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The Use of Bone Scan to Investigate Back Pain in Children and Adolescents

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Study conducted at The Hospital for Sick Children, Toronto, Ontario, Canada

Summary: Children with back pain frequently undergo detailed investigation because of the perception that a high percentage will have a treatable spinal condition. The purposes of this study was (i) to determine the percentage of children with disabling back pain presenting to our institution who had a diagnosis (i.e., to explain their back pain), (ii) to evaluate the clinical markers that should alert clinicians to underlying pathology, (iii) and to determine the prognosis of children with back pain and no specific diagnosis. This study was a retrospective analysis of consecutive children undergoing single-photon emission computed tomography for a primary complaint of back pain. Data collection included chart review, radiographic analysis, and clinical follow-up with the Roland and Morris scale for pain and disability. Two hundred and seventeen patients with an average age of 13 years (range, 2.7–17.7) were reviewed on average 4.4 years after presentation (range, 1.1–7.2 years). One hundred and seventy children (78.3%) had no specific diagnosis to explain their back pain, 15 children (6.9%) had spondylosis, 10 children (4.6%) had tumor, and the remaining 22 children (10.1%) had various diagnoses including infection, Scheuermann's kyphosis, herniated disc, kidney disease, facet arthritis, degenerative disc disease, congenital anomalies, and tethered cord. Factors associated with positive diagnoses were constant pain and male gender. Night pain, constant pain, and duration of symptoms <3 months were associated with the diagnosis of a tumor. Although the majority of children presenting with persistent back pain had no demonstrable cause, of 132 contactable patients 94 (71%) had persisting pain at the time of clinical follow-up. In conclusion, the majority of children with disabling back pain has no demonstrable cause and the majority will continue to have pain years after initial presentation. **Key Words:** Back pain—Child—Neoplasm—Radionucleotide imaging.

Children with spinal pathology present to orthopaedic surgeons for many reasons including back pain, scoliosis (7,11,20,23,24,26,28,32), paraparesis (1,5,6,22), and a foot deformity. Hensinger (17) and King (19) stated that back pain in children is an uncommon complaint and between 66 and 85% of these children will have a demonstrable and often treatable cause of their pain. The main limitation of prior studies is that they are prone to detection bias (13), i.e., patients with a positive diagnosis are more likely to require further treatment increasing their likelihood of being identified in a retrospective study, thereby increasing the percentage of patients with back pain with a positive diagnosis. Therefore, based on these prior studies, children with back pain frequently undergo extensive investigation because of the belief that organic pathology will be found in the majority of instances. Epidemiological studies, however, have reported that 11–33% of school age children complain of intermittent low back pain (3,12,15,25,31). Thus, back pain in childhood may be a common and possibly benign complaint with some children undergoing expensive and potentially unnecessary investigations.

The purposes of this study were (i) to determine the percentage of children with disabling back pain presenting to our institution who had a diagnosis (i.e., to explain their back pain), (ii) to evaluate the clinical markers that should alert clinicians to underlying pathology, and (iii) to determine the prognosis of children with back pain and no specific diagnosis.

METHODS

All children with back pain presenting to The Hospital for Sick Children between 1987 and 1992 without an obvious explanation for their pain on plain radiographs routinely received outpatient single-photon emission computed tomography (SPECT). Some patients had a

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positive finding on the radiographs, but SPECT was performed because of the uncertainty of whether the abnormality on the radiographs was the cause of the pain. We studied all patients younger than 18 years old presenting with a primary complaint of back pain who underwent a bone scan of the spine. Identifying patients by those who received a bone scan eliminates the risk of detection bias (13). All study patients were referred to The Hospital for Sick Children by another physician specifically because of their back pain. Patients were excluded from the study if the primary complaint was not back pain, pain was in the cervical region, evaluation occurred after an acute traumatic event, such as a motor vehicle accident, follow-up was <1 year, patients had had previous spinal surgery, or patients had known pre-existing malignancy or spinal metastases.

The following information was obtained from the medical records: age at presentation, gender, nature of the pain (patients stated the pain was constant or intermittent), night pain (present or absent), radiation of the pain (local back pain only or radicular pain), duration of symptoms before presentation (acute back pain was defined as <3 months duration), location of the pain (lumbar, thoracolumbar, or thoracic), details of the physical examination including neurologic examination (normal or abnormal where abnormal examination was defined as any sensory or motor abnormality including abdominal reflexes and asymmetry of reflexes), straight leg raising (positive or negative), hamstring tightness (present or absent; this finding was inconsistently reported in the medical records), and scoliosis (present or absent and severity).

