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Evaluation of the Prevertebral Soft Tissue Thickness by Magnetic Resonance Imaging in Patients with Mild Neck Problem

Hafif Boyun Sorunu Olan Hastalarda Manyetik Rezonans Görüntüleme ile Prevertebral Yumuşak Doku Kalınlığının Değerlendirilmesi

Ibrahim OZTURK[1], Sema BULUT[1], Mehmet H. ATALAR[1], Ismail SALK[1], Unal OZUM[2]

[1]*Cumhuriyet University, Faculty of Medicine, Department of Radiology, Sivas, Turkey*
[2]*Cumhuriyet University, Faculty of Medicine, Department of Neurosurgery, Sivas, Turkey*

Corresponding Author: Mehmet H. ATALAR / E-mail: mhatalar@gmail.com

ABSTRACT

AIM: We encountered no study conducted on the evaluation of prevertebral soft tissue (PVST) thickness by magnetic resonance imaging (MRI) during our literature search. Measuring PVST thickness by MRI in the cervical region of adult cases was aimed in the present retrospective study.

MATERIAL and METHODS: For the intended purpose, a total of 136 patients, composed of both males and females, with ages ranging from 20 to 69 years, in whom no pathology in the cervical prevertebral region was revealed by MRI modality implemented for various reasons, were included in the study.

RESULTS: The upper limit of normal for PVST thickness was measured in our study to be 10 mm, 7 mm and 20 mm at C1, C2-C3 and C6-C7 vertebral levels, respectively. The least variation in the measurements and standard deviations were obtained at C3-C4 vertebral levels. Upon making a comparison between the measured PVST thicknesses on the basis of gender, the measurements at C2,C4 and C7 were found to display significant difference, whereas that was not the case for the measurements obtained at the other levels.

CONCLUSION: Progressively widespread use of MRI for the traumas inflicting the cervical region makes it obligatory to specify normal values for the thickness of PVST measured by MRI.

KEYWORDS: Cervical region, Magnetic resonance imaging, Prevertebral soft tissue

ÖZ

AMAÇ: Yaptığımız literatür taramasında, PVYD kalınlığı değerlerinin manyetik rezonans görüntüleme (MRG)'de ölçülmesi ile ilgili yayınlanmış çalışmaya rastlamadık. Bu geriye dönük çalışmada, erişkin olgularda servikal bölge için PVYD kalınlığının MRG ile ölçülmesi planlandı.

YÖNTEM ve GEREÇLER: Bu amaçla, çeşitli nedenlerle servikal spinal MRG yapılmış ve prevertebral bölge için patoloji tariflenmemiş 20–69 yaşlar arasındaki kadın ve erkek toplam 136 olgu üzerinde ölçüm yapıldı.

BULGULAR: Çalışmamızda PVYD kalınlığının üst sınırı C1 seviyesinde 10 mm, C2 ve C3 seviyesinde 7 mm, C6 ve C7 seviyesinde 20 mm olarak ölçüldü. En düşük değişkenlik ve standart deviasyon C2 ve C3 vertebra seviyelerinde bulundu. Cinsiyetlere göre olguların PVYD kalınlığı karşılaştırıldığında C2, C4 ve C7 seviyelerinde cinsiyetler arası farklılık önemli bulunurken diğer seviyelerde önemsiz bulundu.

SONUÇ: MRG'nin servikal spinal travmalarda giderek yaygın kullanımı MRG açısından PVYD kalınlığının normal değerlerini belirlemeyi zorunlu kılmaktadır.

ANAHTAR SÖZCÜKLER: Manyetik rezonans görüntüleme, Prevertebral yumuşak doku, Servikal bölge

INTRODUCTION

Composed of the prevertebral muscles, ligaments, the cervical fascias, deep cervical spaces, the posterior pharyngeal/laryngeal/tracheal and proximal part of the esophagus, the prevertebral soft tissue (PVST) is the area located between the pharyngeal/tracheal air column and the vertebral bodies/intervertebral discs (14). A sizable number of factors dictate the PVST thickness. Among them, hematoma and soft tissue edema come first. Congenital lesions such as hemangioma and lymphangioma, benign tumors like lipoma, and malignant tumors such as nasopharyngeal carcinoma and lymphoma are also among the factors likely to involve this region to increase tissue thickness. Moreover, infectious conditions, such as retropharyngeal cellulites and retropharyngeal abscess formation can also affect this area of interest (1, 2, 8).

