Evaluation of an Algorithmic Approach to Pediatric Back Pain

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Abstract: Pediatric patients require a systematic approach to treating back pain that minimizes the number of diagnostic studies without missing specific diagnoses. This study reviews an algorithm for the evaluation of pediatric back pain and assesses critical factors in the history and physical examination that are predictive of specific diagnoses. Eighty-seven pediatric patients with thoracic and/or lumbar back pain were treated utilizing this algorithm. If initial plain radiographs were positive, patients were considered to have a specific diagnosis. If negative, patients with constant pain, night pain, radicular pain, and/or an abnormal neurological examination obtained a follow-up magnetic resonance imaging. Patients with negative radiographs and intermittent pain were diagnosed with nonspecific back pain. Twenty-one (24%) of 87 patients had positive radiographs and were treated for their specific diagnoses. Nineteen (29%) of 66 patients with negative radiographs had constant pain, night pain, radicular pain, and/or an abnormal neurological examination. Ten of these 19 patients had a specific diagnosis determined by magnetic resonance imaging. Therefore, 31 (36%) of 87 patients had a specific diagnosis. Back pain of other 56 patients was of a nonspecific nature. No specific diagnoses were missed at latest follow-up. Specificity for determining a specific diagnosis was very high for radicular pain (100%), abnormal neurological examination (100%), and night pain (95%). Radicular pain and an abnormal neurological examination also had high positive predictive value (100%). Lumbar pain was the most sensitive (67%) and had the highest negative predictive value (75%). This algorithm seems to be an effective tool for diagnosing pediatric back pain, and this should help to reduce costs and patient/family anxiety and to avoid unnecessary radiation exposure.

Key Words: pediatric patients, back pain, radiographs, algorithm

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Back pain has traditionally been considered an uncommon complaint among children and adolescents.[1] However, the recent literature has shown that the incidence of back pain in these age groups occurs more frequently than previously reported.[2–4] Clinically, it is common for a child to have symptoms of back pain that are severe enough to warrant a medical consultation.

A complaint of back pain in a child, unlike in an adult, has been considered a serious issue, and every effort has been made to determine its cause.[5,6] Physicians have been inclined to use every available test to reach a diagnosis. Undoubtedly, there are cases of back pain in children that are caused by serious diseases, but it is also well recognized that there are many cases associated with less serious conditions. Physicians need to be able to distinguish between benign and pathological causes of back pain. No single sign, symptom, or test reliably differentiates between these 2 groups. In the evaluation of back pain, physicians should follow a systematic approach using the minimum number of diagnostic studies, which would have the benefit of reducing radiation exposure, cost, and patient/family anxiety.

An algorithm to assist physicians in the assessment of pediatric back pain was developed by the senior author (DSF). The purpose of this study was to demonstrate the ability of an algorithm to detect specific major spinal pathology, such as tumor or infection, in pediatric patients presenting with a chief complaint of back pain.

MATERIALS AND METHODS

From January 1995 to January 2002, 95 consecutive children (44 boys, 51 girls) with an average age of 13.4 years (range, 4–18 years) presented with a chief complaint of thoracic and/or lumbar back pain. Patients who were referred for scoliosis evaluation or had a history of trauma (fall, motor vehicle injury) within 3 weeks of his or her initial visit were excluded. Institutional Review Board approval was obtained before the study.

Upon the patient's initial presentation, the senior author followed an algorithm (Fig. 1) which included a detailed history, a thorough physical examination, blood tests [complete blood count (CBC)], and plain radiographs. CBC was recommended in patients younger than 10 years because of the association of back pain and leukemia in young children. If the radiographs were positive and adequately corresponded to the patient's history and examination, treatment was based on the specific diagnosis. If the radiographs were negative and the patient reported constant pain, night pain, radicular pain, and/or demonstrated an abnormal neurological examination, a magnetic resonance imaging (MRI) was obtained. Constant pain was defined as pain present at all times, night pain was pain that awoke a

