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Posterior Lumbar Subcutaneous Edema on Spine Magnetic Resonance Images: What Is the Cause?[1]

척추 Magnetic Resonance 영상에서 요추 후방피하조직의 부종: 원인은 무엇인가?[1]

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Purpose: Posterior lumbar subcutaneous (PLS) edema on spine magnetic resonance (MR) images is a common incidental, though neglected finding. This study was undertaken to investigate the relations between PLS edema and pathologic conditions.
Materials and Methods: Between January and December 2009, 138 patients with PLS edema, but without a spinal tumor or a history of recent surgery or trauma, and 80 infectious spondylitis patients without PLS edema were enrolled in this retrospective study. Available medical records and lumbar spine MR images were evaluated. The degree of edema was quantified using an arbitrary scoring system. Further, the correlations between the degree of edema and age, sex, body mass index (BMI), degeneration of posterior spinal structures (PSS) and infectious spondylitis were analyzed.
Results: Of the 93 cases with a calculable BMI, 61 (66%) had a BMI of > 23 kg/m^2. Correlations between the degree of edema and sex, age and BMI grade were all statistically non-significant. Thirty-three cases (24%) had an underlying disease, such as heart problem, diabetes mellitus, liver cirrhosis, chronic renal failure, extra-spinal tumor or connective tissue disorder. The numbers of cases with infectious spondylitis and an idiopathic condition was 61 (44%) and 44 (32%), respectively. The grade of infectious spondylitis was not found to be significantly associated with the degree of edema (p = 0.084). In cases with an idiopathic condition, the correlation between the degree of edema and PSS degeneration was statistically significant (p = 0.042).
Conclusion: Radiologists should not disregard PLS edema, because it is related to an underlying disease and thus may be of clinical significance.

Index terms
Edema
Lumbosacral Region
Magnetic Resonance Imaging
Back Pain
Infectious Spondylitis

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INTRODUCTION

Edema (subcutaneous edema) is an abnormally large fluid volume in the circulatory system or in the tissues between cells (interstitial spaces), and is characteristically observed as a region of T2 hyperintensity and T1 hypointensity on magnetic resonance (MR) images (1). A fluid signal is frequently observed in the subcutaneous soft tissues of the posterior aspect of the spine and is usually considered an incidental finding (2). Thus, most radiologists tend to disregard posterior lumbar subcutaneous (PLS) edema on spine MR images. Of course, edema may be a reasonable and a negligible finding given the obvious history of recent trauma, surgery or a systemic edematous condition. Nevertheless, we considered that a finding of lower back subcutaneous edema or fluid collection warrants careful investigation to determine the cause, particularly when spine MRI is performed as the first imaging evaluation in patients with back pain in the absence of information regarding the nature of the underlying disease or its status. Furthermore, in our opinion, radiologists should report the presence of PLS edema to clinicians, because patients with PLS edema occasionally complain of only tenderness.

Although the precise nature of posterior lumbar subcutaneous edema is unclear, it is probably related to free fluid, partially compartmentalized fluid or lymphatic pooling. The potential causes of edema are numerous and include infectious, inflammatory, traumatic, hydrostatic and even neoplastic causes (2). Shi et al. (2) reported that the severity of PLS edema and the volume of fluid collection, as determined by MR imaging, are positively associated with body weight. However, few scientific reports have been issued on the relations between PLS edema on MR images and clinical findings (2, 3). Accordingly, the present study was undertaken in order to investigate the relations between PLS edema on MR images and the pathologic conditions or clinical findings.

MATERIALS AND METHODS

Patients

The study was approved by the institutional review board of our Hospital, which waived the requirement for informed consent due to the retrospective nature of the study.

