MEDICAL SCIENCE MONITOR

DIAGNOSTIC TECHNIQUES

© Med Sci Monit, 2013; 19: 216-221
DOI: 10.12659/MSM.883850

Received: 2012.02.21
Accepted: 2012.11.20
Published: 2013.03.25

Intraobserver and interobserver reproducibility of the novel transcription method for selection of potential nerve root compression in MRI study in degenerative disease of the lumbar spine

Authors' Contribution:
Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
Funds Collection G

ABCDEF 1,2 Łukasz Kubaszewski
EF 1 Andrzej Nowakowski
EF 2 Robert Gasik
CE 1 Wojciech Łabędź

1 Department of Spine Surgery, Oncologic Orthopaedics and Traumatology, Poznan University of Medical Sciences, Poznan, Poland
2 Clinic and Polyclinic of Neuro-orthopedics and Neurology, Institute of Rheumatology, Warsaw, Poland

Corresponding Author: Łukasz Kubaszewski, e-mail: e-klinika@o2.pl
Source of support: 1. The authors have received a consent to conduct the experiments forming the basis of the proposed publication from the Bioethical Committee of the Poznan University of Medical Sciences, a copy of which will be attached (Resolution No 165/12). 2. Sources of funding of the research: statutory activity of the Clinic and the Department: Department of Spine Surgery, Oncologic Orthopaedics and Traumatology, Poznań University of Medical Sciences, Poznan, Poland

Background: Degenerative disease of the lumbar spine is characterized by symptoms related to the affected nerve root. A recently described method allows the classification of the roots in relation to the occurrence of compression on its course. This method can serve as a clinical selection tool and decision support for semi-invasive pain therapy in back pain patients.

Material/Methods: We examined 40 lumbar spine MRIs in 3 sessions of transcription each, according to the method being evaluated. Every MRI evaluation was performed by each of 3 different observers. Intra- and interobserver reproducibility was calculated using chance-corrected agreement using a weighted kappa (κ) value with quadratic weights to assess reliability for each nerve root separately.

Results: We found high intraobserver agreement in indication of the root with most pronounced interference due to potential compression by degenerative changes, at the level mean κ=0.81 (with 95% CI, range 0.04). Less agreement was observed in the interobserver evaluation test with the mean κ=0.75 (95% CI within the range not exceeding 0.03), although it still reached the substantial agreement.

Conclusions: This zstudy provides evidence for substantial inter- and intraobserver agreement for the decision support method allowing selection of the most serious nerve structure compression in degenerative disease of the lumbar spine based on of the MRI description.

Key words: lumbar spine • spinal nerve root • diagnosis • algorithm • spinal injections • radio frequency ablation • spine

Full-text PDF: http://www.medscimonit.com/download/index/idArt/883850

2303 — 3 20

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS] [Index Copernicus]

Background

Pain is the basic symptom of degenerative processes of the spine and its origin can be a significant diagnostic and therapeutic problem. Most degenerative processes in the spine begin within the intervertebral disc. Mechanical processes of intervertebral disc degeneration can proceed in 2 forms: 1) dehydration of the intervertebral disc; or 2) damage of the lamellar structure of the annulus, causing protrusion, herniation, or even prolapse of the nucleus pulposus, with subsequent conflict against neural structures within the spinal canal [1]. Regardless of the form of disc degeneration, the result is motion segment dysfunction [2]. As a result of these changes, there is overload and instability of the intervertebral joints, which ultimately leads to degeneration. These mechanical disturbances are the basis of nerve root pain syndromes that compose the clinical picture of degenerative disease of the spine. At each of these stages there may occur neurological symptoms associated with compression of the nerve structures in the spinal and root canals [3,4]. Depending on the degree of compression and time of occurrence, neurological symptoms may be transient (e.g., brief irritation of neural structures), or fixed in the form of neuropathy, which is morphologically and functionally irreversible [5].

