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대한영상의학회지

Increased Detection Rate of Syringomyelia by Whole Spine Sagittal Magnetic Resonance Images: Based on the Data from Military Conscription of Korean Young Males[1]

전척추 시상면 T2 강조 자기공명영상의 추가 촬영은 무증상 척수공동증의 발견율을 높일 수 있다: 징병검사자료 기반 연구[1]

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Purpose: We compared the detection rate of syringomyelia according to the type of magnetic resonance (MR) images among the Korean military conscription.
Materials and Methods: Among the total of 238910 examinees (males aged 18 to 32 years old) from January 2008 to December 2011, the examinees with conventional single lesion MR images (cervical, thoracic, and lumbar) with and without whole spine sagittal T2-weighted MR images (WSST2I) totaled 1206 cases, and syringomyelia was observed in 24 cases. The detection rate of syringomyelia according to the MR protocol (the presence of WSST2I or not) was done through analysis by annually and the clinical characters of syringomyelia was reviewed.
Results: The estimated prevalence of syringomyelia was approximately 10.0 cases per 100000 people. The detection rate was increased annually when the WSST2I proportion was increased (from 3.4 to 14.9 cases per 100000 persons, $r = 0.939$, $p = 0.018$). Clinical character of syringomyelia was ambiguous with other spinal diseases. The most affected spinal level was C5 to C7 (83%), and most cases were non-communicating syringomyelia with benign central canal widening (79%).
Conclusion: Whole spine sagittal MR image is useful to detect coexisting spinal diseases such as syringomyelia, and most syringomyelia in young males was benign hydromyelia. A whole spine sagittal MR image is recommended to increase the detection of syringomyelia.

Index terms
Syringomyelia
Hydromyelia
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Korea
Male

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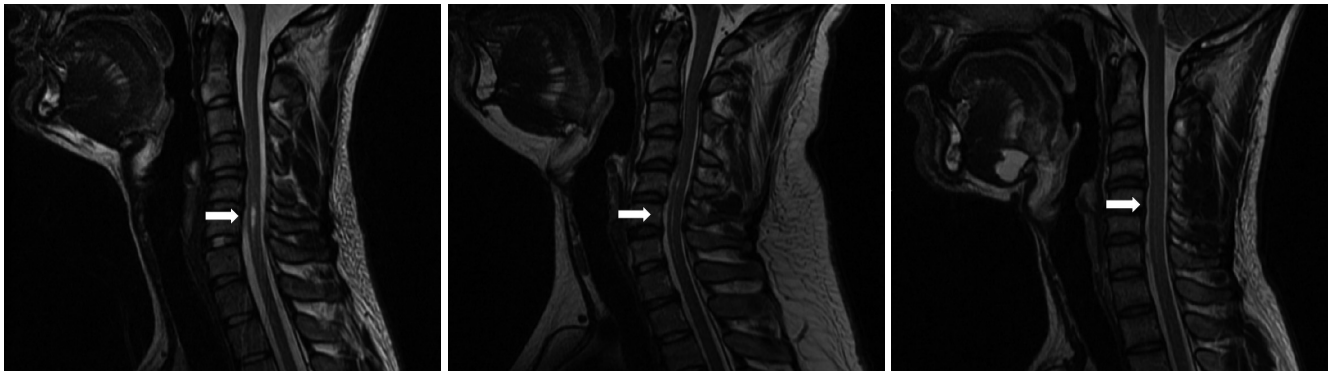
INTRODUCTION

Syringomyelia is a fluid-filled cavity within the spinal cord or brain stem (1-3). Predisposing factors include craniocervical junction abnormalities, spinal cord trauma, and spinal cord tumors (4, 5). Symptoms include flaccid weakness of the hands and arms and deficits in pain and temperature sensation in a capelike distribution over the back and neck; light touch and position sensation as well as vibration sensation are not affected (1, 6). Diagnosis is by magnetic resolution (MR) image. The estimated prevalence of the disease is roughly 8.4 cases per 100000 people in the United States, and no international geographic difference in the prevalence of syringomyelia is known (7). However, in the Korean conscription, the increasing tendency of syringomyelia detection was observed. So, the authors reviewed the change of syringomyelia detection rate during last 4 years, and reviewed the reason regarding the change in prevalence among males in the conscription for Korean military. Furthermore, the clinical character of syringomyelia in Korean young male was also reviewed.