All lumbar spine MR images (*n* = 1524) obtained at our institution between January and December 2009 were collected, and cases with findings of "subcutaneous edema" and "subcutaneous fluid collection in the back area" were selected. Cases of spinal tumor and diffuse bone metastasis were excluded. In total, the case records of 236 patients were retrieved, and of these, 57 patients with a history of lumbosacral spine surgery within six months prior to imaging and 41 patients with a recent trauma history were excluded. Therefore, 138 patients with PLS edema were enrolled in this retrospective study. The study population consisted of 80 women and 58 men (age range, 13-90 years; mean age, 60.7 years). In addition, we searched our radiology database for infectious spondylitis cases detected in the same period in order to evaluate the relation between infection and edema. As a result, 141 patients (64 women, 77 men; age range, 14-84 years; mean age, 63.7 years) with infectious spondylitis with/without PLS edema were identified. Already, 61 of the 141 patients had been included within the 138 study patients. Hence, the remaining 80 infectious spondylitis patients without PLS edema were enrolled as the control.

All available medical records were reviewed, and details of clinical and pathologic conditions, including underlying disease, symptoms, occupational history or lifestyle, operation or trauma history, body weight and height for body mass index (BMI) calculation, and clinical impressions were collated for analysis.

BMI was defined as the weight (kg) divided by the height (m) squared. In Asia, normal BMIs are considered to range from 18.5 to 23 kg/m^2, as determined by the WHO expert panel on appropriate BMIs in Asian populations (2002) (4). For data analysis, BMI was classified as follows: grade 1, < 23 kg/m^2; grade 2, ≥ 23 to < 25 kg/m^2; grade 3, ≥ 25 to < 30 kg/m^2; and grade 4, ≥ 30 kg/m^2.

MR Technique

MR imaging of the spine was performed using a 1.5 or 3 T system equipped with a spinal surface or a phased array coil.

Axial and sagittal T1- and T2-weighted MR images were obtained for all study subjects. T1-weighted turbo spin-echo (SE) images were obtained in the sagittal plane [repetition time (TR)/echo time (TE), 350-767 msec/9.3-15 msec; section thickness, 3-4 mm; field of view (FOV), 250-350 × 250-350 mm; matrix size, 284-512 × 211-358; two or three acquisitions; echo train length (ETL), 4] and in the axial plane (TR/TE, 360-728/8.6-15; section thickness, 4-6 mm; FOV, 140-160 × 140-160 mm; matrix size, 256-512 × 179-256; two or three acquisitions; ETL, 5). T2-weighted turbo SE images were obtained in the sagittal plane (TR/TE, 2500-4790/70-139; section thickness, 3-4 mm; FOV, range 250-350 × 250-350; matrix size, 320-512 × 224-358; two or three acquisitions; ETL, 17) and in the axial plane (TR/TE, 2550-5450/82-118; section thickness, range 4-6; FOV, 140-160 × 140-160; matrix size, 256-512 × 179-288; two or three acquisitions; ETL, 17). In 32 patients, fat-suppressed sagittal T2-weighted images were obtained additionally without specific criteria.

Among 138 patients with PLS edema and 80 patients of the control group, one hundred and fifty one of the 218 study subjects were examined using postcontrast axial (TR/TE, 400-815/10-14; ETL, 5) and sagittal SE T1-weighted sequences (TR/TE, 432-650/10-13; ETL, 4) by applying fat suppression. Due to the retrospective nature of this study, there was no absolute standard of groups that performed contrast enhanced MR images. The slice thicknesses ranged from 3 to 4 mm in the sagittal plane and from 4 to 6 mm in the axial plane. The field of view ranged from 130 to 170 on the axial sequences and from 230 to 280 on the sagittal sequences. The matrices used for examination ranged from 256 × 179 to 320 × 352.

Image Analysis

When a patient underwent multiple MR imaging examinations, only the first examination was included in this study. Lumbar MR images were retrospectively reviewed by two radiologists in consensus. PLS edema was presumed to be present in the subcutaneous soft tissue of the back when an ill-defined or infiltrative reticular pattern of characteristic T2 hyperintensity and T1 hypointensity was observed on MR images. In addition, discrete fluid collections, depicted as well-defined accumulations, were also considered as edema.