Measurements with respect to PVST thickness were performed by lateral cervical roentgenograms and multidetector computed tomography (MDCT). In our thorough

literature review, we encountered no study conducted on the measurements regarding the thickness of this area of interest by magnetic resonance imaging (MRI) modality.

We aimed in this retrospective study to specify the normal values of PVST thickness dictated by the cervical MRI and disclose, if present, their gender-based differences in patients with a mild neck problem.

MATERIAL and METHODS

Study Design

The present study is a descriptive study on a retrospective basis. The required permission for the study was obtained from Cumhuriyet University Clinical Researches Ethics Committee.

Study Group

A total of 136 consecutive patients (47 males and 89 females) who had been admitted to Cumhuriyet University Radiology Clinic with the complaints of neck pain, paresis and numbness in the hands along with some findings suggesting the pre-diagnosis of cervical disc herniation, and had subsequently underwent cervical spinal MRI between November 2009 and March 2010 were included in the study. Meticulous care was taken in order not to include such cases as those with previous history of injury to the cervical region; congenital or acquired anomaly, such as retropharyngeal internal carotid artery; retropharyngeal lymphadenopathy, mass lesion, abscess formation of fluid collection. While the patients with endotracheal or nasogastric tube in place, as well as the patients in whom image data failed to be acquired in appropriate body positions were excluded from the study, those suffering from degenerative disc diseases were not considered contrary to the criteria assigned for the study recruitment.

Imaging Technique

All image acquisitions were performed using of cervical spinal coil by a system of 1.5 Tesla magnetic field power (Excelart, Toshiba, Tokyo, Japan). Among the SE T1-weighted images acquired in the sagittal plane [repetition time (TR): 550 msn, echo time (TE): 10 msn, flip angle (FA): 90/180, section thickness: 5 mm, matrix: 160x256], those displaying the cross-sections of midline cervical region were selected for the evaluation. T1-weighted sagittal images of the cases were transferred to another console where the midsagittal views were identified with the help of the coronal and sagittal views, and the thickness measurements were performed based on this midsagittal views.

MR Evaluation

Normal thickness of the prevertebral soft tissue was described for the adult population using cervical MRI in the present study. The measurements were based on the images acquired in the midline sagittal plane. At the levels from C1 down to C7, the measurements were performed from the craniocaudal midpoint of the anterior arch of C1 and at the midpoint of the vertebral bodies from C2 to C7 to the closest point in the air column (Figure 1).

Statistical Study

Upon loading the study parameters into SPSS program (version 14.0), such related values as minimum, maximum, mean ± SD to these parameters and the 95% safety margins of the former values were determined. The significance test for the difference between two means was used in order to reveal whether or not the measurements exhibited any gender-related significant difference between each other.

RESULTS

The ages of a total of 136 patients included in the study were ranging between 20 and 69 years, with the mean calculated to be 42.51± 10.64 years. Of all the cases, 89 were women (65.4%) and 47 were men (34.6%). The mean age of the females was 43.45 ± 10.56 years and the mean age of the males was 40.90 ± 10.68 years, with no age-related significant difference between the two genders ($t = 1.35$; $p = 0.178$; $P > 0.05$).

