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Original Article

The Value of Additional Cervicothoracic Spine Sagittal T2-weighted Images Included in Routine Lumbar Spine MR Imaging

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Purpose : To evaluate the usefulness of cervicothoracic spine sagittal T2-weighted images (CT SAG T2WIs) included in routine lumbar spine MRI.

Materials and Methods: Institutional review board approval was obtained and informed consents were waived for this retrospective study. The study group comprised 2,113 patients who underwent lumbar spine MRI from January 2005 to December 2005. CT SAG T2WIs were added in the routine lumbar spine MRIs. Radiologic reports were reviewed retrospectively for pathologic lesions on CT SAG T2WIs by one radiologist. Information of additional cervical or thoracic spine MRI and/or CT for further evaluation of positive findings on CT SAG T2WIs and their treatment were collected by retrospectively reviewing medical records.

Results: The CT SAG T2WIs revealed 142 pathologic lesions in 139 (6.58%) of the 2,113 patients. They were easily obtained without positional change in a scan time of less than 2 minutes. Additional cervical or thoracic spine MRI and/or CT for positive findings on CT SAG T2WIs were performed in 13 patients. Seven patients underwent surgical treatment.

Conclusion: CT SAG T2WIs included in routine lumbar spine MRI were useful in finding the pathologic lesions in cervicothoracic spine for the patients who assumed to have lesions in lumbar spine.

Index words : Lumbar spine MRI · Cervicothoracic spine · Sagittal T2-weighted images

INTRODUCTION

MRI is commonly used to evaluate lumbar spine abnormalities in patients with symptoms such as lower back pain, leg pain, paresthesia, weakness in the legs, and claudication. Occasionally, these symptoms are caused by pathologic lesions in the cervical or thoracic spine and mistaken for those caused by lumbar spine lesions. Some pathologic lesions in the cervical or thoracic spine may be serious and need early diagnosis for prompt treatment.

In our hospital, additional cervicothoracic spine sagittal T2-weighted images (CT SAG T2WIs) have been obtained routinely in lumbar spine MRI for eight years. CT SAG T2WIs are easily obtained in short time, about 1 minute 40 seconds, without positional change or additional survey acquisition. According to our experience, CT SAG T2WI is useful for screening a pathologic lesion in the cervical or thoracic spine. However, to the best of our knowledge, there has been no study about the usefulness of CT SAG T2WIs in routine lumbar spine MRI.

The aim of this study was to evaluate usefulness of CT SAG T2WIs included in routine lumbar spine MRI.

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MATERIALS AND METHODS

Patients

Institutional review board approval was obtained. Informed consents were not required for this retrospective study. 2,238 patients underwent lumbar spine MRI from January 2005 to December 2005 in our hospital, for their symptoms such as lower back pain, leg pain, paresthesia, weakness in the legs, and claudication. Among 2,238 patient 125 patients were excluded from the study. Exclusion criteria were; (i) the patients with previous cervical or thoracic spine MRI or CT scan or simultaneously with lumbar spine MRI(n = 13); (ii) the patients who were highly suspected to have concurrent pathologic conditions in cervicothoracic spine and practically indicated for cervical or thoracic MRI (e.g. patient with metastasis [n = 57], multilevel lumbar spine compression fracture [n = 40], primary spinal cord/intradural extramedullary tumors [n = 14], or tethered spinal cord in lumbar spine [n = 1]). One radiologist retrospectively reviewed radiologic report of lumbar spine MRI and medical record in 2,113 patients.

Imaging Studies

All MR imaging were obtained with two 1.5-T units (Gyroscan intera, Philips Medical Systems, Best, the Netherlands; Intera, Philips Medical Systems, Best, the Netherlands) by using a five-channel synergy spine coil. In addition to the conventional lumbar spine MRI sequences, sagittal and axial T1- and T2-weighted images, CT SAG T2-weighted spin-echo (SE) sequence (TR/TE, 3000–4000/100; number of signals acquired - 2; matrix size - 512 × 512; slice thickness - 4 mm; acquisition time - 1 minute 40 seconds) was obtained without positional change by using the same five-channel synergy spine coil.