The degree of PLS edema was quantified using an arbitrary scoring system. Lumbar edema with a reticular pattern along the superficial fascia was scored on a scale of 1-3, according to the edema length relative to the vertebral bodies on sagittal images, as follows: 1, < the height of one vertebra; 2, ≥ the height of the one vertebra but < three vertebrae; 3, ≥ three vertebrae. In addition, lumbar edema with fluid collection, depicted as well-marginated discrete accumulations of homogeneous T2 hyperintensity, was graded in a similar fashion using a three-point scale. Furthermore, when definite fluid collection was observed, a 2-point scoring system was used to describe the width and depth of the fluid collection. Regarding the depth of fluid collection, a score of 1 was awarded when the depth was less than half the full thickness of the dorsal subcutaneous fat layer, whereas a score of 2 was awarded for greater depths. In terms of the width of fluid collection, a score of 1 was awarded when the fluid width did not exceed either the facet joint level, and a score of 2 was awarded when it exceeded the bilateral facet joint levels. The possible maximum score was 10 (Fig. 1A, B).

All abnormal findings on lumbar spine MR images were evaluated. In particular, degenerations of posterior spinal structures, including the facet joint, ligamentum flavum, and the interspinous joint, were assessed in detail to access the associations between PLS edema and the degenerations of posterior spinal structures. However, relations between the degrees of PLS edema and grades of degeneration of posterior spinal structures were not evaluated.

Cases without an underlying disease and other conditions causing general edema were divided into two groups, the infectious spondylitis (n = 61) and idiopathic (n = 44) groups. For patients with infectious spondylitis, disease severity was graded according to the presence or absence and extent of phlegmon or abscess, as follows: 0, no abscess or phlegmon; 1, phlegmon or abscess extending < one vertebral body or a loculated abscess within a disc or a vertebral body at one level only; 2, extensive paraspinal, epidural or psoas phlegmon or abscess extending ≥

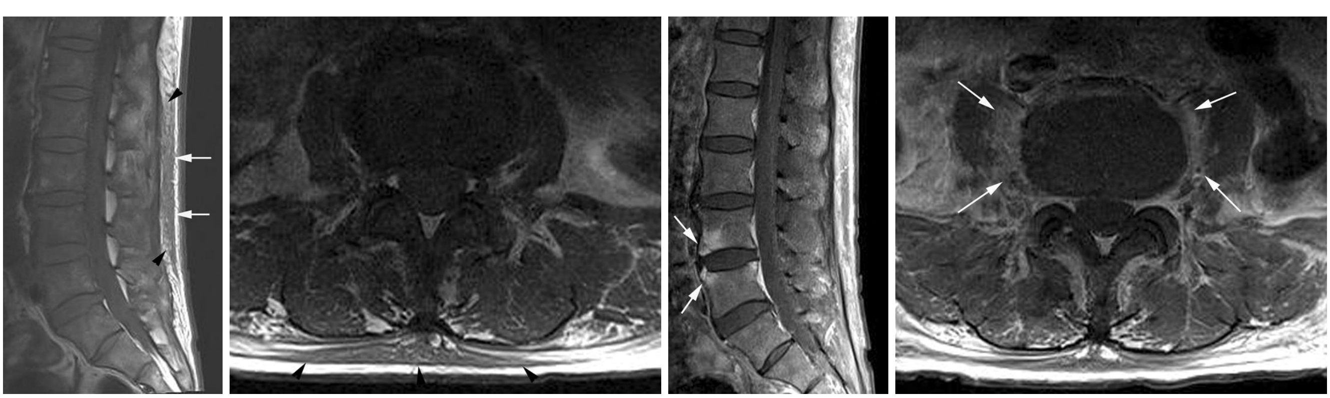
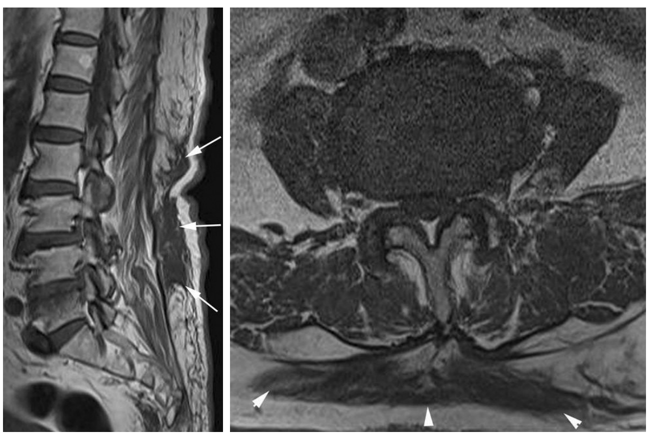


