3	3.417 ± 1.598	0.900	6.380
L5	2	0.910 ± 0.070	0.840	0.980

Correlations:

There were no statistically significant correlations between VH volumes and BMI, and VH volumes and age in the correlation test.

DISCUSSION:

MRI can be used for diagnosis of VHs and evaluation of the compression of spinal cord and nerve root and tumor aggressiveness. VHs with a fatty stroma (hyper-intense on T1-weighted images) are generally indolent, whereas hypervascular lesions (hypo- or isointense on T1- weighted images, extensive flow void areas) have a higher risk for causing pain or spinal cord compression (6,8,). Thus, it can be hypothesized that hypervascular VHs are more frequently symptomatic. We performed our measurement using spinal MRI in this study.

From an epidemiological perspective, patients with symptomatic VHs tend to be younger and female, and their lesions are more likely to be found in the thoracic spine and in the posterior part of vertebrae (6,8,15). Pregnancy is one of the factors that increase the development of VHs and neurological symptoms in previously quiescent VHs. It has been hypothesized that the increase in intraabdominal pressure caused by the growing fetus augments blood flow to the vertebral venous plexus and that increased estrogen levels may enhance endothelial growth in hemangiomas (10,20,24). The incidence of VHs is common and has been differently reported from 10 to 27 % based on autopsy series, plain X-rays and MRI reviews (3,6,12,19).

Barzin and Maleki found that the incidence of VHs was 26.9 %, more common in females (30 %) than males (23 %), in older age group and in lumbar spine (3). Most hemangiomas (65 %) were less than 10 mm in diameter and multiple hemangiomas were seen in 33 % of cases. In our study, we detected VHs in 16 % of the patients who were referred to the clinic because of low back pain. Majority of these patients were females (22 female, 2 male). VHs were more frequently observed in T12, L1 and L3 vertebrae, and were encountered mostly in posterior part of the vertebral body. Although, these rates can be criticized because of the small number of cases, our study is consistent with the literature. But, we have not found any statistically significant correlation between BMI and VH volumes, and age and VH volumes, respectively. We were not able to perform any correlation test between VH volumes and gender and clinical symptoms, because of lower number VHs incidence in men and retrospective study.

VHs are mostly asymptomatic (almost 99 %) and the symptomatic ones may have only pain (54%) or may be associated with variable neurological symptoms (45 %) (8,12). Compression of the spinal nerve, deterioration of the bone's trabecular structures and releasing of cytokine like factors may be main causes of pain due to VHs. The signs and symptoms of lumbar VHs may mimic herniated discs. Lesions in lumbar region can cause cauda equina syndrome and compression of the medullary conus (1,18). Since our study was retrospective in design, involving MR images ordered for evaluating low back pain and some of the patients also had disc degeneration. Therefore, the association of pain with degeneration, muscle spasm or VHs could not be evaluated.

In fact, VHs are slowly growing benign hamartomas, which, in bones, are most commonly found in the calvarium and the spinal column. Within the spinal column, the thoracic vertebrae are most frequently involved in the literatures (23). In our opinion, the reason for this may be that the number of thoracic vertebrae is greater than that of other vertebral groups.

Laredo et al. observed that VHs were located in L2, T8, T9, in order of descending frequency (11). The frequency of VH in L1, L3 and T6 was the same but less than frequency of T9. The vertebral column receives their arterial supply from derivatives of dorsal branches of the intersegmental somatic arteries. Lower thoracic and upper lumbar vertebrae have more blood supply than the other vertebrae. Artery of Adamkiewicz (a. radicularis magna, the great radiculomedullary artery), which is the major artery in this region, originates in the levels between T8 and L3 in the 90 % of the cases (7). In large study series, it was shown that artery of Adamkiewicz originated from aorta in T5-T8, T9-T12 and L1-L2 vertebral levels in the 15 %, 75 % and 10 % of the cases, respectively (21).

In our study, VHs were more frequently observed in T12, L1 and L3 vertebrae. Our findings were partly consistent 196 with the literature mentioned above. In the thorax and abdomen, the main trunk of the posterior intercostal or lumbar arteries passes around the vertebral body, giving off primary periosteal and equatorial branches to the vertebral body, and then a major dorsal branch, on the each side. The dorsal branch gives off a spinal branch which enters the intervertebral foramen. The postcentral branches, which derives from spinal branch and are the main nutrient arteries to the vertebral bodies (2). In our study, VHs were encountered mostly in posterior part (69.23 %) of the vertebral body.

Arteries enter the vertebral bodies through the posterior part. Thus, there is a rich blood supply in posterior part of the vertebra and this may be a reason for the increased frequency of VHs in the posterior compartment. Also, we think that posterior localization of the VHs may be problems resulting from posterior compression.

Plain radiographic findings are characteristic, consisting of either parallel linear streaks (corduroy cloth or jail bar) in a vertebral body of overall decreased density, or a honeycomb pattern. On transverse CT scans a polka-dot pattern is demonstrated because the vertical trabeculas are imaged in cross section (17). Volumes of VHs may be important in differentiating the mimicking tumors. Therefore, more studies about volumetric comparisons of VHs and other vertebral lesions are needed.

Although there were studies on diameter measurements of VHs in the literature, we did not encounter any volumetric study. Therefore we think that our study is the first one in this regard. In our study, total mean volume of VHs was found to be 1.484 ± 0.393 mm^3. Volumes of L3 and L4 VHs were relatively higher.

The current study can be criticized from several points. Firstly, statistical evaluation could not be performed properly due to the small number of cases. Secondly, since it was a retrospective study and the studied MR images were obtained from the clinic and belonged to the patients with back pain, the clinical correlations could not be established. After all, we think that our study may form a basis for the following studies. However, further studies in which there are more cases and detailed clinical information are necessary for better understanding of the VHs.

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