Our findings were as follows: the mean thicknesses and the upper limits of normal at the levels of C1, C2, and C3 were 5.38 mm/10 mm, 3.55 mm/7 mm, 3.72/ 7 mm, respectively. There was a wide range of values measured at C4 and C5. At C4, the mean thickness was calculated to be 5.88 mm, and

Figure 1: The midsagittal T1-weighted cervical MR image demonstrates the vertebral levels where the measurement of the thickness was performed.

the upper normal limit was measured to be 16 mm. At C5, the mean thickness was calculated to be 11.39 mm and the upper normal limit was measured to be 18 mm. At C6, the mean thickness was 12.24 mm, and the upper normal limit was measured to 20 mm. At C7, the mean thickness was 12.06 mm, and the upper normal limit was measured to be 20 mm. The standard deviations for the levels of C2 and C3 were calculated to be lower than that for all other levels. The range of the thickness and the standard deviations showed increase at C4 and below, which translated into lower sensitivity at these levels. Table I displays the assessment of the distributions of PVST thicknesses measured from the cases included in the study.

The assessments of the distributions based on the PVST thicknesses in the female and male cases included in the study are given in Table II and Table III.

When a gender-based comparison was made among the thickness of PVST in the study cases, a significant gender-based difference was found at C2, C4 and C7 ($P < 0.05$), whereas the same did not hold true for the other levels ($P > 0.05$), with greater thickness of PVST in the males than in the females (Table IV).

DISCUSSION

Radiological evaluation plays a pivotal role in the diagnosis and follow-up of the pathologies occurring in the prevertebral region. Among the radiological examinations, the most frequently used ones are conventional radiograms, CT and MRI (16).

The analysis of PVST thickness as an indirect finding of injury to cervical spine is commonly made during the standard evaluation of the cervical spine. Detection of PVST thickness is the most frequently used method implemented in the evaluation of the hematomas and/or tissue edema accompanying osseous or ligamentous injuries (19). Traumatic prevertebral hematoma develops within the loss connective

Table I: The Distributions of Prevertebral Soft Tissue Thickness

	Minimum (mm)	Maximum (mm)	x± s	0/095 CI
C1	2	10	5.38 ± 1.68	2.02; 8,74
C2	2	7	3.55 ± 0.85	1.85; 5.25
C3	2	7	3.72 ± 0.86	2.00; 5.44
C4	2	16	5.88 ± 0.86	0.70; 12.46
C5	3	18	11.39 ± 3.26	4.87; 17.91
C6	8	20	12.24 ± 1.95	8.34; 13.14
C7	5	20	12.06 ± 2.56	6.94; 17.18

Table II: The Distributions of the Paravertebral Soft Tissue Thickness In Female Patients

	Minimum (mm)	Maximum (mm)	$\bar{x}$± s	0/095 CI
C1	2	10	5.23 ± 1.75	1.73; 8.73
C2	2	6	3.41 ± 0.81	1.79; 5.03
C3	2	7	3.68 ± 0.82	2.04; 5.32
C4	3	16	6.55 ± 3.71	0.87; 13.97
C5	3	18	11.32 ± 2.57	6.18; 16.46
C6	8	20	12.05 ± 2.01	8.03; 16.07
C7	5	18	11.26 ± 2.32	6.62; 15.09

Table III: The Distributions of the Paravertebral Soft Tissue Thickness in Male Patients

	Minimum (mm)	Maximum (mm)	$\bar{x}$± s	0/095 CI
C1	3	10	5.66 ± 1.53	2.06; 8.72
C2	2	7	3.78 ± 0.86	2.06; 5.05
C3	2	6	3.78 ± 0.93	1.92; 5.64
C4	2	16	4.74 ± 1.93	0.88; 8.06
C5	4	18	11.52 ± 4.21	3.10; 19.94
C6	8	20	12.56 ± 1.82	8.03; 16.07
C7	9	20	13.44 ± 2.38	8.68; 18.02

Table IV: Comparison of Prevertebral Soft Tissue Thickness According to Gender

	Female (mm)	Male (mm)	Results
C1	5.23 ± 1.75	5.66 ± 1.53	t = 1.43 *P* = 0.154
C2	3.41 ± 0.81	3.78 ± 0.86	t = 2.43 *P* = 0.016 *
C3	3.68 ± 0.82	3.78 ± 0.93	t = 0.60 *P* = 0.544
C4	6.55 ±3.71	4.74 ± 1.93	t = 3.21 *P* = 0.002 *
C5	11.32 ± 2.57	11.52 ± 4.21	t = 0.33 *P* = 0.739
C6	12.05 ± 2.01	12.56 ± 1.82	t = 1.45 *P* = 0,149
C7	11.26 ± 2.32	13.44 ± 2.38	t = 5.20 *P* = 0.001 *