Fig. 1. A 64-year-old female patient of body mass index 21 kg/m^2 (grade 1) with low back pain. Sagittal **(A)** and axial **(B)** T1-weighted (W) magnetic resonance images show the longitudinal extent of edema with a reticular pattern (**A**, arrowheads) and well-margined fluid collection (**A**, arrows; **B**, arrowheads) spanning more than three vertebrae. In addition, depth of fluid collection is greater than half of the thickness of the subcutaneous fat layer and its width exceed both facet joint levels, which correspond to a total edema score of 10. Contrast enhanced, fat-suppressed sagittal **(C)** T1W and axial **(D)** T1W images show focal enhancement (**C**, arrows) at the anterior aspects of the L4 and 5 vertebral bodies and paraspinal phlegmon (**D**, arrows). The grade of infectious spondylitis is 1.

Table 1. Clinical Symptoms Under Different Conditions in Patients with Posterior Lumbar Subcutaneous Edema

	Idiopathic Condition (*n* = 54)	Underlying Disease (*n* = 50)	Infectious Condition (*n* = 61)
NA	9	10	9
LBP	23	20	46
Radiating leg pain	13	10	3
Sciatica	3	5	0
Paraplegia	1	0	1
Gait disturbance	2	2	1
Leg numbness or weakness	3	3	1

Note.—n = number of patients, NA = not applicable, LBP = lower back pain



A B

Fig. 2. A 76-year-old female patient of body mass index 25 kg/m^2 (grade 3) with diabetes mellitus and low back pain. Sagittal **(A)** and axial **(B)** T1-weighted images show extensive lower back subcutaneous edema (arrows and arrowheads) (edema score = 10).

one vertebral body (Fig. 1C, D). Relations were sought between these results and the degree of edema.

Statistical Analysis

Pearson's correlation coefficients and multiple linear regression analysis were used to determine whether the degrees of edema were correlated with age, sex or BMI. In addition, Pearson's correlation coefficients were used to identify associations between the extent of edema and posterior spinal structure degeneration and grades of infectious spondylitis as well as to analyze the relationship between PLS edema and infectious spondylitis. The analysis was conducted using SPSS for Windows (version 18.0; SPSS Inc., Chicago, IL, USA), and statistical significance was accepted for p values < 0.05.

RESULTS

Clinical symptoms were obtained by chart review for 102 of the 138 cases (Table 1). Relations between symptoms and subcutaneous edema were unclear. In two cases, one had a history of repeated rolling and the other had a back that was involved in continuous contact with a medical device. No abnormal findings were evident, other than lower back subcutaneous edema on spine MR images. Occupational history and lifestyles were not available except for these two cases.

