Magnetic Resonance (MR) imaging of lumbar spine:
Use of a shortened protocol for initial investigation of degenerative disease

CP Mullan, BE Kelly

Accepted 23 March 2005

SUMMARY

Purpose: To assess the potential use of shortened protocol MRI of lumbar spine in the investigation of degenerative disc disease in Northern Ireland.

Materials & Methods: Prospective study of 35 patients having MR imaging of lumbar spine performed during a 12-month period by one consultant radiologist. T1-weighted and T2-weighted sagittal images of lumbar spine were obtained in all cases, as well as T2-weighted axial images. The detection of degenerative disc disease by sagittal T2-weighted imaging alone was compared with the diagnostic information obtained by combined use of axial T2 and sagittal T1 and T2 images.

Results: In comparison with the full protocol, the shortened protocol had 100% sensitivity and 100% specificity in detecting loss of disc hydration and loss of disc height. In the detection of disc prolapse, the sensitivity was 87% and the specificity was 91% using the shortened protocol. The sensitivity was 35% for detection of thecal sac indentation, and 33% for nerve root encroachment. Therefore, the shortened protocol had high sensitivity and specificity in the detection of disc degeneration and prolapse, but was less sensitive in the detection of nerve root or thecal sac encroachment.

INTRODUCTION

Degenerative disease of the lumbar spine is a common cause of low back and lower extremity pain. Patients presenting with these symptoms often have imaging studies performed to determine if there is a significant structural abnormality in the lumbar spine. Plain film examination of the lumbar spine is the usual initial imaging technique but provides only limited diagnostic information. Myelography-based examinations have largely been replaced by magnetic resonance imaging (MRI) and computed tomography (CT). MR imaging has a high degree of accuracy in delineating disc abnormalities and demonstrating whether neural tissue is compressed. Figure shows a selected image from a sagittal T2-weighted MR sequence, demonstrating loss of hydration of the L415 disc due to degenerative disease.

Magnetic resonance scans of lumbar spine form a substantial proportion of MR examinations performed in many centres. Despite advances in scanning techniques, MR imaging requires relatively long scan times, limiting the number of examinations which can be performed. A study performed by Robertson et al indicated that a rapid MR protocol was an accurate screening investigation

Royal Victoria Hospital, Grosvenor Road, Belfast BT12 6BA
Department of Radiology:
CP Mullen, MRCP, Specialist Registrar in Radiology
BE Kelly, MD, FRCS, FRCR, FFRRCSI, Consultant Radiologist
Correspondence to Dr Kelly

© The Ulster Medical Society, 2005.
Figure Selected image from sagittal T2-weighted MR sequence of lumbar spine.

for lumbar spondylosis.1 The aim of our study was to determine the potential application of shortened protocol MR in local clinical practice, in light of the recent expansion of MR facilities in Northern Ireland. If sufficient diagnostic information can be obtained with a shorter acquisition time, it would be possible to image a larger number of patients and reduce waiting times.

METHOD

This was a prospective study of 35 sequential patients having MR examination performed for suspected lumbar spine degenerative disease over a 12-month period. Sagittal T1-weighted, sagittal T2-weighted, and axial T2-weighted sequences were obtained by standard technique in all cases. The diagnostic information obtained from the sagittal T2-weighted sequence was first recorded. The final report was subsequently compiled by interpretation of all 3 sequences. Comparison was therefore made between the diagnostic information obtained by the full protocol and the proposed shortened protocol of sagittal T2-weighted images only. All scans were interpreted by one consultant radiologist. The presence of disc prolapse was assessed at each of 5 intervertebral levels, ie L1/2, L2/3, L3/4, L4/5, L5/S1. In addition, the following items were assessed as present or absent – loss of disc height, loss of disc hydration, annular disc tears, nerve root encroachment, and thecal sac indentation.

