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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 the volume and localization of vertebral hemangiomas at the T12–L5 levels by MRI in patients with lower back pain.

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

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

Conclusions: Certain volumetric discrepancies in radiological features exist in vertebral hemangiomas. This study suggests that the localization, features and volume of a vertebral hemangioma are important in order to understand the clinical symptoms and patient history better.

Key word: Benign spinal tumors, hemangioma, MRI, tumor volume

Level of Evidence: Retrospective clinical study, Level III.

This study was presented in the 10th Congress of European Association of Clinical Anatomy as an oral presentation held in Istanbul on 2-5 September 2009, Turkey.

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 T-12L5 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 26,92 %) 7)'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

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 studies, 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 are symptomatic[6,9,12,13,15]. They generally present with pain, and fewer than half of the cases may present with neurological symptoms such as radiculopathy, myelopathy, and paralysis.

VHs may also need to be differentiated from other lesions, such as metastases, multiple myeloma, lymphoma, Paget's 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 growth of VHs. The majority of 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 a 'honeycomb' pattern in the 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 imaging (MRI), increased mottled signals on T1- and T2-weighted images (a mottled or salt/pepper appearance) are characteristic[6,8,12,16].

VHs usually follow a 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 vertebrae[4,8,22]. One of the causes of spinal cord compression depends on the extension of extraosseous soft tissue into the paravertebral and/or epidural space[19]. The level of the vertebra affected, the localization of the VH in the vertebral body (i.e. anterior, central, or posterior), and the volume of the VH play an important role in the symptoms. Thus, the localization and volume of VHs are clinically important.

In this study, we retrospectively investigated VHs and their localizations and morphometry in the thoracolumbar vertebral bodies using MRIs of patients with lower back pain. We consider this to be the first study in the literature of volumetric measurements of VHs.

MATERIALS AND METHODS:

Thoracic-lumbar MRIs were examined retrospectively in a total of 150 patients (48 males, 102 females) with lower back pain. The

mean age, weight, height, and body mass index (BMI) of the cases were 43.04 ± 2.190 years, 73.28 ± 2.018 kg, 162 ± 1.234 cm, and 35.00 ± 0.826, respectively.

The MRIs were obtained from the 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 planes with imaging in 3 mm sections. Hemangiomas observed in the T12–L5 vertebral bodies were assessed, and data were evaluated to determine the ratios with regard to sex, vertebra, and vertebral body localizations.

Localizations of the hemangiomas in vertebral bodies:

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

Volumes of vertebral hemangiomas:

Volumetric estimates were performed on the sagittal plane images, which were printed on films in rectangular frames with dimensions of 83×55 mm. The volumes of the hemangiomas were calculated using the Cavalieri principle, one of the stereological methods, as described previously[5,14]. A square grid system with 2.5 mm between the test points, i.e. representing an area of 6.25 mm2 per point, were used to estimate the surface area of slices of the sagittal section planes. The films were then placed on a light box, and hemangiomas were identified with the guidance of a 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 a volume estimation using the formula given below:

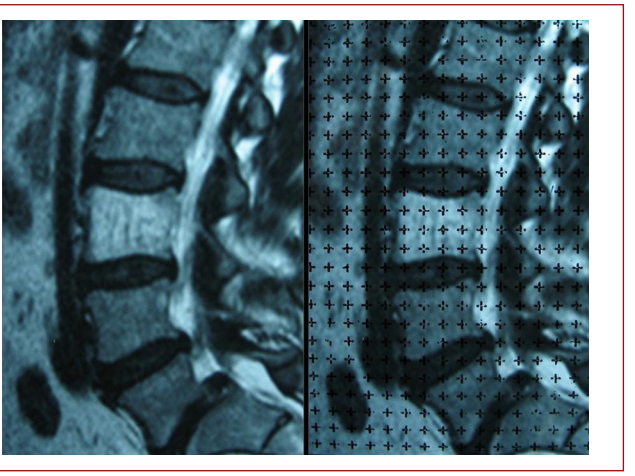

Figure-1. MRI scans of a specimen a. without the point counting grid, and b. with the grid superimposed, in the sagittal plane.

RESULTS:

Hemangiomas were observed in a total of 24 patients (16%), of whom 22 were females, in the 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 (26 hemangiomas in total). Localizations of the VHs were as follows: six (23.08%), six (23.08%), three (11.54%), six (23.08%), three (11.54%), and two (7.69 %) in the T12–L5 levels, respectively .

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

According to the formula above, t is the thickness of the section, SU is the scale unit (the real length of the scale marked on the MRI), d is the distance between two points

in the point grid, SL is the scale length (the actual measure of the scale on the MRI) and P is the number of points counted. All data were entered into 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:

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

Localizations of the VHs in vertebral bodies:

The localizations of the hemangiomas in the vertebral bodies were classified as being in the central part, anterior half, or posterior half. Seven (26.92%) of the hemangiomas were in the anterior part, 18 (69.23%) were in the posterior part, and only one (3.84%) hemangioma was found to be in the central part of the vertebral body (Figure-2).