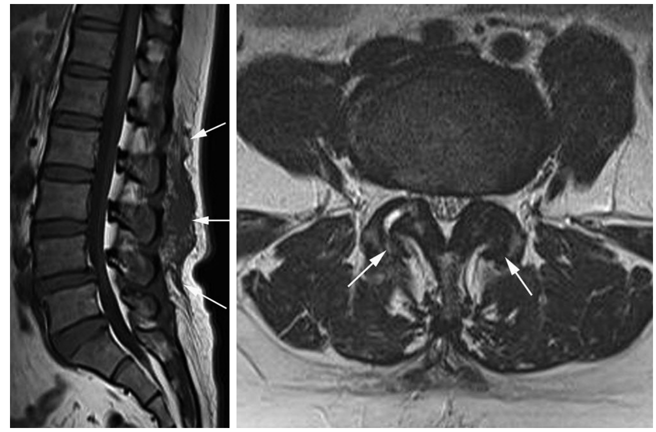
BMIs were available for 93 cases; 61 (66%) were overweight with a BMI of ≥ 23 kg/m^2. The average score of edema extent for the 138 cases was 5.29. However, the correlations between PLS edema degree and sex, age and BMI grade (Fig. 1) were non-significant, according to Pearson's correlation coefficients [r = -0.163 (p = 0.60), r = 0.071 (p = 0.412), and r = -0.50 (p = 0.626), respectively]. The result was confirmed by a multiple linear regression analysis.

Thirty three cases (24%) had an underlying disease; diabetes mellitus (DM) in 28 (Fig. 2), a tumor in 10 (breast cancer in three, cervical cancer in two, hepatocellular carcinoma in two, prostatic cancer in one, brain tumor in one, and multiple myeloma in one), a heart problem (including congestive heart failure and valve disease) in 6, chronic renal failure (CRF) in 6, liver cirrhosis (LC) in 5, and connective tissue disorder in one. Twelve cases had more than one underlying disease.

Sixty-one (44%) and 44 (32%) of the 138 cases had infectious spondylitis or an idiopathic condition, which did not have an underlying disease, and other conditions causing general edema. Infectious spondylitis cases were all pyogenic. Of the 61 cases with infectious spondylitis, eight had an infectious condition only at the thoracic spine level (Fig. 3). The average edema score of the 61 cases with infectious spondylitis was 5.05. Of the 141 study subjects with infectious spondylitis patients, 61 (43%) cases showed PLS edema and 80 (57%) presented no PLS edema. Pearson's correlation coefficients showed no significant correla-

A B

Fig. 3. A 76-year-old female patient with low back pain. Fat-suppressed, sagittal T2-weighted magnetic resonance (MR) image **(A)** shows extensive lower back subcutaneous edema (arrows) (score = 10). Fat-suppressed, contrast enhanced sagittal T1-weighted MR image of thoracolumbar spine **(B)** shows enhancements of T6 and T7 vertebral bodies (arrows) and of the anterior epidural space, indicating infectious spondylitis.



A B

Fig. 4. A 49-year-old female patient of body mass index 27 kg/m^2 (grade = 3) and an edema score of 7 with low back pain. Sagittal T1-weighted magnetic resonance (MR) image **(A)** shows lower back subcutaneous edema (arrows). Axial T2-weighted MR image **(B)** shows facet arthropathy with subluxation (arrows) at L4-5 level.

tion between the presence of infection and PLS edema (r = 0.129, p = 0.147). Moreover, between PLS edema degree and sex, age and infectious grade [r = -0.081 (p = 0.596), r = -0.26 (p = 0.119), and r = -0.175 (p = 0.084), respectively], the latter were confirmed by a multiple linear regression analysis. BMIs were available for 106 of 141 patients with infectious spondylitis; 31 (29%) were overweight with a BMI of ≥ 23 kg/m^2. However, of the 61 infectious spondylitis cases with PLS edema, 21 (47%) of 45 with available BMIs were overweight (BMI of ≥ 23 kg/m^2). In the cases with infectious spondylitis, the correlation between PLS edema degree and BMI was also non-significant, according to Pearson's correlation coefficients (r = 0.091, p = 0.357); this was confirmed by a multiple linear regression analysis (B = 0.291, p = 0.475). Of 44 patients with idiopathic conditions, 21 patients showed degenerative changes of posterior spinal structures or intervertebral discs, 18 showed disc herniations, and 5 showed normal findings of discs and bony structures. In the cases with idiopathic conditions, the average edema score was 4.6, and the correlation between posterior spinal structure degeneration and edema score was statistically significant (r = 0.312, p = 0.042) (Fig. 4).