Table 2. Pathologic Lesions on CT SAG T2WIs

Pathologic lesions on CT SAG T2WIs	Number of lesions (%)
SCS without IM-T2-HSI	66 (46.5%)
DH with cord compression but no IM-T2-HSI	35 (24.6%)
IM-T2-HSI associated with SCS or DH	17 (12.0%)
Compression fracture	10 (7.0%)
Syrinx	5 (3.5%)
Block vertebra	4 (2.8%)
Idiopathic spinal cord herniation	2 (1.4%)
CSF leakage in spontaneous intracranial hypotension	1 (0.7%)
Focal spinal cord atrophy	1 (0.7%)
Ankylosis resulting from previous tuberculous spondylitis	1 (0.7%)
Total	142[†]

Note.— CT SAG T2WIs: cervicothoracic spine sagittal T2-weighted images, SCS: spinal canal stenosis, IM-T2-HIS: intramedullary T2-high signal intensity, DH: disc herniation, CSF: cerebrospinal fluid, [†]Among 139 patients, 3 patients with disc herniation concurrently had block vertebrae (n = 2) and syrinx (n = 1)

Table 1. Definition of Pathologic Lesion on CT SAT T2WIs

Pathologic lesions	Definition
Spinal canal stenosis (1)	Narrowing of the spinal canal, partially obliterating of the anterior or posterior subarachnoid space or of both resulting from spondylosis, disc bulging, LFH, or OPLL
Syrinx (2)	Centrally located well-defined, fluid-filled intramedullary tubular lesion with low signal intensity on a T1-weighted image and high signal intensity on a T2-weighted image
Spinal cord atrophy	Thinning of the spinal cord both on sagittal and axial images
Idiopathic spinal cord herniation (3)	Focal anterior kinking of the spinal cord with or without cord thinning
CSF leakage in spontaneous intracranial hypotension (4)	Extradural fluid collection with enhancement on gadolinium enhanced T1-weighted image at the spine in a patient with no history of dural puncture or penetrating trauma but who was suffering postural headaches and low CSF pressure

Note.— CT SA4G T2WIs: cervicothoracic spine sagittal T2-weighted images, LFH: ligamentum flavum hypertrophy, OPLL: ossification of the posterior longitudinal ligaments, CSF: cerebrospinal fluid

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Imaging Analysis

In 2005, one of four spine radiologists who have eight, six, five and five years of experiences, respectively, interpreted lumbar spine MRI. In May 2011, one radiologist retrospectively reviewed radiologic report for whether pathologic lesion was present or absent on CT SAG T2WIs. In all subjects, radiologist also assessed the following lesions on the radiology report: spinal cord compression associated with spinal stenosis or disc herniation with or without intramedullary T2-