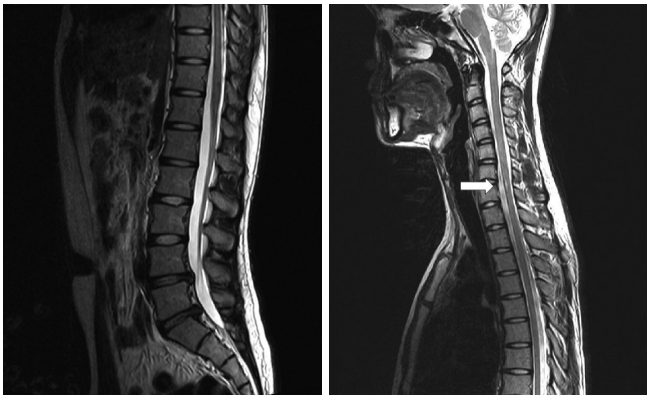


A B C

Fig. 1. Three cases of syringomyelia check by C spine regional magnetic resonance (MR). Syringomyelia is a well demarcated cavity (arrows) with an increase signal on a T2 weighted image on a MR image within the spinal cord in the level of C6 **(A)**, C5-6 **(B)**, and C3-6 **(C)**.

A B

Fig. 2. The whole spine sagittal magnetic resonance images of a 19-year-old male with chronic neck and back pain. There is no definite lesion in the thoracolumbar image **(A)**, but the syringomyelia (arrow) is observed at the level of T2 in the cervicothoracic image **(B)**.



A B

Fig. 3. The whole sagittal magnetic resonance images of a 20-year-old male with back pain. There is multiple degenerative disc protrusion observed in the lumbar region **(A)**, and the syringomyelia (arrow) is observed at the level of C6 in the whole spine sagittal MR images **(B)**.

MATERIALS AND METHODS

Korea has adopted the conscription system and all men are examined for the conscription. This survey was conducted at the Military Manpower Administration (MMA) in Seoul from January 2008 to December 2011. In this period, a total of 238910 examinees participated in the conscription, and the examinees with spinal (cervical/thoracic/lumbar) MR images totaled 1206 cases. MR images were reviewed and divided into 2 groups; group A with conventional regional MR images, which were not including whole spine sagittal T2-weighted MR images (WSST2I), and group B with conventional regional MR images including WSST2I or more than 2 regional MR images including cervical and lumbar regions.

The authors defined the syringomyelia as the lesion which has a well demarcated cavity, demonstrates a low signal on the T1 weighted image and increased signal on the T2 weighted image regarding the MR image, within the spinal cord without consideration in regards to expansion to the cord or the abnormal adjacent cord signal (Figs. 1-3). Syringomyelia was observed in 24 cases. For standardization of imaging protocols, all syringomyelia lesions detected by outside imaging were re-confirmed by a single 1.5T MR machine (Signa Excite, General Electronics Inc., Milwaukee, MI, USA) in Seoul Military Manpower Administration, as the original MR images were taken by multiple outside MMA-certified institutes using multiple MR machines. All images were reviewed by one neurosurgeon and one radiologist. Also, all medical certificates, which were brought by examinees, were review by one neurosurgeon. The authors devised the data by the level of syringomyelia, conscription year, checked MR images, and clinical presenting symptoms, cervical degenerative disc disease, syringomyelia type,

Table 1. Type of Spinal MR Images and Detection of Syringomyelia according to the Conscription Years

Conscription Year		2008	2009	2010	2011	Total
Group A	Only cervical regional MR	13	14	19	23	69
	Only thoracic regional MR	2	3	4	4	13
	Only lumbar regional MR	249	223	239	247	958
Group B	More than 2 regional MR	27	21	31	33	112
	Cervical MR with WSST2I	0	3	5	11	19
	Thoracic MR with WSST2I	0	0	2	2	4
	Lumbar MR with WSST2I	0	5	9	17	31
Total		291	269	309	337	1206
Proportion of group B over total MR (%)		9.3	10.8	15.2	18.7	13.8
Syringomyelia cases		2	4	9	9	24
Total conscription cases		59417	58895	60286	60312	238910
Prevalence per 100000 person		3.4	6.8	14.9	14.9	10.0