Patients were imaged using a 1.5 tesla Philips Intera system. The sagittal T1-weighted sequence was performed using TR 400 ms, TE 11 ms, matrix 512 x 384, slice thickness 4.4 mm, interslice gap 0.4 mm, field of view 325 mm, acquisition time 4 min 24 sec. The sagittal T2-weighted sequence was performed using TR 3500 ms, TE 120 ms, matrix 512 x 384, slice thickness 4.4 mm, interslice gap 0.4 mm, field of view 325 mm, acquisition time 3 min 54 sec. The axial T2-weighted sequence was performed using TR 2500 ms, TE 120 ms, matrix 512 x 384, slice thickness 4.0 mm, interslice gap 0.4 mm, field of view 225 mm, acquisition time 4 min 52 sec.

RESULTS

The mean age of the patients studied was 54.5 years (standard deviation 18.1 years), with male:female ratio 0.84. Five disc levels were assessed for each of the 35 patients, yielding 175 disc evaluations in all. The sensitivity and specificity of the shortened protocol was calculated using the detailed protocol as the reference standard. In comparison to the

|                | Sensitivity | Specificity |
|----------------|-------------|-------------|
| Loss disc height | 100         | 100         |
| Loss disc hydration | 100       | 100         |
| Annular disc tears  | 73.7       | 100         |
| All disc prolapses   | 86.7       | 90.8        |
| Central prolapse      | 87.5       | 90.4        |
| Lateral prolapse      | 40.0       | 100         |
| Thecal indentation    | 35.3       | 100         |
| Nerve root encroach   | 25.0       | 100         |

The Ulster Medical Society, 2005.
full protocol, the shortened protocol had 100% sensitivity and 100% specificity in detecting loss of disc hydration and loss of disc height (Table I). For annular disc tears, the sensitivity was 73.7% and the specificity was 100% (Table I).

Table II shows the detection of all types of disc prolapse by the full and shortened imaging protocols. The detailed protocol demonstrated a total of 45 disc prolapses in the group of 175 discs evaluated. 39 of the 45 prolapses were detected on the shortened protocol, while 12 discs declared prolapsed on the shortened protocol were found to be normal on the full protocol. This resulted in sensitivity of 86.7% and specificity of 90.8% for the shortened protocol in the detection of all types of disc prolapse.

Of the 40 central disc prolapses found on the full protocol, 35 were detected on the shortened protocol (Table III). The calculated sensitivity was 87.5% and the specificity was 90.4% in the detection of central disc prolapses. Table IV shows the detection of lateral prolapse of intervertebral discs. A total of 10 lateral disc prolapses were detected using the full protocol, four of which were seen on the shortened protocol. The sensitivity was 40.0% and the specificity was 100% for the shortened protocol in the detection of lateral disc prolapse.

CONCLUSIONS

The shortened protocol would be a suitable initial investigation for suspected degenerative disc disease, in view of the short acquisition time required. More detailed imaging would be indicated for patients with significant abnormality on the shortened MR examination. Initial investigation by MR would reduce radiation exposure incurred in lumbar spine radiographs and provide greater diagnostic information.

The detailed protocol detected 17 prolapsed discs which were causing thecal sac indentation, with only six of these discs detected by the shortened protocol. The shortened protocol therefore had sensitivity of 35.3% and specificity of 100% in the detection of thecal sac indentation. Of the four discs causing nerve root encroachment on the detailed protocol, one was detected on the shortened protocol. The sensitivity was 25.0% and the specificity 100% for nerve root encroachment by prolapsed discs.

DISCUSSION

The shortened protocol was reliable in the detection of disc degeneration, with high sensitivity and specificity for loss of disc height and loss of disc hydration. The shortened MR imaging protocol was mostly reliable in visualising annular disc tears, with sensitivity of 73.7% and specificity of 100%. In the detection of all types of disc prolapse, the shortened protocol was relatively accurate with sensitivity of 86.7% and specificity of 90.8%.
particular, the shorter examination was reliable in visualising central prolapse, the most common type of intervertebral disc prolapse in the study. However, the shortened protocol was less satisfactory in detecting lateral disc prolapses, with sensitivity of 40%. The sensitivity of the shorter MR examination in the detection of thecal sac indentation (35.3%) and nerve root encroachment (25%) was also relatively low, although specificity was 100%.

