

Less Is More: Efficacy of Rapid 3D-T2 SPACE in ED Patients with Acute Atypical Low Back Pain

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CES
cauda equina syndrome

ED
emergency department

EMR
electronic medical record

FS
fat saturated

LBP
low back pain

LS
lumbar spine

Sens
sensitivity

Spec
specificity

TA
acquisition time

3D-T2 SPACE
3D-T2 Sampling Perfection
with Application optimized
Contrasts using different flip
angle Evolution

MRI
magnetic resonance imaging

Rationale and Objectives: Emergency department (ED) patients with acute low back pain (LBP) may present with ambiguous clinical findings that pose diagnostic challenges to exclude cauda equina syndrome (CES). As a proof of concept, we aimed to determine the efficacy of a rapid lumbar spine (LS) magnetic resonance imaging (MRI) screening protocol consisting of a single 3D-T2 SPACE FS (3D-T2 Sampling Perfection with Application optimized Contrasts using different flip angle Evolution fat saturated) sequence relative to conventional LS MRI to exclude emergently treatable pathologies in this complex patient population.

Materials and Methods: LS MRI protocol including a sagittal 3D-T2 SPACE FS pulse sequence was added to the routine for ED patients presenting with acute atypical LBP over a 12-month period. Imaging findings were categorically scored on the 3D-T2 SPACE FS sequence and separately on the reference standard conventional LS MRI sequences. Patients' symptoms were obtained from review of the electronic medical record. Descriptive test statistics were performed.

Results: Of the 206 ED patients who obtained MRI for acute atypical LBP, 118 (43.3 ± 13.5 years of age; 61 female) were included. Specific pathologies detected on reference standard conventional MRI included disc herniation ($n = 30$), acute fracture ($n = 3$), synovial cyst ($n = 3$), epidural hematoma ($n = 2$), cerebrospinal fluid leak ($n = 1$), and leptomeningeal metastases ($n = 1$), and on multiple occasions these pathologies resulted in nerve root impingement ($n = 36$), severe spinal canal stenosis ($n = 13$), cord/conus compression ($n = 2$), and cord signal abnormality ($n = 2$). The 3D-T2 SPACE FS sequence was an effective screen for fracture (sensitivity [sens] = 100%, specificity [spec] = 100%), cord signal abnormality (sens = 100%, spec = 99%), and severe spinal canal stenosis (sens = 100%, spec = 96%), and identified cord compression not seen on reference standard. Motion artifact was not seen on the 3D-T2 SPACE FS but noted on 8.5% of conventional LS MRI.

Conclusions: The 3D-T2 SPACE FS sequence MRI is a rapid, effective screen for emergently actionable pathologies that might be a cause of CES in ED patients presenting with acute atypical LBP. As this abbreviated, highly sensitive sequence requires a fraction of the acquisition time of conventional LS MRI, it has the potential of contributing to increased efficiencies in the radiology department and improved ED throughput.

Key Words: Acute LBP; 3D-T2 SPACE; MRI.

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INTRODUCTION

In the emergency department (ED) setting, the main role of magnetic resonance imaging (MRI) of the lumbar spine (LS) is not to confirm chronic problems, but to detect emergently actionable pathologies that, if not treated expeditiously, could result in permanent neurological deficits. Cauda equina syndrome (CES) is the most important example of such a critical clinical and imaging diagnosis that warrants emergent exclusion to prevent permanent neurological damage. Clinical guidelines set forth in the radiology (1,2) and emergency medicine literature (3), based upon the presence of specific clinical “red flags,” are useful for stratifying the risk of an underlying serious low back pain (LBP) etiology (e.g., malignancy, infection, and/or trauma). While the CES diagnosis is frequently suspected in ED patients complaining of LBP, multiple prior studies have demonstrated that true CES is quite uncommon, found in only 1%–2% of suspected ED patients (4–7). The surgical literature estimates that true CES accounts for only 1%–3% of patients requiring lumbar spinal surgery (8–10). The varied clinical presentation, sundry etiologies, potential gravity of findings, and medicolegal liability of a missed diagnosis all serve as driving forces for the increasing utilization of emergent LS MRI (4,11). In our institution, more than 200 emergent LS MRI examinations per year on average are performed to “rule out” CES in ED patients with acute LBP (4,5), and although this is disproportionate to the true incidence of this rare entity, imaging is crucial to exclude critical pathology.