Note.—MR = magnetic resonance, WSST2I = whole spine sagittal T2-weighted MR images

Table 2. Syringomyelia Cases with Level of Syringomyelia, Conscription Year, Type of MR Images, Clinical Symptoms, and Combine Disease

Case No	Age	Lesion Level	Conscription Year	MR Image Type	Neck Pain	Headache	Stiffness in Upper Tunk	Arm Weakness	Leg Weakenss	Loss of Temperature	CDDD	Comment
1	23	C2	2008	C spine MRI	Yes	Yes	No	No	No	No	Yes	
2	29	C5-C7	2008	C spine MRI	Yes	No	Yes	Yes	No	No	Yes	
3	19	C5-C6	2009	C spine MRI	Yes	Yes	Yes	No	No	No	Yes	
4	24	C5-C7	2009	C spine MRI	Yes	Yes	Yes	No	No	No	Yes	
5	31	C6-C7	2009	C spine MRI	Yes	Yes	Yes	No	No	No	Yes	
6	23	C4-T9	2009	WSST2I + C spine MR	Yes	Yes	Yes	Yes	No	Yes	Yes	
7	20	C3-C4	2010	C spine MRI	Yes	Yes	No	No	No	No	Yes	
8	23	C4-C6	2010	C spine MRI	Yes	Yes	Yes	No	No	No	Yes	Block vertebrae
9	19	C5-C7	2010	C spine MRI	Yes	Yes	Yes	Yes	No	No	Yes	
10	27	C5-C7	2010	C spine MRI	Yes	No	Yes	No	No	No	Yes	
11	21	C6-C7	2010	C spine MRI	Yes	No	Yes	Yes	No	Yes	Yes	Chiari malformation I
12	32	C6	2010	Whoe spine MR	No	Yes	No	No	Yes	No	No	
13	19	C6-C7	2010	WSST2I + L spine MR	Yes	Yes	No	No	No	No	Yes	Scoliosis
14	20	C6	2010	WSST2I + L spine MR	Yes	Yes	Yes	No	No	No	Yes	
15	24	T2-T4	2010	WSST2I + L spine MR	Yes	No	No	No	Yes	No	Yes	
16	25	C1-T2	2011	C spine MRI	Yes	Yes	Yes	Yes	No	Yes	Yes	
17	23	C5	2011	C spine MRI	Yes	Yes	Yes	No	No	No	Yes	
18	20	C6	2011	C spine MRI	Yes	Yes	Yes	No	No	No	Yes	
19	28	C5-C7	2011	C spine MRI	Yes	Yes	Yes	No	No	No	Yes	
20	19	T4	2011	C spine + L spine MR	Yes	No	No	No	No	No	No	
21	19	C6-C7	2011	WSST2I + C spine MR	Yes	Yes	Yes	Yes	No	No	Yes	Chiari malformation I
22	22	C5-T2	2011	WSST2I + L spine MR	Yes	No	No	No	Yes	No	Yes	
23	21	C2-T2, T5-T7	2011	WSST2I + C spine MR	Yes	Yes	Yes	Yes	Yes	No	Yes	Chiari malformation I
24	24	C7-T2	2011	WSST2I + C spine MR	Yes	Yes	Yes	Yes	No	Yes	Yes	

Note.—CDDD = cervical degenerative disc disease, MR = magnetic resonance, WSST2I = whole spine sagittal T2-weighted MR images

benign central canal widening, and the enlarged 4th ventricle.

The statistical analysis was performed using Statistical Analysis System (SAS) (version 9.1.3, SAS Institute, Inc., Cary, NC, USA) with Pearson product-moment correlation coefficient, and considered significant at *p*-values less than 0.05. This study was conducted with the approval of the committee in the Military Manpower Administration in Seoul.

