Is Lumbar Spinal Reserve Capacity on CT-Myelography Significant?

BT Miyelografide Lomber Omurga Kanalı Yedek Kapasitesi Önemli midir?

T. ERHAN COŞAN, BAKİ ADAPINAR, ALİ ARSLANTAŞ, EŞREF TEL, FEZZAN ŞAHİN

Osmangazi University Medical Faculty Departments of Neurosurgery (TEC, AA, ET), Radiology(BA), and Biostatistics (FS), Eskişehir, Turkey

Abstract: A statistical comparison is made between neurological conditions and areas of lower lumbar spinal structures, as ascertained by CT-myelography, in patients with lumbar complaints. CT-myelography was taken of 38 patients with low back pain and/or radicular pain complaints, most of whom were suffering disc herniation. Measurements of cross-sectional area of spinal canal, dural sac, disc herniation beyond interspace (where appropriate) and ligamentum flavum were taken in 43 levels. These were levels L4-5 and L5-S1 lumbar disc hernia was assumed prediagnostically every case. The spinal reserve capacity area was calculated by substracting the rest from the spinal canal area. The ratio between spinal canal and dural sac area as well as that between spinal canal area and spinal reserve capacity were separately calculated for each level. These ratios were then examined for possible correlation with the neurological condition of the patients. Statistical analyses show the neurological condition of the patient to be in relation to reduction of spinal reserve capacity area rather than to reduction of dural sac area. This result is particularly marked at the L5-S1 level. An evaluation of spinal reserve capacity is appropriate as an aid to investigations of clinical status, particularly of cases with lower lumbar complaints.

Key Words: CT-myelography, herniated nucleus pulposus, spinal canal dimensions

Özet: Lomber yakınmaları olan hastalarda BT - Miyelografi ile saptanan alt lomber spinal yapıların alanı ile nörolojik durumları arasında istatistiksel karşılaştırma yapıldı. Bel ağrısı ve/veya radiküler ağrı şikayetleri olan ve çoğunluğunda disk hemiasyonu var olan 38 hastaya BT - Miyelografi uygulandı. Spinal kanal, dural kese, interspace boyunca disk herniasyonu ve ligamentum flavum bölgelerinin 43 seviyede kesitsel ölçümleri yapıldı. Ölçümler teşhis öncesi düşündüğümüz L4-5, L5-S1 lomber disk hernisi seviyelerine uygulandı. Spinal yedek kapasite alanı, spinal kanal alanından geri kalanı çıkararak hesaplandı. Spinal kanal ve dural kese alanı arasındaki oran ile spinal kanalın alanı ve spinal yedek kapasitesi arasındaki oran her seviyede ayrı ayrı ölçüldü. Sonra bu oranlar hastanın nörolojik durumu ile muhtemel bir korelasyon için incelendi. İstatistiksel analizler hastanın nörolojik durumunun dural kese alanındaki azalmadan çok spinal reserv kapasite alanındaki azalmayla ilişkili olduğunu gösterdi. Bu sonuç özellikle L5-S1 seviyelerinde belirgindi. Spinal yedek kapasitesinin değerlendirilmesinde, özellikle alt lomber yakınması olan hastaların klinik durumlarının araştırılmasında yardımcı olacağı düşünüldü.

Anahtar Sözcükler: BT -Myelografi, nükleus pulposus herniasyonu, spinal kanal ölçümleri

INTRODUCTION

There have been many explanations put forward to account for neurological dysfunction in patients with lumbar complaints (6, 7, 8, 12, 14, 15, 18, 20, 22, 23). Our purpose is to contribute to these interpretations.

Ninty percent of cases of lumbar disc herniation are at the L4 - L5 and L5 - S1 levels (5). Disc herniations are classified by their anatomical localization as "central", "paracentral" and "lateral" (8). Zawadzki termed these "disc extensions beyond interspace". These are "bulging" and "herniation" that feature protrusions and extrusions (24). In addition to these classified herniations, "extreme lateral lumbar disc herniations" were reported (1,17).