We hypothesized that a single-sequence fat-saturated (FS) 3D-T2 turbo spin echo with variable flip angles (3D-T2 SPACE [3D-T2 Sampling Perfection with Application optimized Contrasts using different flip angle Evolution]; Siemens AG, Munich, Germany) can serve as a rapid and accurate screening examination for excluding potentially emergently actionable etiologies (i.e., fracture, cord compression, cord signal abnormality, and/or severe spinal canal stenosis) in these acute atypical LBP ED patients. As a proof of concept study, we present the sensitivity and specificity for a single-sequence 3D-T2 SPACE FS MRI screen compared to the reference standard conventional LS MRI to validate this screening study in ruling out important etiologies in this complicated patient population. Furthermore, given that this rapid, abbreviated MRI can be completed in a fraction of the time of conventional LS MRI, there is the *real* potential of improving efficiency in the radiology department and patient throughput in the ED. With limited charge for the abbreviated LS MRI protocol, there is also the potential for overall decreased healthcare costs.

MATERIALS AND METHODS

Participants

This study was approved by our institutional review board and was a compliant of Health Insurance Portability and Accountability Act. As a retrospective study, written informed

consent was waived. As part of an institutional quality improvement and lean initiative, the sagittal 3D-T2 SPACE FS pulse sequence was added to the routine LS MRI protocol for consecutive examinations in ED patients presenting with acute atypical LBP over a 12-month period from February 1, 2014 through January 31, 2015. The LS MRI had been requested for specific exclusion of etiologies that would require emergent surgical intervention for CES. All subjects underwent the same imaging protocol with complete compliance to protocol in all cases. LS MRI examinations were ordered by the ED physician and the electronic medical record (EMR) was retrospectively reviewed for patient symptomatology. Of the acute LBP ED patients who underwent MRI evaluation, our study cohort included those patients over 18 years of age presenting with acute LBP and additional symptoms (e.g., lower extremity weakness, bowel/bladder incontinence, perineal numbness, focal neurological deficit). Those patients with significant LS trauma were excluded as the etiology of these patients was already known. Those patients with known malignancy and intravenous drug use were excluded as we wanted a parallel comparison of nonenhanced MRI exams, and patients with history of cancer and intravenous drug use undergo contrast-enhanced MRI at our institution.

Magnetic Resonance Imaging

All imaging was performed on one of two 1.5 T MRI scanners (Aera or Avanto; Siemens AG). In addition to the sagittal 3D-T2 SPACE FS sequence, all subjects underwent a routine full LS MRI protocol, including localizer sequences, sagittal T1 inversion recovery, sagittal short tau inversion recovery, sagittal T2-weighted, sagittal diffusion tensor imaging (DTI), including sagittal DTI Trace and ADC map, axial T1-weighted, axial T2-weighted orthogonal, and axial T2-weighted angled sections through discs. On the Aera unit, the 3D-T2 SPACE FS sequence parameters were as follows: repetition time (TR) ms/echo time (TE) ms: 1500/120; matrix: 320 × 320; field of view (FoV): 270 mm; averages: 1.4; concatenations: 1; slice thickness: 1 mm; slices per slab: 48; voxel volume: 0.8 × 0.8 × 1 mm; and acquisition time (TA): 4 minutes 56 seconds. On the Avanto unit, the 3D-T2 SPACE FS sequence parameters were as follows: TR ms/TE ms: 1500/128; matrix: 317 × 320 mm; FoV: 260 mm; averages: 1.8; concatenations: 1; slice thickness: 2 mm; slices per slab: 30; voxel volume: 0.8 × 0.8 × 2 mm; and TA: 3 minutes 14 seconds. For comparison, the routine LS MRI without 3D-T2 SPACE FS sequence TA amounted to approximately 25 minutes of scan time.

Image Analysis

The 3D-T2 SPACE FS images were separately evaluated by three reviewers of varying levels of experience (reviewer 1: a senior certificate of added qualification (CAQ) neuroradiologist with 17 years of experience; reviewer 2: a senior CAQ neuroradiologist with 10 years of experience; reviewer 3: a

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