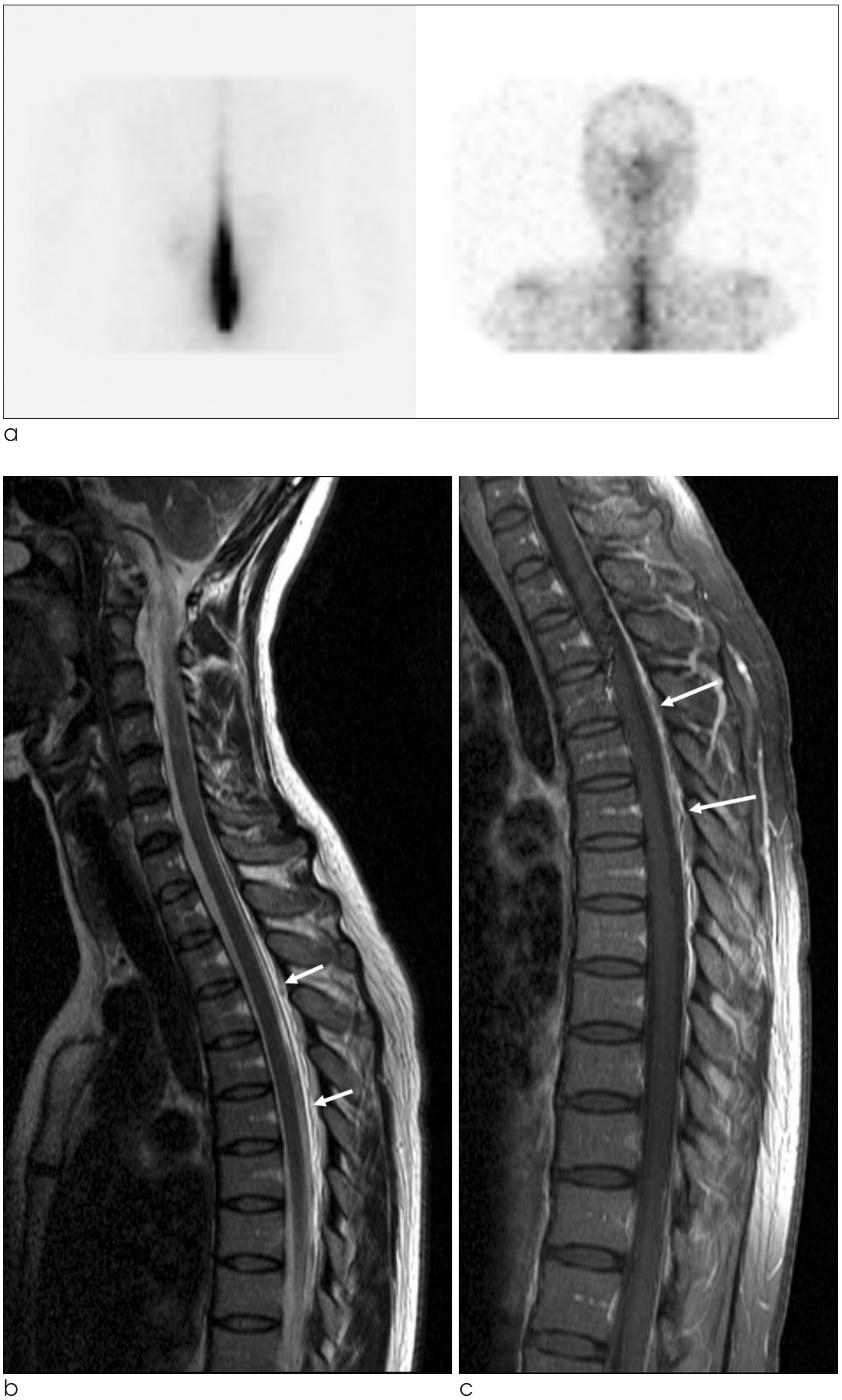

Fig. 1. 33-year-old woman with headache due to spontaneous intracranial hypotension.
a. Six-hour delayed image of cisternography shows remaining radiotracer at lumbar spine level and delayed migration.
b. Additional cervicothoracic sagittal T2-weighted image included in lumbar spine MRI demonstrates posterior epidural fluid (arrows) at thoracic spine level.
c. Gadolinium-enhanced fat-suppressed sagittal T1-weighted image performed 8 hours later shows enhancement of posterior epidural space (arrows).

high signal intensity (IM-T2-HSI), spinal cord abnormalities (e.g., syrinx, spinal cord atrophy, spinal cord tumors or demyelinating disease, idiopathic spinal cord herniation), vertebral abnormalities (e.g., fracture, anomaly, tumor, or infection), and epidural abnormalities (e.g., hematoma, abscess, or cerebrospinal fluid leakage) in the cervical or thoracic spine. Definitions of these pathologic lesions are in Table 1 (1–4). The radiologist also reviewed record of cervical or thoracic spine MR imaging or CT which were additionally obtained for further evaluation for positive finding on CT SAG T2WIs.