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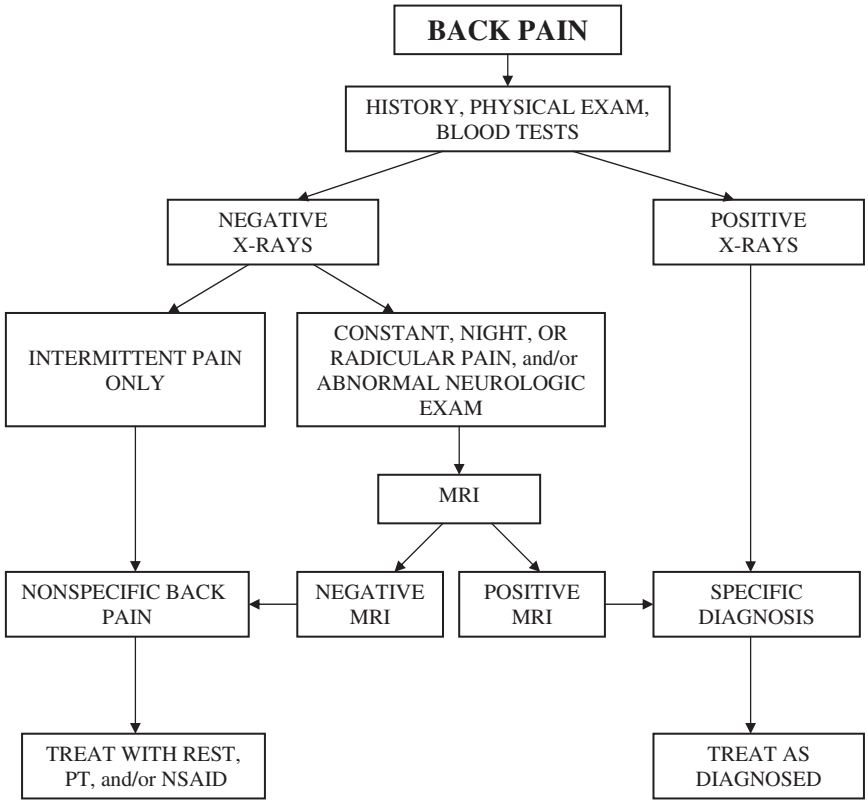

FIGURE 1. Pediatric back pain algorithm.

patient from sleep, and radicular pain was pain distributed in a radicular pattern. Patients who had negative radiographs and only reported intermittent pain were diagnosed with nonspecific back pain and treated with rest, physical therapy, and/or nonsteroidal anti-inflammatory medications. If a patient with negative radiographs was found to have a positive finding on MRI, he/she was treated for that specific diagnosis. Specific diagnoses included spondylolisthesis, spondylolysis, scoliosis, herniated nucleus pulposus, and tumors. Those who had both negative radiographs and a negative MRI were treated for nonspecific back pain. Nonspecific diagnoses included strains, sprains, and overuse syndrome.

A chart review was performed, and the following data were recorded: sex, age, frequency (constant or intermittent) and location of pain (thoracic, thoracolumbar, or lumbar), presence of radicular or night pain, neurological examination (normal or abnormal), presence of scoliosis, results of all radiological studies, and diagnosis. Patients who were diagnosed with nonspecific back pain or who did not have a follow-up visit were interviewed by telephone to determine if they had developed any new signs or symptoms that suggest a change in their diagnosis. After all the data were collected, each patient was placed into the treatment algorithm. The efficacy of the algorithm was assessed by examining the ability of certain signs, symptoms, and tests to predict the presence of a specific diagnosis and by determining if any specific diagnoses such as tumors, infection, or other significant pathology were missed.

Statistical Analysis

The sensitivity, specificity, positive predictive value, and negative predictive value of the signs and symptoms (constant pain, night pain, radicular pain, thoracic pain, thoracolumbar pain, lumbar pain, abnormal neurological examination, and scoliosis) of adolescent back pain were analyzed to determine the ability of each of these variables to detect the presence of a specific diagnosis. Using constant pain, night pain, radicular pain, and abnormal neurological examination as predictors, the predicted probability of having a specific diagnosis on the basis of the number of these variables present was calculated.