When determining clinical status, demonstration of the clinical and radiological correlation is needed due to the fact that 28% of cases with a herniated disc or spinal stenosis are asymptomatic (3). CT and/or myelography is still in use although the magnetic resonance imaging (MRI) has more advantages (2). Pulsation of cerebrospinal fluid, truncation artifacts (Gibbs phenomenon) and chemical shifts are probable errors on MRI (19). CT-myelography provides additional useful information especially for decisions on clinical status (8,9,19). CT-myelography can provide important information for the evaluation of clinical status as well as treatment protocol. The cross-sectional visualization of vertebral spinal canal and its structures are possible through transverse axial tomography (10,21). CT-myelography is more reliable for displaying intracanal structures such as dural sac, ligamentum flavum and low density area. Our study takes low density area and spinal reserve capacity as equal. Obliteration of the spinal reserve capacity on CT-myelography may induce signs of neural compression of spinal stenosis (23). It may, therefore, be regarded as essential in the diagnosis not only in spinal stenosis but in all cases of external compression to dural sac and other neural structures.

PATIENTS AND METHODS

This was a prospective study, and we report 38 patients with low back pain and/or radicular pain. The mean age of the patients was 40,4 years. Twenty-one were men and 17 women. They had lumbar disc hernias at the paracentral or central localization. Lateral and extreme lateral disc herniations were excluded, especially if a part of them was outside of the spinal canal. There were 43 affected levels of these patients. Of these 22 were L4-5 and 21 were L5-S1.

CT-myelographic slices (by using CT-scanner, 512x512 matrix, Toshiba-TCT600) were obtained in all 43 levels. Flexion and extension of the lumbar spine affect cross-sectional areas of structures of the spinal canal on CT-myelograms. Spinal reserve capacity may be enlarged on the position of flexion (6,12). Slices of CT-myelograms of our patients were taken in the same position, as far as possible. Each patient was put in a supine position while the slices were being taken. All levels were examined thoroughly at 3mm intervals and 5mm thickness, thus approximately 7 and 11 slices were taken from regions of disc herniation from both above and below. If there was no disc herniation apparently beyond bulging, then slices were taken from all regions of intervertebral disc. All slices of each level were evaluated. Cross-sectional areas (CSA) of the structures inside of the spinal canal and the spinal canal (SC) itself were measured. Structures measured inside of the spinal canal were disc extension beyond interspace (DEBI), dural sac (DS), ligamentum flavum and spinal reserve capacity(SRC). Measurement of the spinal reserve capacity within the entire spinal canal was difficult. For this reason, the spinal reserve capacity area was ascertained by substracting the dural sac, ligamentum flavum and DEBI from the total spinal canal area. Nerves exiting dural sac filled with contrast media were added to the dural sac. Ratio of the CSA of dural sac to the CSA of spinal canal (DS / SC x 100) and ratio of the CSA of SRC to the CSA of spinal canal (SRC / SC x 100) were calculated at the slices of disc herniation or intervertebral disc. DS / SC x 100 and SRC / SC x 100 in levels of L4-5 and L5-S1 were evaluated for each patient individually. Owing to the fact that the ligamentum flavum areas did not exceed normal boundaries in all patients and a definite correlation between disc area and neurological state could not be established, further calculations were not undertaken. No neurological deficiency is likely to occur at all, even in cases where spinal canals are narrower than others or where there is a pronounced disc bulging (3). For this reason, patients with no neurological deficits were also added to our study. Figure 1 shows lumbar CT-myelography of a patient. It shows low density area as hatched area in the spinal canal.