** P < 0.05 significant.*

tissue entrapped between the constrictor pharyngeal muscles in the retropharyngeal space and the prevertebral fascia (24). Inferiorly, the retropharyngeal space exhibits continuity with the retrotracheal space. Hematomas originate both from soft tissue injuries and the fractures of the anterior vertebral column (17). The sensitivity of radiographic detection of the soft tissue edema induced by cervical spine injuries becomes around 66%, on accepting the upper normal limit as 4 mm at C3 (11). Presence of radiographically-detected soft tissue edema is of greater diagnostic significance, compared with its absence. False positive results, however, can be encountered at C3/C4, with the rates varying between 13% and 66% from 13-66%, based on the definitions with respect to the upper limit of normal (12, 23). Confidence in the measurement decreases in the cases with wide osteophytes and following endotracheal or nasogastric intubations (23).

The sole radiographic sign of a number of severe cervical traumas has been increase in the thickness of PVST (7). At C1 and C2, increase in the thickness of PVST may be a herald of atlanto-occipital subluxation, occipital condylar fracture, C1 vertebral fracture, odontoid fractures, and rupture of the transverse atlantal ligament or hangman fracture (9, 17). As for the increase in the thickness of PVST in the lower vertebral levels, they may indicate such conditions as hyperflexion- or hyperextension-induced stress, angular or teardrop fractures, unilateral and bilateral facet dislocations (17).

In the presence of spinal injuries at the lower levels, the associated edema and hematoma are detected more commonly at the upper levels (C2, C3). This condition can be explained by several mechanisms, such as higher degree of laxity that PVST has possessed at the higher levels, relatively greater thickness of PVST at the lower levels depending on the esophagus and broader range of normal values at the lower levels. Occult lower level spinal injuries becomes manifest radiographically as they progress cranially to increase the thickness of PVST at C2 and C3 (17).

The PVST thickness, apart from the cervical injuries, is likely to be increased in cases of facial and mediastinal traumas, rupture of the thoracic aortic aneurysm, severe cough, bleeding within a tumoral mass, and presence of a foreign body in the esophagus (5, 6). Postmortem studies showed that wide retropharyngeal hematomas may possible develop in the absence of osseous injuries (7, 9). Such condition can easily complicate even a minor trauma in the elderly (especially those on anticoagulation therapy) (15, 22).

Other non-traumatic etiologies, such as infections, neoplasms or pseudotumors may also be responsible for the increase in the thickness of PVST (6, 25). Surprisingly, patient's yelling or swallowing during exposure can increase the PVST thickness at C2 and C3. Notwithstanding flexion/extension, rotation and expiration may cause an increase in the thickness of PVST at C4 and C5, such movements do not exert a significant impact at C2 and C3 (13).

The analysis of the PVST thickness has been a method utilized for the detection of the pathologies occurring in this region for more than half a century. It was reported in 1930s that the pathologies of retropharyngeal and retrotracheal location might be recognized by evaluating radiographically the soft tissues in the lateral cervical radiographs (10). In a study conducted on 75 patients (50 adults, 25 children aged below 14), the mean thickness was accepted as the retropharyngeal space between the levels of C1 and C5, while the mean thickness was accepted as the retrotracheal space at C5 and C6. The parameters used in the radiographic examinations and measurements were not debated. The normal mean values and the variations of the retropharyngeal space for the adult males and females were found to be 2 mm (1.5-4 mm) and 1.9 mm (1.5-3.4 mm), respectively. As for the retrotracheal space, the normal mean value and the variations were measured to be 5.4 mm (3.5-7 mm) for males and 5 mm (3.5-6 mm) for females (10).