RESULTS

Among the 1206 cases regarding the study population having spinal MR images, 69 cases have only cervical regional MR images, 13 cases only thoracic regional MR images, 958 cases only lumbar regional MR, 112 cases more than 2 regional MR images, an 19 cases having cervical regional MR with WSST2I, 4 cases thoracic regional MR with WSST2I and 31 cases having lumbar regional MR images with WSST2I (Table 1). Magnetic resolution images were divided into 2 groups; group A as conventional regional MR images without WSST2I, and group B as conventional regional MR images with WSST2I or conventional regional MR images including more than 2 regions, and the proportion of group B according to the conscription years were shown in Table 1. The proportion (group B / group A + B) was 9.3 in 2008, but it progressively increased by the year, and finally reached 18.7 until December 2011.

Those diagnosed with syringomyelia during conscription totaled 24 cases (Tables 1-3). Two cases in 2008, 4 cases in 2009, 9 cases in 2010, and 9 cases of syringomyelia in 2011 were diagnosed. The detection rate of syringomyelia was approximately 1.4% (12 cases among 822 cases) in conventional MR images without WSST2I, but the rate was increased to 6.0% (10 cases among 166 cases) with WSST2I or more than 2 regional MR images. The overall estimated prevalence of syringomyelia was 10.0 cases per 100000 people, but annually the prevalence was increased from 3.4 to 14.9 cases per 100000 people during the last 4 years (Table 1). The relation between the annual propor-

Table 3. Syringomyelia Cases with Level of Syringomyelia, Syringomyelia Type, Central Canal Widening and 4th Ventricle

Case No	Age	Level of Syringomyelia																Type of Syringomyelia	Benign Central Canal Widening	Enlarged 4th Ventricle
		C1	C2	C3	C4	C5	C6	C7	T1	T2	T3	T4	T5	T6	T7	T8	T9			
1	23		S															Non-communicating	Yes	
2	29					S	S	S										Non-communicating	Yes	
3	19					S	S											Non-communicating	Yes	
4	24					S	S	S										Non-communicating	Yes	
5	31						S	S										Non-communicating	Yes	
6	23				S	S	S	S	S	S	S	S	S	S	S	S	S	Communicating	No	Yes
7	20			S	S													Non-communicating	Yes	
8	23				S	S	S											Non-communicating	Yes	
9	19					S	S	S										Non-communicating	Yes	
10	27					S	S	S										Non-communicating	Yes	
11	21						S	S										Non-communicating	No	Yes
12	32						S											Non-communicating	Yes	
13	19						S	S										Non-communicating	Yes	
14	20						S											Non-communicating	Yes	
15	24									S	S	S						Non-communicating	Yes	
16	25	S	S	S	S	S	S	S	S	S								Communicating	No	Yes
17	23					S												Non-communicating	Yes	
18	20						S											Non-communicating	Yes	
19	28					S	S	S										Non-communicating	No	
20	19											S						Non-communicating	Yes	
21	19						S	S										Non-communicating	Yes	Yes
22	22					S	S	S	S	S								Non-communicating	Yes	
23	21		S	S	S	S	S	S	S	S			S	S	S			Non-communicating	No	Yes
24	24							S	S	S								Non-communicating	Yes	

tion (group B / group A + B) and the annual prevalence of syringomyelia was shown in Fig. 4. The correlation coefficient was 0.939 and the *p*-value was 0.018.

In the cases of syringomyelia, the age distribution was 19 to 32 years old and all cases were men due to the data coming from military conscription. The location of syrinx was distributed from C2 to T9 and length was variable. The presenting symptoms were neck pain (96%), headaches (75%), stiffness in the back, shoulders, arms, or legs (71%), arm weakness (33%), leg weakness (17%), and a loss of the ability to feel extremes of hot or cold (17%). Each examinee experienced a different combination of symptoms. These symptoms might vary depending on the extent and the location of the syrinx within the spinal cord, the correlation between the symptom and these variations were not studied in this study. Twenty two cases among a total of 24 cases (92%) were checked for cervical multiple degenerative disc change in MRI, and the compressive disc protrusion/extrusion without myelomalacia was seen in 8 cases (33%). Among 24 cases, 20 cases (83%) observed syringomyelia at spinal levels from C5 to C7. Twenty two cases (92%) were non-communicating syringomyelia, belonging to central canal dilatations or primary parenchymal cavitations by the classification of Milhorat (8). Nineteen cases (79%) belonged to benign central canal widening, and 4th ventricle enlargement was observed in only 5 cases (21%). A case was observed block vertebrae's in C4/5 and C6/7, and scoliosis was observed in one case with approximately 23 degrees of Cobb's angle. And, three cases observed Chiari malformation type I.