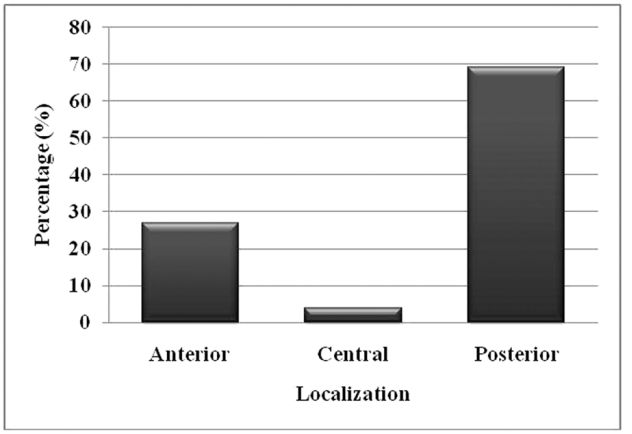

Figure-2. Localizations of the hemangiomas in the vertebral bodies. The result is shown as a percentage. A: Anterior part, C: Central part and P: posterior part of vertebrae in the sagittal plane.

Volumes of VHs:

The mean volumes of the VHs were 0.780 ± 0.165, 1.018 ± 0.210, 0.527 ± 0.079, 2.282 ± 1.333, 3.417 ± 1.598, and 0.910 ± 0.070 cm3 for the T12–L5 levels, respectively. The total mean volume of the VHs was found to be 1.484 ± 0.393 (range: 0.350–8.780) cm^3 (Table-1).

Table-1. The mean volumes of vertebral hemangiomas in the T12–L5 vertebrae. Data are shown as 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 the VH volumes and BMI, or VH volumes and age, in the correlation tests.

DISCUSSION:

MRI can be used for the diagnosis of VHs, and evaluation of the compression of the 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 measurements using spinal MRIs 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 parts of the vertebrae[6,8,15]. Pregnancy is one of the factors that can increase the development of VHs, and neurological symptoms in previously quiescent VHs. It has been hypothesized that the increase in intra-abdominal 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 variously reported from 10% to 27%, based on autopsy studies, plain X-rays, and MRI reviews[3,6,12,19].

Barzin and Maleki found that the incidence of VHs was 26.9%, and that they were more common in females (30%) than males (23%), in an older age group, and in the 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 patients who were referred to the clinic because of lower back pain. The majority of these patients were female (22 female, two male). VHs were more frequently observed in the T12, L1 and L3 vertebrae, and were encountered mostly in the 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. However, we found no statistically significant correlations between BMI and VH volume, or age and VH volume. We were not able to perform any correlation tests between VH volumes and gender or clinical symptoms because of the lower incidence of VHs in men, and because our study is retrospective.

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

VHs are slow-growing benign hamartomas, which, in bones, are most commonly found in the calvaria and the spinal column. Within the spinal column, the thoracic vertebrae have been

shown in the literature to be most frequently involved[23]. In our opinion, the reason for this may be that the number of thoracic vertebrae is greater than the other vertebral groups.

Laredo et al. observed that VHs were located in L2, T8, and T9, in order of descending frequency[11]. VHs were seen in L1, L3 and T6 with the same frequency, less frequently than in T9. The vertebral column receives its arterial supply from derivatives of the dorsal branches of the intersegmental somatic arteries. The lower thoracic and upper lumbar vertebrae have a greater blood supply than the other vertebrae. The artery of Adamkiewicz (the arteria radicularis magna, the great radiculomedullary artery), which is the major artery in this region, originates between the T8 and L3 levels in 90% of cases[7]. In a large study series, it was shown that the artery of Adamkiewicz originated from the aorta at the T5–8, T9–12 and L1–2 vertebral levels in 15%, 75%, and 10% of cases, respectively[21].

In our study, VHs were more frequently observed in the T12, L1 and L3 vertebrae. Our findings were partly consistent 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 each side. The dorsal branch gives off a spinal branch which enters the intervertebral foramen. The postcentral branches, which derive from the spinal branch, are the main nutrient arteries to the vertebral bodies[2]. In our study, VHs were encountered mostly in the posterior part (69.23%) of the vertebral body.

Arteries enter the vertebral bodies through the posterior. Thus, there is a rich blood supply in the posterior part of the vertebrae, and this may be a reason for the increased frequency of VHs in the posterior compartment. We also think that the posterior localization of the VHs may be a problem 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 as the vertical trabeculae are imaged in cross-section[17]. The volumes of VHs may be important in differentiating them from tumors. Therefore, more studies into volumetric comparisons of VHs and other vertebral lesions are needed.

Although there have been studies on diameter measurements of VHs in the literature, we did not encounter any volumetric studies. Therefore, we think that our study is the first one in this regard. In our study, the total mean volume of VHs was found to be 1.484 ± 0.393 mm3. The volumes of L3 and L4 VHs were relatively higher.

The current study can be criticized on 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 MRIs were obtained from the clinic and belonged to patients with back pain, the clinical correlations could not be established. Our study will form a basis for subsequent studies. However, further studies including more cases and detailed clinical information are necessary for a better understanding of VHs.

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