Among the diagnostic and treatment methods for these symptoms are selective nerve root injections. This treatment involves administering anesthetics (e.g., lidocaine or bupivacaine) combined with steroids in the proximity of the nerve on its course along the intervertebral canal or after it exits the canal. The diagnostic tool has a high specificity and can provide short-term relief of symptoms. As treatment of neuropathy, a minimally invasive treatment using pulsed electromagnetic fields of high frequency (RF – radio frequency) can be used for symptom relief [6].

The choice of the location in which to perform the procedures is based in practice on a combination of MRI studies and clinical symptoms. In diagnostically difficult cases, neurophysiological examination (i.e., ENG) may be helpful [7].

It is quite simple to determine the level of intervention required when there is mononeuropathy, confirmed in clinical examination by a radiological study. A problem arises when multilevel degeneration of the lumbar spine combines with a vague clinical picture. The solution in this case can be a novel technique, published recently [8], that allows transcription of complex MRI description into simple semi-structural notation.

The aim of this study was to evaluate intra- and interobserver agreement of the novel method assessing the most afflicted nerve root, based on the MRI description. This method may be a useful tool for decision support in site selection for semi-invasive diagnostic and treatment methods in patients with low back pain due to lumbar degenerative disease.

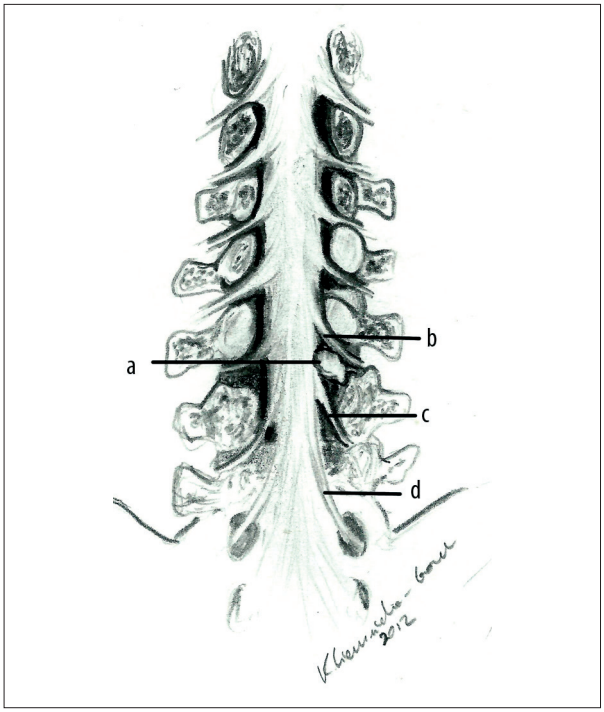

Figure 1. There are two major places of potential nerve root compression. Narrowing of the vertebral canal due to the disc degeneration (a), assign value „1" for all the roots passing the constriction (d), except for ones leaving the spinal canal directly below (c – assigned value „4"). The second site is compression of the nerve root in the intervertebral canal (b) yields the value „2" for particular root.

Material and Methods

The description of an MRI examination by a radiologist proceeds systematically. The description of advanced degenerative changes can be too extensive and cumbersome for swift reevaluation and analysis. The method allows a synthetic description of radiological methods that takes into account MRI analysis.

The proposed method uses the concept of numerical notation as used in the UNIX computer operating system. The coding computer system uses only 3 values (1, 2, or 4), representing different levels of authority for managing the files, called "octal notation"[9]:
1 – permission to execute, run (x)
2 – permission to write (w)
4 – permission to read (r).

The sum of possible combinations is 1 digit (1, 2, 3=1+2, 4, 5=1+4, 6=2+4, and 7=1+2+4). It also allows retrograde

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS] [Index Copernicus]