The frequencies of the following were determined: (1) patients with specific diagnoses, (2) specific diagnoses made by radiograph, (3) specific diagnoses in patients with a negative radiograph, (4) specific diagnoses in patients with a negative radiograph and who had a follow-up MRI, and (5) patients in which a specific diagnosis was missed.

RESULTS

Eighty-seven of the 95 patients with thoracic and/or lumbar back pain were treated utilizing this algorithm (Fig. 1). Five patients who were not available for follow-up, 2 who failed to obtain an MRI, and 1 who had MRI and computed tomography (CT) scan done previously were excluded. Follow-up data were obtained at an average of 3.3 years (range, 2–8 years) after initial visit.

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Twenty-one patients had initial radiographs that were positive for a specific diagnosis, including spondylolisthesis, scoliosis, and tumors. Of these 21 patients, 8 had follow-up MRI confirming the diagnosis. Three of these 8 patients who had MRI additionally had CT scans. All 21 patients were treated for their specific diagnosis.

Sixty-six patients had negative findings on initial radiographs. Nineteen (29%) of the 66 patients reported having constant pain, night pain, radicular pain, and/or demonstrated an abnormality on neurological examination. Utilizing the algorithm, these 19 patients obtained an MRI. Ten (53%) of the 19 patients had MRI findings that were positive for a specific diagnosis, including spondylolysis, herniated nucleus pulposus, and osteoid osteoma. Five of the 10 patients also had CT scans that confirmed the diagnosis and aided in treatment decision making. The other 9 patients, who had negative MRI, did not undergo further diagnostic testing and were given the diagnosis of nonspecific back pain. These patients were contacted and reported that their symptoms had not changed.

The remaining 47 patients with negative radiographs only had intermittent pain and were diagnosed with nonspecific back pain. These patients were contacted and reported no change in their symptoms. Collectively, the 56 patients diagnosed with nonspecific back pain were treated with rest, physical therapy, and/or nonsteroidal anti-inflammatory medications.

In summary, 31 (36%) of the 87 patients were found to have a specific diagnosis (Table 1). Twenty-one (68%) of these 31 patients had a positive finding on his or her initial radiographs. The other 10 patients, who had negative radiographs, were found to have a specific diagnosis by MRI. All 10 patients reported having constant pain, night pain, radicular pain, and/or had an abnormal neurological examination.

The sensitivity, specificity, positive predictive value, and negative predictive value of the location of pain, type of pain, scoliosis, and abnormal neurological examination for predicting a specific diagnosis are shown in Table 2. The specificity and positive predictive value of both radicular pain and an abnormal neurological examination were 100%. Night pain also had a very high specificity (95%) for determining a specific diagnosis. Lumbar back pain was found to be the most sensitive (67%) and to have the largest negative predictive value (75%) of the variables.

TABLE 1. Frequency of Specific Diagnoses

Diagnoses	No. Patients
Spondylolisthesis	10
Herniated nucleus pulposus	6
Scoliosis	5
Spondylolysis	3
Osteoid osteoma	2
Scheuermann kyphosis	1
Masson tumor	1
Congenital spinal dysraphism	1
Degenerative disc changes	2

The predicted probability of having a specific diagnosis using the 4 predictors (constant pain, night pain, radicular pain, and abnormal neurological examination) was 100% when a patient had 3 of the predictors, 85.7% for 2 predictors, 61.1% for 1 predictor, and 18.6% for zero predictors (Table 3).

DISCUSSION

Pediatric back pain has been more extensively evaluated in the recent literature as the result of the documentation of a higher prevalence than those previously described. In a longitudinal study that included 216 adolescents over a 5-year period, Burton et al[7] found an annual incidence of lumbar pain of 12% at the age of 12 years and 21.5% at the age of 15 years. Similarly, Brattberg[8] reported a 20% incidence over a 2-year period, and Nissinen et al[9] found an annual incidence of low back pain of 17.6% in 859 children aged 12.8 years, with 4.4% requiring medical care.