Review of Medical Records

In patients with positive findings on CT SAG T2WIs, medical records were reviewed retrospectively by one radiologist. The radiologist checked interval between initial lumbar spine MRI and additional cervical or thoracic MRI or CT and management of these lesions. Patients' chief complaints were assessed to analyze their correlation between pathologic lesions on CT SAG T2WIs.

RESULTS

Pathologic lesions on CT SAG T2WIs

139 (6.58%) of 2,113 patients had 142 pathologic lesions on CT SAG T2WIs (Table 2). Forty of the patients (mean age, 69 years; range, 54–81 years) had concurrent cervical and lumbar spinal stenosis which is called tandem spinal stenosis. Four patients had pathologic lesions only at cervical and/or thoracic spine level on CT SAG T2WIs without any pathologic lesions in the lumbar spine level. One patient who was suspected to have CSF leakage at the lumbar spine level revealed no abnormal finding at lumbar spinal level. But CT SAG T2WIs showed fluid collection in posterior epidural space with CSF leakage and posterior epidural enhancement at upper thoracic

a b

Fig. 2. 50-year-old man with paraplegia due to compressive myelopathy associated with cervical disc herniation.
a. Cervicothoracic sagittal T2-weighted image included in lumbar spine MRI shows herniated disc and intramedullary high signal intensity (arrow) at the level of C5-6 disc.
b. Cervical spine MRI was performed one day later. Sagittal T2-weighted image demonstrates disc herniation and intramedullary high signal intensity at C5-6 level.

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Table 3. Patients Who Underwent Cervical/Thoracic MR Imaging or CT for Further Evaluation of Pathologic Lesions on CT SAG T2WIs

Patient	Sex/ age	Chief complaint	Pathologic lesions on CT SAG T2WIs	Further evaluation	Final diagnosis	Interval between lumbar MRI and cervical/ thoracic MRI/ CT (days)	Management	Duration between cervical/ thoracic MRI/CT and surgery (days)	Outcome
1	F/63	LBP with RP (Lower extremity)	SCS (OPLL)	Thoracic CT	SCS (OPLL)	9	Observation		
2	M/52	LBP with RP (Lower extremity)	SCS (OLF) with IM-T2-HSI	Thoracic CT & MRI	SCS (OLF) with compressive myelopathy	3	Partial laminectomy and en block resection, T3-5	20	Improved
3	F/51	RP (Upper extremity)	SCS with IM-T2-HSI	Cervical MRI & CT	SCS with compressive myelopathy	730	Laminoplasty, C3-7	1, 2	Improved
4	F/74	Paraplegia	SCS and DH with IM-T2-HSI	Cervical MRI	SCS and DH with compressive myelopathy	138	Laminoplasty, C3-7	7	Improved
5	M/58	RP (Upper extremity)	DH with IM-T2-HSI	Cervicothoracic MRI	DH with compressive myelopathy	65	Refusal of operation		
6	M/50	Paraplegia	DH with IM-T2-HSI	Cervical MRI	DH with compressive myelopathy	1	ACDF, C4-6	0	Improved
7	M/55	Neck pain with RP (Upper extremity)	DH with IM-T2-HSI	Cervical CT & MRI	DH with compressive myelopathy	1, 5	Laminoplasty, C4-7	1	Improved
8	M/49	Neck pain with RP (Upper extremity)	DH with cord compression	Cervical MRI	DH with cord compression	577	ACDF 5-6, TDR 6-7	90	Improved
9	F/46	RP (Upper extremity)	Angulation	Thoracic MRI	Idiopathic spinal cord herniation	23	Observation		Improved
10	F/61	Paraplegia	Idiopathic spinal cord herniation	Thoracic MRI	Idiopathic spinal cord herniation	9	Observation		Improved
11	F/33	Headache	CSF leak in SIH	Enhanced thoracic MRI	CSF leakage	5	Conservative management		Improved
12	M/69	Paresthesia	Ankylosis with linear IM-T2-HIS	Thoracic MR	Tuberculous spondylitis and syrinx	28	Conservative management		Improved
13	M/68	LBP	Linear Fx	Thoracic MR	Linear Fx	13	Conservative management		Improved