Wholey et al. (27) measured the retrotracheal space at C6 level and reported the thickness of PVST at the same level as 14 mm (9-22 mm). Shumaker et al. (20) reached results associated with retrotracheal space as 14 mm. Again, Chen et al. (3) documented in their study similar results as 15.46 mm at C5.

In addition to the fact that increase in the thickness of PVST in the lateral cervical radiographs is a well-documented sign of acute cervical trauma, MRI also possess a crucial role in the demonstration of spinal cord, vertebral disc and ligamentous injuries (4, 18).

Prevertebral edema developing after a trauma generally displays a rapid improvement within the 1st week, followed by a complete resolution within two weeks (17). In an MRI-based study conducted on the patients with acute

neurological deficit and prevertebral soft tissue swelling, MRI modality was implemented after an average delay of 9 days. A prevertebral widening was recognized on radiographs in 14 out of 27 patients, 13 of whom had tear in the anterior longitudinal ligament detected on MRI. Of 8 patients with isolated prevertebral soft tissue swelling in the absence of any vertebral fracture and/or severe subluxation, 7 had tear in the anterior longitudinal ligament recognized on MRI (21). In a study by White et al. (26), MRI managed to reveal a tear in the anterior longitudinal ligament in 7 out of 14 patients with radiographically-evident prevertebral soft tissue swelling. Of 8 patients with hyperextension-induced stress, 7 had prevertebral soft tissue swelling detected on radiographs and 4 had tear in the anterior longitudinal ligament confirmed on MRI, 3 of which were identified to be accompanied by spinal cord injury. In case of injuries caused by traumas other than the hyperextension stress, no correlation was noted between neurological deficits and prevertebral hematomas.

Rojas et al (19) utilized MDCT in the evaluation of the normal values for the thickness of PVST in the adult population. In their study including a total of 192 patients, the respective mean thickness and the upper normal limit were 4.4 mm and 8.5 mm at C1; the respective mean thickness and the upper normal limit were 3.7 mm and 6 mm at C2; the respective mean thickness and the upper normal limit were 4.2 mm and 7 mm at C3. The values at C4 and C5 could not be assesses due to varying superposition of the esophagus and the larynx. They measured the respective mean thickness and upper limit for normal to be 13 mm and 18 mm at C6; and, 11.6 mm and 18 mm at C7. Standard deviations for C2 and C3 were calculated to be lower than those for all other levels. Standard deviations, range of the values and the upper limits for normal displayed a general increase at C4 and below. Our findings bear a robust similarity to those of Rojas et al. (19) in their MDCT-based study.

Thanks to its ability to provide higher tissue resolution and detailed information associated with spinal cord, ligamentous, muscle and fat tissue planes, MRI has become progressively widespread for clinical use. Moreover, MRI is preferred in the attempts to determine the presence and the level of any probable spinal cord injury in posttraumatic cases with neurological deficit. Some factors, such as agitation overwhelming such patients and longer image acquisition time with MRI modality compared to the MDCT, limit the use of MRI in trauma patients (21). There are a sizable number of studies using lateral radiographs to evaluate the thickness of this area. Moreover, MDCT-based studies also exist. In our literature search, we encountered no MRI-based study directed to evaluate the normal values of the thickness of PVST. Progressively widespread use of MRI modality for the cervical spinal traumas made it obligatory to specify the normal values of the thickness of PVST. It was for this reason that we performed a study for measurement in a total of 136 adult patients (89 women and 47 men), where only the cases without any reported cervical spinal injury or any pathology involving the prevertebral area. We performed the measurements in the images from midanterior vertebral body of C3-C7 and from the craniocaudal midpoint of the anterior arch of C1 to the pharyngeal and the tracheal air column, thereby avoiding the possible detrimental effects of disc degenerations or osteophytic ridging on the prevertebral tissue. Depending on the different phases and positions of swallowing, the laryngeal and esophageal superpositioning may be at different levels. This, in turn, translates into wider range of measurements at C4 and C5 and hence ending up with statistically meaningless results.

In conclusion, we believe that the PVST thickness values we obtained can prove useful in the diagnosis of the pathologies involving the prevertebral area.

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