Overall, the shortened protocol for MR imaging of the lumbar spine was satisfactory in assessing disc degeneration, disc tears, and most types of disc prolapse. The shorter examination was limited in the ability to detect lateral disc prolapse, thecal sac indentation and nerve root encroachment. However, all of the patients with lateral disc prolapses which were not detected on the shortened protocol had other evidence of degenerative disease that was found on this protocol. This demonstrates that MR imaging with the shortened protocol would be a suitable initial investigation for patients with low back pain due to suspected degenerative disc disease. Detailed MR examination would be indicated for those patients with significant anomalies detected on the shortened protocol, such as large disc protrusions, abnormal bone marrow or spinal cord lesions.

MR facilities are becoming more widely available in hospitals throughout Northern Ireland. As access to MRI increases, a shortened protocol such as that used in this study could replace plain films as the initial imaging investigation for low back pain. The yield of plain films in the work-up of patients with low back pain is low. The Royal College of Radiologists recommends MRI as the first-choice investigation for patients with persistent or severe back pain. MRI of lumbar spine enables visualisation of disc hydration changes, end plate changes, and the nature of disc prolapse. This approach would also reduce medical radiation exposure as MRI does not involve the use of ionising radiation. As shown in Table V the national reference radiation dose for plain film lumbar spine examination with three views is dose area product (DAP) of 7600 mGy cm². Accordingly, the calculated risk of inducing a fatal cancer due to a plain film examination of lumbar spine is 1 in 15,400. The calculated risk of inducing non-fatal cancer is 1 in 2,080. Approximately 21,000 plain film lumbar spine examinations are performed each year in Northern Ireland, therefore inducing 1.36 fatal cancers and 10.10 non-fatal cancers.

In summary, this study shows that a shortened MR examination of lumbar spine using a sagittal T2-weighted sequence is effective in detecting degenerative disc changes and most types of disc prolapse. The vast majority of treatable lesions will therefore be detected by use of the shortened protocol. The shorter acquisition time and the increasing availability of MRI facilities mean that this examination is becoming more suitable than plain film radiography in the initial assessment of patients with low back pain. This approach would improve diagnostic yield and reduce the risk of radiation-induced malignancy due to medical exposure in the Northern Ireland population. Widespread implementation of the shortened protocol examination would require sufficient resources to maximise the use of MRI facilities.

### Table V

| View          | Dose Area Product |
|---------------|-------------------|
| Lumbar spine AP | 1600 mGy cm²      |
| Lumbar spine lateral | 3000 mGy cm² |
| Lumbar spine LSJ  | 3000 mGy cm²      |
| Total for 3 views | 7600 nGy cm²     |

REFERENCES

1. Robertson WD, Jarvik JD, Tsuruda JS, Koepsell TD, Maravilla KR. The comparison of a rapid screening MR protocol with a conventional MR protocol for lumbar spondylosis. AJR Am J Roentgenol 1996; 166(4): 909-16.

2. Peh WC, Siu TH, Chan JH, Chan FL. Lumbar spine magnetic resonance imaging: comparison between fast spin echo proton density and spin echo T1 axial scans. Br J Radiol 1998; 71(845): 487-91.

3. Hart D, Hillier MC, Wall BF. Doses to patients from medical X-ray examinations in the UK: 2000 Report No.: NRPB W 14. London: Health Protection Agency.

4. The Royal College of Radiologists. Making the best use of a department of clinical radiology: Guidelines for doctors. 5th ed. London: Royal College of Radiologists.