Note.— CT SAG T2WIs: cervicothoracic spine sagittal T2-weighted images, LBP: lower back pain, RP: radiating pain, SCS: spinal canal stenosis, OPLL: ossification of the posterior longitudinal ligament, OLF: ossification of the ligamentum flavum, IM-T2-HIS: intramedullary T2-high signal intensity, DH: disc herniation, ACDF: anterior cervical discectomy and fusion, TDR: total disc replacement, CSF: cerebrospinal fluid, SIH: spontaneous intracranial hypotension, Fx: fracture spine level (T3-5) (Fig. 1). The other three patients, each of them had spinal canal stenosis and IM-T2-HSI at the level of the C6-7 disc, disc herniation and IM-T2-HSI at C4-5 and linear fracture at C7 and T8 in the third.

Further evaluation with cervical or thoracic spine MRI and/or CT for pathologic lesions on CT SAG T2WIs

In 139 patients who had pathologic lesions on CT SAG T2WIs, thirteen patients underwent additional cervical or thoracic spine MRI and/or CT (Table 3). Nine patients underwent MRI of the cervical or thoracic spine. Three patients were performed both MRI and CT. One patient underwent thoracic spine CT. The intervals between lumbar spine MRI and cervical or thoracic spine MRI or CT spanned from one day to 730 days (mean = 123.2 days).

Pathologic lesions were followings: spinal stenosis or disc herniation with definite IM-T2-HSI (n = 6) (Figs. 2 and 3); disc herniation with cord compression but no IM-T2-HSI (n = 1); spinal stenosis resulting from ossification of the posterior longitudinal ligament (OPLL) (n = 1); idiopathic spinal cord herniation (n = 2) (Fig. 4); ankylosis of vertebral bodies resulting from tuberculous spondylitis (n = 1); CSF leakage in spontaneous intracranial hypotension (n = 1) (Fig. 1); and compression fracture (n = 1). Diagnoses of these pathologic lesions were consistent with CT SAG T2WI findings except for one patient initially reported as thoracic spinal cord angulation, who diagnosed as idiopathic spinal cord herniation after her thoracic spine MRI.

Treatment for pathologic lesions on additional CT SAG T2WIs

Seven of 139 patients who had pathologic lesions on CT SAG T2WIs with correlated symptom underwent surgery for their lesions in cervical or thoracic spine. One of the patients who had spinal canal stenosis and IM-T2-HSI at the level of C5-6 on CT SAG T2WIs underwent surgical treatment in 82 days after initial lumbar spine MRI without additional cervical spine MRI or CT scan. In other six patients, either cervical/thoracic MRI or CT scans were performed for further evaluation of pathologic lesions on CT SAG T2WIs before the surgery. Then, they underwent surgery within 90 days (mean: 19.83 days) after their cervical or thoracic MRI or CT scans. Their symptoms were improved after their surgical treatment. The pathologic lesions on CT SAG T2WIs, symptoms of the patient, the management and outcome of these lesions are described in Table 3.