In our study, we needed a neurological grading system for demonstrating the neurological and radiological correlation. We collected certain signs

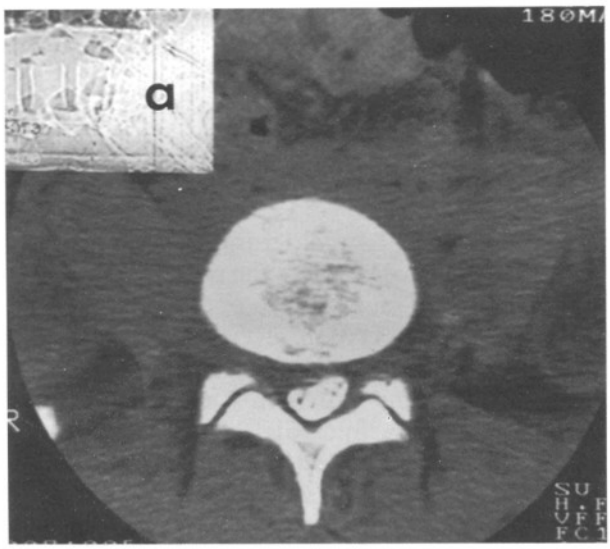

Figure 1. a. CT-myelogram in a patient, b. line tracing of CT image shown in a; hatched area shows low density area.

of the neural dysfunction (11). The neurological grading was constructed by adding points as shown in Table I. Certain signs were power of extensor hallucis longus (EHL), reflexes (ankle), root tension sign and sensorial disturbance. Grade 1 has no neurological deficit, grade 5 has reduced power of EHL with atrophy, reduced or absent ankle reflex and root tension sign less than 300. Neurological grades, the DS/SC x 100 and the SRC / SC x 100 in 22 levels of L4-5 are shown in Table II, and 21 levels of L5-S1 in Table III.

In order to effect a comparison between the calculated ratios and neurological status, statistical analysis was used. All data of 43 levels and neurological grades were determined by using " Spearman Correlation Analysis".

RESULTS

Most of the CSAs of spinal canals were within normal limits (180-350 mm^2) and there was no thickened ligamentum flavum secondary (CSA>150 mm^2) (16). There were no cases of spinal stenosis.

While neurologic grades increased, SRCs decreased at a statistically significant rate for all levels including L4-5 and L5-S1 ($r=-0,88$ $p<0,001$); a

Table I: Neurological Grading System in Lumbar Spine (11).

Certain signs	0	1 point	2 points
Power of extensor hallucis longus (EHL)	Normal	Reduced Atrophy (-)	Reduced or absent Atrophy(+)
Reflexes (Ankle)	Normal	Reduced or absent	-
Root tension sign	Absent	300-600	Less than 300
Sensorial disturbance	Absent	(+)	

If root tension sign is less than 300 and sensorial disturbance is positive, with no reflex and muscle power disturbance, then the neurological grade is 3. If power of extensor hallucis longus is reduced with atrophy, ankle reflex is absent and sensorial disturbance positive, then neurological grade is 5.

Table II : Neurologic grades and DS / SC x 100 and SRC / SC x 100 in 22 levels of L4-5. (DS=Dural Sac, SRC=Spinal Reserve Capacity, SC=Spinal Canal Areas)

Neurologic grades	0	0	0	0	0	1	1	2	2	2	2	2	3	3	3	3	3	4	4	4	5	5
SRC/SC x 100	57	55	52	50	36	46	42	42	41	38	35	29	39	32	28	26	26	31	30	28	34	23
DS/SC x 100	28	36	29	30	37	40	40	45	38	32	30	29	28	32	30	24	29	20	30	33	25	20

Table III :Neurologic grades and DS / SC x 100 and SRC / SC x 100 in 21 levels of L5-S1. (DS=Dural Sac, SRC=Spinal Reserve Capacity, SC=Spinal Canal Areas)

Neurologic grades	0	0	0	0	0	1	1	1	1	1	1	2	2	2	3	3	3	4	4	5	5
SRC/SC x 100	66	64	55	47	45	56	49	44	43	42	40	37	36	32	30	30	26	20	18	27	25
DS/SC x 100	15	24	37	28	30	7	16	38	34	23	34	38	37	42	27	21	34	19	44	40	29

statistical correlation was not found between neurological grades and CSAs of the DS ($r=-0,066$ $p>0,05$). When data of the L4-5 or L5-S1 levels were evaluated separately, different results were obtained. For levels of the L5-S1, statistically significant correlation was established between SRCs and neurologic grades ($r= -0,93$ $p<0,001$); between CSAs of DS and neurological grades no statistical correlation was found ($r= +0,23$ $p>0,05$). For levels of the L4-5, there was an indication of statistically significant correlation between SRCs and neurological grades ($r= -0,79$ $p<0,001$), and also between CSAs of the DS and neurological grades ($r= -0,47$ $p<0,05$).