DISCUSSION

Physiologically, extracellular edema has two causes: that is, the abnormal leakage of fluid from the plasma into the interstitial spaces across capillaries driven by increased capillary pressure, decreased levels of plasma proteins, increased capillary permeability, and a failure of the lymphatics to return fluid from the interstitium to blood (5). Many conditions can cause fluid accumulation in the interstitium; however, the causes and mechanisms involved have not been determined. Furthermore, few detailed reports have been issued on the diagnosis or distribution of lower back subcutaneous edema or fluid collection depicted by MRI, despite the fact that these conditions are well known to radiologists.

Cooper et al. (3) reported that lumbar edema accumulates at the subcutaneous fascia plane on CT images. Nevertheless, MRI is a well-established imaging modality for the evaluation of acute soft tissue disorders due to its excellent contrast resolution, high sensitivity for pathologic fluid accumulation, and its ability to depict abnormal tissue compartments. Furthermore, in this context, it has been shown to be superior to other cross-sectional imaging techniques, such as the ultrasound and the CT (6). In addition, Shi et al. (2) found that PLS edema occurred more frequently and more severely in overweight patients. It is in the extremely obese patients (BMI > 40), in which the most pronounced incidence of edema is expected. Obesity impedes lymphatic flow, leading to the collection of protein-rich lymphatic fluid in the subcutaneous tissues, which frequently results in lymphedema (7). In the present study, although the degree of edema was not significantly correlated with the BMI grade, 61 (66%) of 93 cases were overweight, indicating that PLS edema and fluid accumulation are more common in obese patients. In addition, Shi et al. (2) found that PLS edema was significantly more severe in women and in older patients. However, in the present study, the degree of edema was not found to be correlated with sex or age.

Furthermore, no correlation was found between edema or the fluid collection degree on MR images and clinical findings. However, the greater severity of subcutaneous edema in the cases with lower back pain (LBP) might have been due to poorer lymphatic drainage in these patients due to pain-related physical activity restriction (8). In the cases without other nearby abnormal findings, the posterior lumbar soft-tissue edema may have been caused by a general condition. Some conditions, such as DM, LC, CHF or other heart problems, can cause diffuse subcutaneous edema in any region of the body, particularly in the dependent regions. Furthermore, 33 cases had an underlying disease in this study, and 28 of these had DM. Edema is common in patients with LC or heart failure; yet, in the present study, only five cases had LC and six had heart failure. However, this may be due to a lack of spine MR examinations in LC or heart failure patients.

Edema in CHF is the result of the activation of a series of humoral and neurohumoral mechanisms which promote sodium and water reabsorption by the kidneys and the expansion of extracellular fluid. Furthermore, edema in LC is the result of sodium retention and is caused by mechanisms that lower the effective arterial blood volume, such as the overproduction of vasodilatory factors, by a damaged liver. These factors primarily lead to a marked fall in mesenteric vascular resistance and blood pooling as well as to a decrease in total peripheral vascular resistance. Decreased hepatic albumin synthesis causes hypoalbuminemia and reduces plasma oncotic pressure, which enhances the movement of fluid into the interstitium (9). The causes of diabetic edema include cardiovascular disease and its complications, such as nephritic syndrome or acute renal failure; renal artery stenosis; acute liver failure, cirrhosis, chronic hepatitis; drugs used to treat diabetes and a mixture of other factors, such as protein losing enteropathy, thiamine deficiency, simple premenstrual fluid retention, pregnancy and acute anaphylaxis (10, 11). Edema in patients with extra-spinal tumor may be a result of multiple organ complications, including the liver, kidney or intestine, by treatment medicines or by the tumor itself. Also, pain-related physical activity restriction may be related with edema. Therefore, radiologists and clinicians should investigate the presence of the underlying diseases when lower back subcutaneous edema is detected on spine MR images.