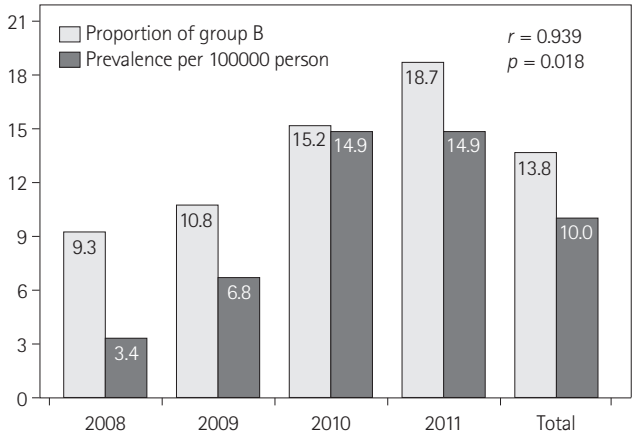


Fig. 4. The relation between the annual proportion (group B / group A + B) and the annual prevalence of syringomyelia according to the conscription year. Group A is conventional regional magnetic resonance (MR) images without whole spine sagittal T2-weighted MR images (WSST2I), and group B is conventional regional MR images with WSST2I or conventional regional MR including both the cervical and lumbar spine region.

DISCUSSION

Hydromyelia is a condition characterized by the widening of the central canal regarding the spinal cord. Fluid can accumulate in this space, creating increased pressure on the spinal cord. The term hydromyelia is sometimes used interchangeably with a closely related condition, syringomyelia. Syringomyelia is a condition in which fluid collects in the area of the spinal cord that is outside the central canal. Syringomyelia is a paramedian, usually irregular, longitudinal cavity. For simplicity, the term syringomyelia is used to refer to a fluid-filled cyst in the spinal cord that is inside or outside of the central canal. It commonly begins in the cervical area but may extend downward along the entire length of the spinal cord. In this study, 83% of syringomyelia was observed at the levels from C5 to C7, but the syrinx location was widely distributed from C2 to T9. The end result of hydromyelia and syringomyelia is essentially the same: an abnormal cyst having a collection of fluid in the spinal cord that is associated with a wide range of neurological complaints and signs. In this study, the most common neurological complaints were neck pain and headache. The weakness of extremities was observed in 17-33%, and the loss of the ability to feel extremes of hot or cold, the noteworthy symptom of syringomyelia, was observed in only 17%.

Syringomyelia usually results from lesions that partially obstruct the flow of cerebrospinal fluid (9-11). This result showed that the lesions usually involved the levels from C3 to C5 (83%). Although few cases were related to Chiari malformation in this study, it was generally reported that at least half of syrinxes occur in patients with congenital abnormalities of the craniocervical junction (e.g., herniation of cerebellar tissue into the spinal canal, called Chiari malformation), brain (e.g., encephalocele), or spinal cord (e.g., myelomeningocele) (6, 12). For unknown reasons, these congenital abnormalities often expand during ones teens or young adult years, as our result showed. A syringomyelia can also develop in patients who have a spinal cord tumor, scarring due to previous spinal trauma, or no known predisposing factors (13-17). Although no case was presented in this

study, roughly 30% of people with a spinal cord tumor eventually develop a syringomyelia (18).

Symptoms usually begin insidiously between adolescence and age 45 (18, 19). Syringomyelia develops in the center of the spinal cord, causing a central cord syndrome. But, as in this study, most of syringomyelia did not present specific symptoms, so it was labeled benign central canal widening (20). Pain and temperature sensory deficits occur early but may not be recognized for years. The first abnormality recognized may be a painless burn or cut. In some cases, syringomyelia typically causes weakness, atrophy, and often fasciculation's and hyporeflexia of the hands and arms; a deficit in pain and temperature sensation in a capelike distribution over the shoulders, arms and back is characteristic (4). Light touch, position and vibration sensation are not affected. Later, spastic leg weakness develops. Deficits may be asymmetric.