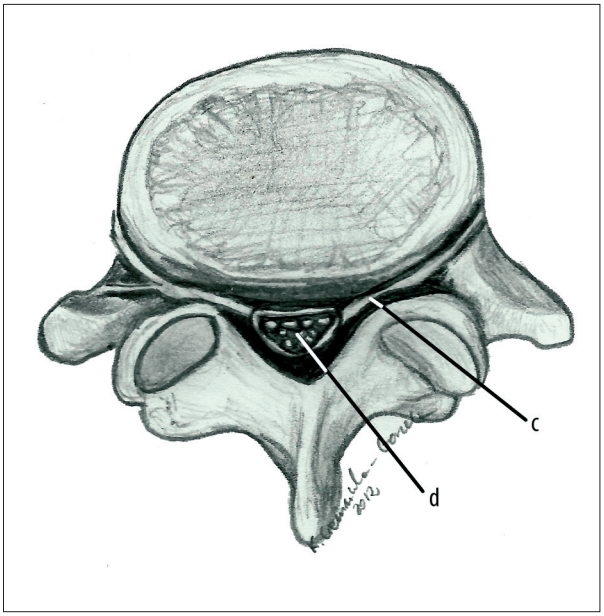

Figure 2. Passing of the nerve root through constriction of the spinal canal at the level of the intervertebrla disc. Most affected are the roots leaving the spinal canal just below the constriction level, passing the recessal region. The potential irritation basis is twosome: chemical – the proximity of the degenerated disc, and mechanical – entrapment within the recesses. Those spine roots are assigned the value of "4" (c). Other roots are assigned the value of "1" (d) considering the fact of crossing the region of the disc, which can be potential background for neuropathic changes due to th inflammatory process.

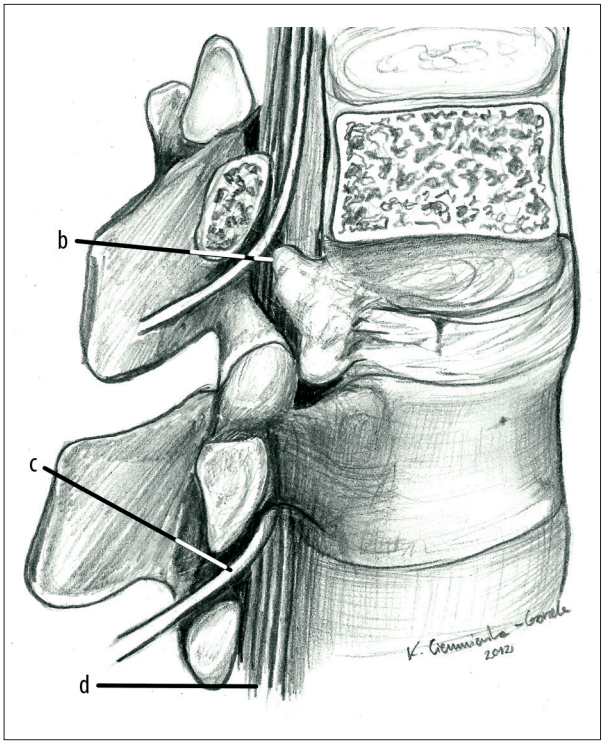

Figure 3. Passing through the narrowed intervertebral canal is major reason for single root neuropathy (lower two motion segments). The primary reason for neuroapthic changes is mechanical constriction of the foramina secondary to disc height loss. In that case the root is assigned the value of "2" (b). (c) and (d) as in the Figures 1 and 2.

information retrieval. As long as the outcome sum is unrepeatable for each set, its original combination can be recovered. The groundwork for this type of annotation was developed to manage the limited memory space of the first computers.

In analogy, this annotation was adopted for the purpose of designation of the most afflicted nerve root that can come into conflict against degenerative changes at different levels of the lumbar spine, based on the magnetic resonances examination.

Value = 4 is assigned to the roots exiting the spinal canal just below the level of discopathy, causing spinal canal constriction with involvement of lateral recesses (Figures 1 and 2). Within the spinal constriction most potential risk for compression is for the root in the lateral recess, which exits the spinal canal directly below.

Neuropathic changes in lumbar spine degeneration are related to mechanical chronic constriction and proinflammatory cytokines released by the degenerated disc [10]. Both changes are more likely to be observed at the degenerated disc level coexisting with lateral recess narrowing, secondary to degeneration of the facet joints. In addition, the sensory symptoms are more often observed when the interference occurs proximal to dorsal root ganglia (DRG) localized in the intervertebral foramina [11], thus potential interference at this level was assigned the highest value.