DISCUSSION

Among 2,113 patients, 139 (6.58%) had 142 pathologic lesions on CT SAG T2WIs. The most common pathologic lesions found on CT SAG T2WIs in this study were spinal stenosis or disc herniation with or without IM-T2-HSI (n = 118, 85%). In 139 patients who had pathologic lesions on CT SAG T2WIs, thirteen patients underwent additional cervical or thoracic spine MR imaging and/or CT for confirmative diagnosis and management planning. Six of the thirteen patients underwent surgical treatment. Besides, one patient underwent surgery without additional cervical spine MRI or CT scan

Spinal canal stenosis, the most common pathologic lesion in this study, can occur in any level; however, it presents most commonly in cervical and lumbar spines. Cervical spinal stenosis may coexist with lumbar spinal stenosis, a condition that is called tandem spinal stenosis. Tandem spinal stenosis has a reported prevalence rate of 5–25% (5–7). In tandem spinal stenosis, the symptoms of either the cervical or the lumbar type can overlap in such a way that the symptoms caused by cervical myelopathy might erroneously be deemed symptoms of lumbar spinal stenosis. Therefore, patients with symptom of severe lumbar spinal stenosis should be evaluated for the presence of cervical myelopathy (5, 8). In our study, out of 139 patients who had pathologic lesions on CT SAG T2WIs, 40 patients (mean age, 69 years; range, 54–81 years) had concurrent cervical and lumbar spinal stenosis.

Patients with cervical myelopathy can present with a broad spectrum of signs and symptoms according to the location and extent of spinal cord dysfunction. The criteria for evaluation of the severity of cervical myelopathy by the Japanese Orthopaedic Association (JOA) included upper extremity motor function, lower extremity motor function, upper extremity sensory

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Fig. 3. 52-year-old man with lower back pain, radiating pain, and numbness at both medial side of thigh, anterior lower legs, and feet due to spinal canal stenosis associated with ossification of ligamentum flavum.
a. Cervicothoracic sagittal T2-weighted image included in lumbar spine MRI shows hypertrophy of the ligamentum flavum at the T1-2 and T3-4 levels (arrows), and suspicious intramedullary high SI at T3-4 levels (white arrowhead).
b. Sagittal T2-weighted image of the lumbar spine shows mild disc bulging and degeneration at L5-S1.
c, d. Thoracic spine MRI and CT were performed three days later. Sagittal T2-weighted image (**c**) demonstrates hypertrophy of the ligamenta flava at the T1-2 and T3-4 levels (arrows) and consistent intramedullary high signal intensity at the T3-4 level (white arrowhead). Sagittal reformatted CT image (**d**) shows ossification of the ligamenta flava with spinal canal narrowing at the T3-4 level.

Fig. 4 . 46-year-old woman with radiating pain in right leg due to idiopathic spinal cord herniation.

a. Cervicothoracic sagittal T2-weighted image included in lumbar spine MR imaging shows a focal anterior kink of the spinal cord at the level of T3-4 (arrowhead).

b, c. Thoracic spine MRI was performed 23 days later. Sagittal T2-weighted (**b**) and axial T1-weighted (**c**) images clearly demonstrate herniation of the left anterolateral portion of the cord through a dural defect.

d. Sagittal T2-weighted image in thoracic spine MR imaging performed three years later shows reduction of spinal cord herniation and suspicious anterior subdural or epidural fluid collection at thoracic and lumbar spine level.

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deficits, lower extremity sensory deficits, trunk sensory deficits, and bladder function (8). If the patient presents with sensory deficits, motor weakness in the lower extremities or sphincter dysfunction, his or her symptoms and signs may be mistaken due to pathologic lesions in the lower thoracic or lumbar spine. Slipman et al. (9) reported etiologies of failed back surgery syndrome and noted that 5.6% (11/197) had unknown etiology despite a complete workup of lower thoracic or lumbar spine. We can assume that cervical myelopathy might be a cause of failed back surgery syndrome, considering its symptoms. Furthermore, motor weakness, pain, or paresthesia of the lower extremities may result from a variety extraspinal lesions including peripheral nerve compression by tumors, ganglion cysts or synovial cysts, bone excrescence, abnormal muscle origin or accessory muscle, vascular disease as well as pathologic lesions in the spine (myelopathy or radiculopathy). CT SAG T2WIs included in the lumbar spine MRI may be helpful for evaluation of obscure cervical myelopathy or exclusion of cervicothoracic myelopathy from these various causes. It allows prompt workup and treatment without additional examination of the cervicothoracic spine.