DISCUSSION

The effectiveness of CT and especially CT-myelography is improved when the cross-sectional area of the dural sac is measured (4). In the measurement of CSAs of spinal canal and its structures, narrow dural sac and normal spinal bony canal may be measured (20). It is clear that CSAs can give sounder information. It may be considered that there would be a relation between any one of the spinal canal structures and clinical status (6,15,22). Since a direct relation to clinical status was not established in our patients for either spinal canal area or ligamentum flavum and disc area , analyses were done only on SRC and DS areas. Disc herniation area is not correlated with the outcome measures. Oland G and Hoff TG showed that area measurements on computed tomography-myelography could not predict outcome (13). We consider that more correlative results were found if the low density area (SRC) is measured. Our aim was to establish whether these two areas (SRC and DS) were of clinical significance or not. Radiological assessment can not be based only on the dimensions of the spinal canal structures (18). For this reason we did not favor measuring the dimensions of the spinal canal structures.

The obliteration of spinal reserve capacity as shown on CT-myelography may induce signs of neural compression of spinal stenosis (23). It may therefore be proposed as essential in the diagnosis not only of spinal stenosis but of all of the external compression to dural sac and other neural structures. Disc extension beyond interspace causes compression on nerve roots, however, this compression directly to dural sac may not always be the sole cause of radicular dysfunction (7). The interspace which was SRC contains vascular bed, nerves exiting dural sac and fat tissue (16). In our study, nerves exiting dural sac filled with contrast media were added to dural sac. Narrowing of the lumbar spinal canal produces compression of both neural and vascular structures, and neurological symptoms may be related to arterial obstruction and/or venous hypertension as well as to neural impingement (8). Vascular compression leads to increased permeability of the blood vessels, resulting in intraneural edema and neurological dysfunction. Olmarker has proved that changes in blood flow in lumbosacral nerve roots might be induced at very low pressure compression (14). We are similarly of the opinion that the neurological condition of patients with lumbar complaints corresponds to vascular bed compression.

Our study has shown spinal reserve capacity to be of significance in the clinical evaluation of patients with lumbar complaints. This is particularly valid at the L5-S1 level. As is known, the dural sac at L4-5 is normally narrower and thus the clinical effect of SRC would be expected to be greater at this level. In summary, it is revealed that patients' neurological conditions correspond not only to the compression of the dural sac, as has previously been assumed, but at the same time to reductions in SRC.

CONCLUSION

It is important to demonstrate the neurological and radiological correlation while determining clinical status in cases with lumbar complaints. When cross-sectional areas of the intraspinal structures were measured, neurological dysfunction may have been related to decreasing SRC rather than to decreasing CSA of the DS alone and other structures. This result is more clear at the L5-S1 level. We suggest that the measurement of the cross-sectional area of SRC on

CT-myelograms should be included to forward determining clinical status, especially at the L5-S1.

Correspondence: T. Erhan Coşan
Osmangazi Üni. Tıp Fak. Hastanesi
Nöroşirürji A.B.D.
Meşelik 26440
Eskişehir, Turkey
Phone: 222-2397565
222-2392979 ext. 7179 or 7182
E-mail : ecosan@ada.net.tr