Many physicians believe that the complaint of back pain in a child is a red flag, and every effort should be made to reach a diagnosis that they believe is caused by an organic pathology.[5,10,11] This has led many children to undergo extensive and often unnecessary investigations, resulting in an increase in radiation exposure, patient/family anxiety, and cost. Certainly, the complaint of back pain in a child may be caused by a serious pathology, but it may also be caused by a benign disease. Feldman et al[12] have demonstrated a high frequency of benign pediatric back pain in that 78.3% of their cases did not have a specific diagnosis to explain their pain.

In evaluating pediatric back pain, physicians should aim at differentiating between nonspecific (benign) and specific (pathological) causes using as few diagnostic tests as possible. Included in the differential diagnosis are developmental abnormalities (scoliosis, Scheuermann kyphosis, spondylolysis, spondylolisthesis), mechanical derangement (posture, muscle strain, herniated nucleus pulposus), infection (diskitis, vertebral osteomyelitis), benign neoplasms (osteoid osteoma, osteoblastoma, aneurysmal bone cyst), or malignant neoplasms (leukemia, lymphoma, sarcoma).[5,13]

A detailed history should be obtained from the patient and his or her parents inquiring about the onset, duration, frequency, and location of pain, including any exacerbating and alleviating factors. A careful and thorough physical examination should be conducted, including a neurological examination and gait evaluation. The initial radiographic assessment should consist of anteroposterior and lateral plain radiographs of the spine. Simple hematological tests such as CBC and sedimentation rate can be helpful to rule out certain diagnoses, such as infection or leukemia. On the basis of the patient's signs and symptoms, the physician should decide which additional laboratory tests and imaging studies will assist in reaching a diagnosis, such as oblique radiographs of the spine to rule out spondylolysis.

When the signs and symptoms do not point to a specific diagnosis and the above-mentioned investigations are normal, the physician is faced with the dilemma of deciding whether to proceed with more extensive and often more expensive tests or to consider the symptoms to be not worrisome and provide conservative treatment. Turner et al[11] recommended that in the absence of neurological signs, patients with a

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TABLE 2. Usefulness of the Type and Location of Pain, Scoliosis, and an Abnormal Neurological Examination in Predicting a Specific Diagnosis

	Sensitivity (%)	Specificity (%)	Positive Predictive Value (%)	Negative Predictive Value (%)
Constant pain	36	89	63	72
Night pain	24	95	72	70
Radicular pain	21	100	100	70
Thoracic pain	15	59	17	56
Thoracolumbar pain	18	87	43	66
Lumbar pain	67	54	44	75
Scoliosis	27	89	56	69
Abnormal neurological examination	18	100	100	69

mobile spine should be treated with a "wait-and-see" policy. If their symptoms persist in the presence of clinical suspicion, they suggested that other investigations such as skeletal scintigraphy, myelography, or CT scans are warranted.

Controversy exists in the literature regarding the best radiographic modality to use after plain radiographs. According to Turner et al,[11] the greatest diagnostic yield in these patients comes from myelography, which is an invasive, expensive, and uncomfortable test. Richards et al[13] suggested that when the plain radiographs and the neurological examination are normal, a technetium bone scan or single-photon emission CT should be the next imaging study to be obtained. If the neurological examination is abnormal, an MRI is the optimal study to follow plain radiography to assess the neural axis. When a bone lesion is detected on plain radiography or bone scan, the investigators recommended doing a complete scan to clarify the extent of the lesion. Feldman et al[12] found that the bone scan alone was positive in only 22% of the patients and had low sensitivity and specificity. Five of their patients with both normal plain radiographs and a single-photon emission CT had spinal neoplasms. According to the authors, the main indication for a bone scan is to evaluate patients with suspected spondylolysis and spondylolisthesis presenting with negative plain radiographs or to determine if the lysis is the probable cause of pain. The authors could not state whether an MRI should be part of the routine assessment of children with back pain because the patients in their study inconsistently received MRI.