Value = 2; root gets this value where MRI study suggests that the interference is within the intervertebral canal (i.e., foraminal stenosis) (Figure 1 and 3). This site of constriction, although it can produce the inflammatory response in the DRG [12], is considered as primary chronic constriction injury with predominant mechanical ground [5].

Value = 1 A is given automatically to spinal nerves that run through the stenotic region on their course along the spinal canal, except for the nerve exiting immediately below (value=4) (Figures 1 and 2).

The value 1 considers every proximity of the degenerated disc as a potential contact with an inflammatory site potentially producing clinical symptoms, proven to be observed distant from the pathology or even on the opposite side [13].

According to the proposed method the following values by may be attributed to each nerve root:

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS] [Index Copernicus]

1 – possible pressure, narrowing of the spinal canal in more than 1 segment above the exit site;
2 – selective narrowing within a single intervertebral canal;
3 – 1 + 2; spinal stenosis more than 1 segment above the intervertebral canal stenosis;
4 – stenosis (also recessal) in the segment immediately above the intervertebral canal for the nerve to exit;
5 – 4 +1; multilevel narrowness of the spinal canal, when one of the narrowings is in the motion segment just above the exit site;
6 – 4 +2; stenosis of the spinal canal within the segment directly above,and the potential compression in the intervertebral canal;
7 – 4 +2 +1; multi-crowding, within the segment above, the narrowing of the intervertebral canal.

As the outcome, a semi-structural summary may be presented:
0 – L 4–2;
2 – L5–0;

which stand for compression within the intervertebral canal of the L4 root on the right and L5 on the left.

The description below:
0 – L3–2;
6 – L4–4;
1 – L5–1;
1 – S1–1;

means discopathy at the level of the L3/L4 intervertebral disc. A bulging disc causes compression of the L3 root on the right side within the intervertebral canal.

Both L4 roots receive the value 4 due to stenosis at the level above. Additionally, the left L4 root is compressed within its foramina. All the roots exiting below receive the value 1 because they pass through the stenotic region at the L3/L4 intervertebral disc.

Combination of the outcome of this method (root with highest score) and clinical presentation yields the decision on the intervention site for the semi-invasive diagnostic or therapeutic procedures.

The material used in this study consisted of 40 lumbar MRI study reports, performed in 1 diagnostic center in 2011. The MRI examinations were performed using a 1.5-T superconductive unit (Siemens Medical Systems, Germany) with 3 mm slice, T1 and T2-weighted images in sagittal and transverse plane. Examinations with diagnoses suggesting other pathologies (e.g., spondylolisthesis, discitis, malignant lesion), as well cases with prior spinal operation, were excluded. The subjects of this study underwent or were candidates for percutaneous pain intervention methods due to degenerative changes in the lumbar spine. Patients' ages ranged from 37 to 62 years.

Three 4th-year orthopedic residents with similar experience in treatment of spinal degenerative disease were presented with the method above during single training session.

They were given blinded MRI reports and asked independently read and perform transcription according to the method 3 times on separate occasions at a mean of 3 weeks apart.

The 3 surgeons were blinded to each others' interpretations. The MRI description included no patient identifiers and coding was changed for each session.

The participants were also blinded to cases' clinical data.

The initial ratings of the 3 surgeons provided the basis for estimates of interobserver reliability. Second and 3rd ratings performed at a mean of 3 weeks apart provided the basis for estimates of intraobserver reliability.

Chance-corrected agreement using a weighted kappa (κ) value with quadratic weights was used to assess reliability for each nerve root separately. The test value ranges from +1 (perfect agreement) to –1 (absolute disagreement). A value of 0 represents an agreement no better than that which occurs by chance alone. With multiple observers involved in the study, the κ value was calculated. Interpretation of the values was done according to the guidelines proposed by Landis et al. [14]: values of 0 to 0.2 represent slight agreement, 0.21 to 0.40 fair agreement, 0.41 to 0.60 moderate agreement, and 0.61 to 0.80 substantial agreement. Values above 0.80 are considered to be almost perfect agreement. We calculated 95% confidence intervals (CI) for each κ value. For the outcome correlation analysis between the surgeons' the Spearman rank correlation coefficient was calculated.