In the present study, 44% of 138 cases had an infectious disease of the spine. These diseases in our cohort were all of suppurative types. In general, suppurative spondylitis progresses more rapidly than the non-suppurative (tuberculous) variety. Most vertebral column infections are acquired via a hematogenous route and progressive subcutaneous and body-cavity edema typically develop in patients with sepsis, suggesting a widespread increase in vascular permeability (12, 13). However, the present study also depicts that the grade of infectious spondylitis was not significantly associated with the degree of edema. In eight of 61 cases with an infectious condition, only the thoracic level was affected, indicating that edema usually occurs in a dependent region. In addition, this study indicates that the correlation between the presence or absence of posterior spinal structure degeneration and the degree of PLS edema is significant. A higher subcutaneous edema ratio in patients with a degenerative posterior spinal structure may have been due to poorer lymphatic drainage in patients with LBP resulting from pain-related physical activity restriction (8).

The present study has several limitations that warrant consideration. First, the study is inherently limited by its retrospective nature. Therefore, we were unable to calculate the BMI values for all patients due to a lack of data. Furthermore, we could not investigate drug use in detail, or patient's physical habits or occupational histories due to incomplete records. Second, the number of cases included was relatively small, possibly because the presence of 'PLS edema or fluid collection' was not reported. Third, we assumed that abnormal edema-like signals on MR images were due to edema or discrete fluid collections, and these were not confirmed by image-guided aspiration or surgery. However, the determination of the precise nature of this abnormal signal is not straightforward, and confirmatory techniques often return ambiguous results.

In summary, MRI findings of posterior lumbar subcutaneous edema or fluid collection are commonly encountered by clinicians and radiologists. However, the present study shows that these findings are associated with a higher BMI along with the presence of underlying diseases, such as DM, LC, CHF, CRF, tumors or an infectious disease of the spine. Furthermore, in idiopathic cases, posterior spinal structure degeneration was found to be associated with lower back edema. Thus, radiologists should not disregard this finding but rather try to identify the underlying cause.

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척추 Magnetic Resonance 영상에서 요추 후방피하조직의 부종: 원인은 무엇인가?[1]

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목적: 척추 magnetic resonance (MR) 영상에서 요추 후방 피하조직의 부종은 흔하지만 간과되기 쉬운 소견이다. 본 연구에서는 요추 후방피하조직의 부종과 병적 상태와의 연관성을 밝히고자 한다.

대상과 방법: 2009년 1월에서 12월 동안, 척추종양이 없고, 수술이나 외상의 과거력이 없는 요추 후방피하조직의 부종이 관찰된 138명의 환자 및 요추 후방피하조직의 부종이 없는 감염성 척추염 환자 80명이 연구에 포함되었다. 이용 가능한 의무기록 및 요추 MR 영상을 평가하였다. 부종의 정도는 임의의 점수 시스템으로 정량화 하였다. 부종의 정도와 환자의 나이, 성별, body mass index (BMI), 후 척추구조물의 퇴행성 변화, 감염성 척추염의 연관성에 대해 분석하였다.

결과: BMI가 계산된 93 증례 중, 61명(66%)의 BMI는 23 kg/m^2을 초과하였다. 부종의 정도와 성별, 나이, BMI 등급과의 관계는 모두 통계학적으로 유의성이 없었다. 33 증례(24%)에서 심장 문제, 당뇨, 간경화, 만성 신질환, 척추외종양 또는 결합조직질환 같은 기저질환을 가지고 있었다. 요추 후방피하조직의 부종이 있는 환자에서 감염성 척추염 및 특발성 부종의 증례는 각각 61(44%) 및 44(32%)였다. 감염성 척추염의 등급은 부종의 정도와 유의한 상관관계를 보이지 않았다(p = 0.084). 특발성의 경우, 부종의 정도와 후 척추구조물의 퇴행성 변화와는 통계학적으로 유의한 상관성을 보였다 (p = 0.042).

결론: 요추 후방피하조직의 부종이 있는 경우, 이는 기저질환과 연관이 있고 임상적 의의가 있는 소견이므로 영상의학과 의사가 간과해서는 안 될 것이다.

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