REFERENCES

1. Abdullah AF, Ditto EW, Byrd EB: Extreme lateral disc herniations: Clinical syndrome and special problems of diagnosis. J Neurosurgery 41: 229-234, 1974
2. Albeck MJ, Hilden J, Kjaer L, Holtas S, Preastholm J, Henriksen O, Gjerris F: A controlled comparison of myelography, computed tomography, and magnetic resonance imaging in clinical suspected lumbar disc herniation. Spine 20: 443-448, 1995
3. Boden SD, Davis DO, Dina TS: Abnormal magnetic resonance scans of the lumbar spine in asymptomatic subjects. J Bone Joint Surg Am 72: 403-408, 1990
4. Bolender NF, Schönström NSR, Spengler DM: Role of computed tomography and myelography in the diagnosis of central spinal stenosis. J Bone Joint Surg 67-A(2), 240-246, 1985
5. Fries JW, Abodeely DA, Vijungeo JG: Computed tomography of herniated and extruded nucleus pulposus. J Comput Assist Tomogr 6: 874-887, 1982
6. Fukuyama S, Nakumara T, Ikeda T, Takagi K: The effect of mechanical stress on hypertrophy of the lumbar ligamentum flavum. J Spinal Disord 8: 126-130, 1995
7. Garfin SR, Rydevik BL, Brown RA: Compressive neuropathy of spinal nerve roots, a mechanical or biological problem? Spine 16: 162-166, 1991
8. Gaskill MF, Lukin R, Wiot JG: Lumbar disc disease and stenosis. Radiol Clin NA 29: 753-764, 1991
9. Goldberg AL, Soo MSC, Deeb ZL, Rothfus WE: Degenerative disease of the lumbar spine role of CT-myelography in MRI era. Clin Imaging 15: 47-55, 1991
10. Jacobson RE, Gargano FP, Rosomoff HL: Transverse axial tomography of the spine. Part 1: Axial anatomy of the normal spine. J Neurosurg 42: 406-429, 1975
11. Jönsson B, Strömqvıst B: Symptoms and signs in degeneration of the lumbar spine. J Bone Joint Surg (Br) 75-B: 381-385, 1993
12. Liyang D, Yinkan X, Wenming Z, Zhıhua Z: The effect of flexion-extension motion of the lumbar spine on the capacity of the spinal canal. Spine 14(5), 523-525, 1989
13. Oland G, Hoff TG: Intraspinal cross-section areas measured on myelography—computed tomography. The relation to outcome in nonoperated lumbar disc herniation (abstract). Spine 21: 1985-1989, 1996
14. Olmarker K, Bagge U, Holm S, Rydevik B: Effects of experimental graded compression on blood flow in spinal roots. J Orthop Res 7: 817-823, 1989
15. Penning L, Wilming JT: Posture-dependent bilateral compression of L4 or L5 nerve roots in facet hypertrophy. Spine 12: 488-500, 1987
16. Poletti CE: Central lumbar stenosis caused by ligamentum flavum: Unilateral laminotomy for bilateral laminectomy: A preliminary report of two cases. Neurosurgery 37: 343-347, 1995
17. Porchet F, Fankhauser H, Tribolet N: Extreme lateral lumbar disc herniation: Clinical presentation in 178 patients. Acta Neurochir (Wien) 127: 203-209, 1994
18. Postacchini F, Ripani M, Carpano S: Morphometry of the lumbar vertebrae. Clinical Orthop 172: 296-303, 1983
19. Reul J, Gievers B, Weis J, Thron A: Assessment of the narrow cervical spine: a prospective comparison of MRI, myelography and CT-myelography. Neuroradiology 37: 187-191, 1995
20. Schonstrom NSR, Bolender NF, Spengler DM: The pathomorphology of spinal stenosis as seen on CT scans of the lumbar spine. Spine 10: 806-811, 1985
21. Ullrich CG, Binet EF, Sanecki MG, Kieffer SA: Quantitative assessment of the spinal canal by computed tomography. Radiology 134: 137-143, 1980
22. Van Schaik JPJ, Verbiest H, Van Schaik FDJ: The orientation of laminae and facet joints in the lower lumbar spine. Spine 10: 59-63, 1985
23. Weisz GM, Lee P: Spinal stonosis. Concept of spinal reserve capacity: Radiologic measurement and clinical application. Clinical Orthop 179: 134-140, 1983
24. Zawadzki MB, Jensen M: Imaging corner, spinal nomenclature. Spine 20: 388-390, 1995