Etiology of syringomyelia is unclear. One study reported that the estimated prevalence of the disease is about 8.4 cases per 100000 people in United States, and no international geographic difference in the prevalence of syringomyelia is known (7). But, aside from this study, there was no satisfied prevalence study in the literature. In the autopsy data, 175 cadavers with syringomyelia were reported for 39 years (8). The nationwide epidemiological survey in Japan, totaling 1243 cases of syringomyelia was ascertained for 2 years (21). In this study, 24 syringomyelia cases regarding young males was reported and the overall estimated prevalence among young adults is 10.0 cases per 100000 persons. This prevalence was similar to the result of a previous report (7). However, the annually prevalence increased as observed in this study (Table 1, Fig. 4). Moreover, this increase was statistically significantly correlated with the increased proportion of the type of WSST2I (Fig. 4). WSST2I or more than 2 regional MR images encouraged the detection of incidental syringomyelia.

The clinical use of the WSST2I technique was first reported in 2001 for the evaluation of spinal scoliosis (22, 23). The necessity of WSST2I has been advocated for the precise diagnosis and proper treatment of specific spinal diseases (24-27). However, its routine use for the diagnosis of spinal diseases is controversial because it is seen as unnecessary and expensive requiring long scanning time for at least two different MRI studies: cervicothoracic and thoracolumbar scans. Recently, the development of coil systems for whole spine and image recombination software allowed whole spine sagittal images to be obtained more conveniently (28). In some reports, WSST2I is useful for diagnosing coexisting spinal diseases and to avoid missing a significant cord-compressing lesion in spinal diseases (29, 30). In this study, WSST2I is also useful for detecting coexisting spinal diseases such as syringomyelia.

In conclusion, in young Korean males, non-communicating benign hydromyelia is the most common type of syringomyelia. The symptom of syringomyelia was not specific, so it could be overlooked. But, the detection rate of syringomyelia has increased with the use of WSST2I in Korean young males. WSST2I is useful for detecting coexisting syringomyelia in various spinal diseases. So, WSST2I is recommended for the detection of syringomyelia.

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전척추 시상면 T2 강조 자기공명영상의 추가 촬영은 무증상 척수공동증의 발견율을 높일 수 있다: 징병검사자료 기반 연구[1]

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목적: 전척추 시상면 T2 강조 자기공명영상(whole spine sagittal T2-weighted magnetic resonance images; 이하 WSST2I)의 추가 여부에 따른 척수공동증의 발견율 변화 여부를 징병검사 대상자 자료를 바탕으로 비교하였다.

대상과 방법: 서울지방병무청에서 2008년 1월부터 2011년 12월까지 징병검사를 받은 238910명 중 경추, 흉추 또는 요추 MR을 촬영한 자는 1206명이었으며, 척수공동증이 발견된 경우는 24명이었다. WSST2I의 촬영 여부에 따른 척수공동증의 발견율을 연도별로 비교하였으며, 이렇게 우연히 발견된 척수공동증의 임상적 특성을 기술하였다.

결과: 전체적인 척수공동증의 이환율은 10만 명당 10명이었다. 촬영연도가 최근일수록 WSST2I를 촬영한 비율이 증가하였으며, 이에 따라 척수공동증의 발견율도 연도가 최근일수록 증가하는 양상을 보였다(10만 명당 3.4건에서 14.9건, p = 0.018). 이렇게 우연히 발견된 척수공동증의 임상 증상은 다른 척수 질환에 비해 특이점이 없으며, 가장 많이 이환되는 부위는 경추 5~7번 높이 척수이고, 가장 많은 형태는 수두증이 없는 비교통성 양성 중심강 확장형 수척수증이었다.

결론: 전척추 시상면 T2 강조 자기공명영상의 추가 촬영은 무증상 척수공동증의 발견에 유용하다. 젊은 성인 남자에서 우연히 발견되는 척수공동증은 대부분 양성 수척수증이다.

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