Our algorithm to diagnose specific causes of back pain included initial work-up of history, physical examination, and plain radiographs of the spine. If the radiographs were positive, the patient was given a specific diagnosis based on the radiographic findings and was treated according to the diagnosis. If the radiographs were negative and no diagnostic physical signs were present, then the patient was treated as having nonspecific back pain. These patients were observed and symptomatically treated with rest, physical therapy, and/or nonsteroidal anti-inflammatory medications. Patients who had a negative radiograph, constant pain, night pain, radicular pain, and/or abnormal neurological examination were evaluated further with MRI. By following this algorithm, we found that we did not miss any specific major spinal pathology such as tumor or infection, and at the last follow-up, none of the patients who were labeled as having nonspecific back pain had a change in their diagnosis.

Similar to the previously noted results of Feldman et al,[12] 64% (56/87) of our patients presenting with a chief complaint of back pain had a nondemonstrable cause for their symptoms and were labeled as having nonspecific back pain and treated conservatively. Among the patients who had a specific diagnosis, 21 (68%) of 31 patients were diagnosed by simple plain radiograph. Although some of these patients had other radiographic modalities (CT scans, MRI) to confirm the diagnosis, the abnormality was seen initially on plain radiographs. We strongly agree with the recommendation that all children presenting with back pain have plain radiographs as their initial radiographic assessment[10,14] and disagree with Selbst et al[1], who found that plain radiographs of the spine were rarely helpful. Plain radiographs are a cost-effective, easily performed modality with a high yield.

Our results also showed that certain parameters in the history and physical examination were associated with the presence or absence of specific diagnoses. Constant pain, radicular pain, night pain, and abnormal neurological examination were found to have high specificity, that is, the absence of these parameters would have a high true negative rate for the presence of specific diagnosis. The presence of these clinical markers should alert the physician to possible

TABLE 3. Predicted Probability of a Specific Diagnosis on the Basis of the Number of Predictors Present

No. Predictors	Patients with Nonspecific Diagnosis [n (%)]	Patients with Specific Diagnosis [n (%)]	Predicted Probability of Specific Diagnosis (%)
0	48 (85.7)	11 (35.5)	18.6
1	7 (12.5)	11 (35.5)	61.1
2	1 (1.8)	6 (19.3)	85.7
3	0	3 (9.7)	100
4	0	0	–

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underlying pathology and indicate that further investigations are warranted.

With respect to the location of pain, lumbar pain had the highest sensitivity (67%) and was, therefore, associated with a specific diagnosis. Although lumbar pain was not included in our algorithm to plan for further investigations, our findings suggest that referral of pain specifically to the lumbar area is a relatively important marker that might warrant further evaluation.

The presence of scoliosis was found on radiographs in 18% (16/87) of our cases. Five (31%) of these 16 patients had no other underlying pathology to explain their symptoms, and therefore, scoliosis was considered to be the direct cause of their back pain. The association between scoliosis and back pain has been demonstrated by Ramirez et al[15] who found that 23% of patients with adolescent idiopathic scoliosis at initial time of presentation had back pain, and an additional 9% developed back pain during the period of observation.

In conclusion, although we cannot rule out missing an occult specific diagnosis, the patients were followed for an average of 3 years without the development of additional signs or symptoms to suggest the presence of a serious pathological condition. Our study suggests that history and physical examination with plain radiographs and an MRI when indicated should be the evaluation for back pain. MRI has supplanted bone scan as a screening tool, and bone scan is used to rule out metastatic disease or determine activity of a spondylolysis. This algorithmic approach provided a systematic methodology of selecting patients for further diagnostic studies. A child who has back pain in which a diagnosis cannot be firmly established based on history, physical examination, and plain radiographs should be further evaluated with MRI of the spine provided that he/she shows certain clinical markers, including constant pain, radicular pain, night pain, and/or abnormal neurological examination. This strategy should reduce costs, decrease patient /family anxiety, and avoid unnecessary radiation exposure.

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