In this study, idiopathic spinal cord herniation was found on CT SAG T2WIs in two patients. Idiopathic spinal cord herniation is also known as spontaneous transdural spinal cord herniation and is a rare cause of thoracic myelopathy (10–12). However, it has been reported with increasing frequency in recent years (10). Wada et al. (11) reviewed literature on 26 cases of idiopathic spinal cord herniation. Their clinical symptoms were motor weakness, muscle atrophy, or both, presenting predominantly in a unilateral lower extremity, and sensory deficits below the upper or middle thoracic level that were sometimes strong in the contralateral side of motor weakness (Brown-Séquard syndrome). MRI is sufficient for diagnosis of idiopathic spinal cord herniation in most cases. On sagittal MR images, an anterior kinking of the spinal cord is observed with an enlargement of the posterior subarachnoid space, most commonly between the levels of the T4 and T7 vertebrae (10, 12). Patients whose symptoms are mild may be treated with less invasive therapy and monitoring (10). However, early surgical reduction of the hernia is recommended in patient with slow progressive or stepwise deterioration in the neurologic status (12). Hence, CT SAG T2WIs may be useful for detecting idiopathic spinal cord herniation which is rare but may result serious sequalae if not treated timely.

Our study had some limitations. First, this was a retrospective study depending on radiologic reports. There is the likelihood of missing pathologic lesions on CT SAG T2WIs. Considering the clinical course of the patient, reviewing the initial radiologic report would be more relevant method of following the actual management performed for the pathologic lesions of these patients. Second, diagnoses of pathologic lesions on CT SAG T2Wis, such as idiopathic spinal cord herniation or CSF leak in spontaneous intracranial hypotension, were made by MR imaging and not surgically.

CONCLUSION

CT SAG T2WIs included in the routine lumbar spine MRI are easily obtained on routine process and useful for evaluating cervicothoracic lesions in those patients having symptoms resulting from cervicothoracic pathologies.

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요추 MR영상에 포함된 경흉추 시상T2강조영상의 효용성 평가

분당서울대학교병원 영상의학과

서지운 · 박소영 · 이준우 · 이근영 · 강흥식

목적: 요추 MR 영상에 추가된 경흉추 시상T2강조영상(CT SAG T2WI)의 임상적 효용성을 평가하고자 한다.
대상과 방법: 2005년 1월부터 2005년 12월까지 요추 MRI를 시행하였던 2,113명의 환자를 대상으로 하였다. 경흉추 시상T2강조영상을 후향적으로 분석하였고, 의무기록을 후향적으로 검토하여 경추 또는 흉추 병변의 추가적인 평가를 위한 MRI 또는 CT 시행여부와 이러한 병변에 대한 치료 및 경과를 알아보았다.
결과: 2,113명중 139명의 환자에게서 총 142개의 병변이 경흉추 시상T2강조영상에서 관찰되었다. 요추 MRI 촬영 시, 환자의 자세변화 없이 2분 이내에 경흉추 시상T2강조영상을 추가적으로 얻었다. 13명의 환자만이 경추 또는 흉추의 병변에 대해 MR영상 또는 CT를 시행하였고, 7명의 환자는 T2강조영상 고신호강도 여부에 상관 없이 척추관협착증 또는 추간판탈출증에 대해 수술적 치료를 받았다.
결론: 요추 MRI촬영 시, 2분 이내로 소요되는 경흉추 시상T2강조영상의 추가촬영은 요추의 증상으로 오인된 경흉추의 병변을 평가하는데 유용하다.

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