Results

We observed high intraobserver agreement at the level mean κ=0.81, with κ values of 0.79, 0.81, and 0.84 for participating surgeons, with 95% CI within the range not exceeding 0.04 for all.

Intraobserver agreement variation was primarily due to the vague description of the potential interference of the nerve root within the intervertebral canal. In some cases the "intervertebral canal narrowing" caused the observer to assign the value of 2 for a particular root, where on the other occasion the value of 2 was assigned by the same surgeon only when

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS] [Index Copernicus]

the radiologist suggested potential entrapment of the nerve root in the spinal canal.

There was no such problem with transcription of the narrowed spinal canal. The isolated recessal stenosis was rarely described by the radiologist (2 cases) and thus was overall uniformly transcribed by observers in consecutive observations.

Less agreement was found in interobserver reproducibility tests with the mean κ=0.75 (0.73, 0.74, and 0.79 for each surgeon) with 95% CI within the range not exceeding 0.03 for all, although it still reached the substantial agreement level in all cases.

In this case the variability was caused by personal understanding of the different radiological descriptions of the stenosis. Some radiologists used descriptive form for radiological presentation of stenosis (combination of disc bulging, facet hypertrophy, and edema of the facet joint capsules) without using the term "stenosis". In cases where the radiologist defined the problem as "stenosis" there were no problem in transcription. As we reviewed the controversial examination results, retrieving MRI scans and talking to radiologists, some mismatches in definition of stenosis appeared. In several cases the term "stenosis" was not used because the mid-sagittal diameter of the spinal canal was preserved, but the whole picture of the spinal canal at this level showed sever degenerative changes, with significant limitation of the spinal canal area.

Discussion

The analyzed method can be viewed as a compact transcription of extensive MRI structural records. This should allow, in treatment algorithm, a quick, reproducible way to verify and predict the affected spinal nerve, which in its course could face several mechanical obstacles within the spinal canal and intervertebral canals, especially when multilevel nerve root compressions result in a complex clinical picture.

This study was limited only to reading and analyzing the raw data from the MRI reports. The method allows low intraobserver variation, with slightly higher interobserver variability (reaching the substantial level of agreement in both cases: κ=0.81 and 0.75, respectively).

The variability is a due to differences in individual understanding of descriptive terms used by the radiologist, which is a form of interpretation bias. This is inevitable when MRI scans are described by the radiologist, who is usually unaware of the clinical status. To some extent the subjective impression was correlated with the clinical status by the orthopedist, neurosurgeon, or physical therapist.

Planimetric methods are available that can be used to assess neural interference within the spine [15], which are characterized by high reproducibility of results. However, the complexity of carrying out the measurements means that it is not normally used in the evaluation of magnetic resonance images.

In the clinical correlation, the best results are achieved when combined methods are employed [16]. Myelography is the most sensitive method for evaluating the entrapment of the neural structure in the spinal canal, especially when combined with CT scans.

Other methods have been used, with variable results [17–19].

A significant advantage of this transcription method is the presentation of the results quantitatively. Simplifying the information decreases the data, but also limits the influence individual interpretation bias in the treatment decision process.

The most important step is the correlation of test results with proper clinical symptoms [20]. At this stage of reviewing the information from imagining studies we strongly advise that, along with reading the description provided by the radiologist, the physician who makes treatment decisions should also review the MRI scans. All those information combined with the clinical status may give the best understanding of the clinical symptoms.

Conclusions

We have provided evidence for substantial inter- and intraobserver agreement for the method of transcription of lumbar spine MRI reports in degenerative disc disease in the lumbar spine.

This method may be a suitable decision support tool in planning semi-invasive pain management procedures in patients with degenerative disc disease in the lumbar spine.

Acknowledgments

We would like to thank Monica Chrzanowski for help in translation of the manuscript.

Statement

The authors received consent to conduct the experiments forming the basis of the proposed publication from the Bioethics Committee of Poznan University of Medical Sciences, a copy of which will be attached (Resolution No 165/12).

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS] [Index Copernicus]

References:

1. Alireza R, Abdolrahman B, Reza A, Seyyed Ali N: Clinical Manifestations and MRI Findings of Patients With Hydrated and Dehydrated Lumbar Disc Herniation. Acad Radiol, 2006; 13: 1485–89
2. Rohlmanna A, ZanderaT, Schmidta H et al: Analysis of the influence of disc degeneration on the mechanical behaviour of a lumbar motion segment using the finite element method. J Biomechanics, 2006; 39: 2482–90
3. Postacchini F. Lumbar Spinal Stenosis. Springer-Verlag, New York, 1989
4. Crock HV: Normal and pathological anatomy of the lumbar spinal nerve root canals. J Bone Joint Surg [Br], 1981; 63: 487–90
5. Kobayashi S, Uchida K, Takeno K et al: Imaging of Cauda Equina Edema in Lumbar Canal Stenosis By Using Gadolinium-Enhanced MR ORIGINAL Imaging: Experimental Constriction Injury. Am J Neuroradiol, 2006; 27: 346–53
6. Sluijter M: Radiofrequency. Flivopress, Switzerland, 2003
7. Lee JH, Lee SH: Physical examination, magnetic resonance image, and electrodiagnostic study in patients with lumbosacral disc herniation or spinal stenosis. J Rehabil Med, 2012; 44(10): 845–50
8. Kubaszewski L, Nowakowski A, Gasik R: Method of the nerve root selection in diagnostic and therapeutic process in patients with multilevel nerves entrapment in lumbar spine due to the degenerative process. Chir Narzadow Ruchu Ortop Pol, 2011; 76(5): 299–302
9. *http://en.wikipedia.org/wiki/Filesystem_permissions*
10. Sekiguchi M, Sekiguchi Y, Konno S et al: Comparison of neuropathic pain and neuronal apoptosis following nerve root or spinal nerve compression. Eur Spine J, 2009; 18(12): 1978–85
11. Mondelli M, Aretini A, Arrigucci U et al: Sensory nerve action potential amplitude is rarely reduced in lumbosacral radiculopathy due to herniated disc. Clin Neurophysiol, 2013; 124(2): 405–9
12. Chang YW, Winkelstein BA: Schwann cell proliferation and macrophage infiltration are evident at day 14 after painful cervical nerve root compression in the rat. J Neurotrauma, 2011; 28(12): 2429–38
13. Jancálek R, Dubový P, Svízenská I, Klusáková I: Bilateral changes of TNF-alpha and IL-10 protein in the lumbar and cervical dorsal root ganglia following a unilateral chronic constriction injury of the sciatic nerve. J Neuroinflammation, 2010; 7: 11
14. Landis JR, Koch GG: The measurement of observer agreement for categorical data. Biometrics, 1977; 33: 159–74
15. Cramer GD, Cantu JA, Dorsett RD et al: Dimention of the lumbar intervertebral foramina as determined from the sagittal plane magnetic resonance imaginig scans of 95 normal subjects. J Manip Physiol Ther, 2003; 26(3): 160–70
16. Osborne DR, Heinz ER, Bullard D, Friedman A: Role of computed tomography in the radiological evaluation of painful radiculopathy after negative myelography: foraminal neural entrapment. Neurosurg, 1984; 14(2): 147–53
17. Kettler A, Wilke HJ: Review of existing grading systems for cervical or lumbar disc and facet joint degeneration. Eur Spine J, 2006; 15(6): 719
18. Weishaupt D, Zanetti M, Boos N, Hodler J: MR imaging and CT in osteoarthritis of the lumbar facet joints. Skeletal Radiol, 1999; 28(4): 215–19
19. Jenis LG, An HS: Spine update. Lumbar foraminal stenosis. Spine, 2000; 25(3): 389–94
20. Postacchini F: Spine Update Surgical Management of Lumbar Spinal Stenosis. Spine, 1999; 24(10): 1043–47

Indexed in: [Current Contents/Clinical Medicine] [SCI Expanded] [ISI Alerting System] [ISI Journals Master List] [Index Medicus/MEDLINE] [EMBASE/Excerpta Medica] [Chemical Abstracts/CAS] [Index Copernicus]