Follow-up information was obtained both from the medical records and from personnel contact with the patients. A patient was said to have a "positive" diagnosis if (i) the chart indicated one of the imaging studies demonstrated pathology that was thought by the treating surgeon to explain the patient's symptoms or (ii) subsequent phone interview of these patients, performed by a research assistant, indicated a "positive" diagnosis had been made. Patients received a standardized interview by phone including the Roland and Morris Disability Questionnaire, a reliable and valid scale measuring spine-related pain and disability, as an outcome measure of clinical result (9,29). As part of the Roland and Morris scale, patients rated the severity of their pain in categories of no pain at all, little pain, moderate pain, quite bad pain, very bad pain, and pain that is almost unbearable. Patient characteristics were compared among three groups of patients: no diagnosis, positive diagnosis, and the subgroup of patients with a positive diagnosis in which the final diagnosis was neoplasm. The data were analyzed utilizing χ^2 test, Student's t test, and multiple linear regression analysis. A p value of ≤ 0.05 was considered statistically significant. Clinical usefulness of patient characteristics for detecting a positive diagnosis at any time throughout their clinical course was analyzed utilizing specificity, sensitivity, and positive and negative predictive values.

RESULTS

Diagnosis

Of the 453 patients who underwent SPECT of the spine from 1987 to 1992, 236 patients were excluded; known pre-existing malignancy or disease (159 patients), primary complaint not referable to the back (44 patients), acute traumatic events (19 patients), follow-up <1 year (nine patients), and cervical pain (five patients). For the remaining 217 patients, the average clinical follow-up was 4.4 years after presentation (range, 1.1–7.2 years). The average age at presentation of 13.2 years (range, 2.7–17.7 years); 127 were females and 90 were males. The average duration of the pain was 12.8 months (range, 0.5–108 months). Of the 217 patients, 170 (78.3%) had no diagnosis, 15 (6.9%) had spondylolysis, 10 (4.6%) had tumors, and the remaining 22 (10.1%) had various diagnoses including four with Scheuermann's disease, four with herniated discs, three with infection, two with kidney disease, two with facet arthritis, two with degenerative disc disease, two with leg-length discrepancies, two with congenital anomalies of the spine (one case of hypoplastic posterior elements of L5 and one case of congenital kyphosis), and one case of a tethered cord. For the 10 patients with tumors, two had osteoid osteoma, and the rest were single cases of neurofibroma, leptomeningeal medulloblastomas, astrocytoma, arterial venous malformation, schwannoma, eosinophilic granuloma, osteoblastoma, and non-Hodgkin's lymphoma.

The frequencies of positive findings according to different patient characteristics are shown in Tables 1 and 2. Overall a younger age at presentation was not associated with either a positive diagnosis or tumors. The average age for tumor patients was 11.5 versus 13.3 years for the other patients ($p = 0.20$). No specific age could be uti-

TABLE 1. *Patient characteristics at baseline and their relationship with a positive diagnosis*

	No. with any positive diagnosis (%)	p Value
Age		
<10 years	6/35 (17%)	0.48
>10 years	41/182 (23%)	
Male	28/90 (31%)	0.004
Female	19/127 (15%)	
Constant pain	29/87 (33%)	0.0007
Intermittent pain	18/130 (14%)	
Night pain	10/33 (30%)	0.19
No night pain	37/184 (20%)	
Radicular pain	14/44 (32%)	0.07
Back pain	33/173 (19%)	
Duration		
<3 months	18/67 (27%)	0.21
>3 months	29/150 (19%)	
Thoracic pain	12/58 (21%)	0.83
Lumbar pain	35/159 (22%)	
Abnormal neuro	5/14 (36%)	0.39
Normal neuro	42/203 (21%)	
Scoliosis	6/54 (11%)	0.04
No scoliosis	41/163 (25%)	

TABLE 2. *Patient characteristics at baseline and their relationship with a diagnosis of tumor*

	No. with any positive diagnosis (%)	*p* Value
Age		
<10 years	3/35 (8.6%)	0.20
>10 years	7/182 (3.8%)	
Male	5/90 (5.6%)	0.58
Female	5/127 (3.9%)	
Constant pain	9/87 (10%)	0.001
Intermittent pain	1/130 (0.8%)	
Night pain	7/33 (21%)	0.000001
No night pain	3/184 (1.6%)	
Radicular pain	4/44 (9.1%)	0.10
Back pain	6/173 (3.4%)	
Duration		
<3 months	6/67 (8.9%)	0.04
>3 months	4/150 (2.7%)	
Thoracic pain	4/58 (6.9%)	0.33
Lumbar pain	6/159 (3.8%)	
Abnormal neuro	2/14 (14%)	0.07
Normal neuro	8/203 (3.9%)	
Scoliosis	3/54 (5.6%)	0.70
No scoliosis	7/163 (4.3%)	

Neuro, neurologic examination.

lized as a clinical marker for tumor. For example, arbitrarily using age 10 years as a cut-off had low sensitivity and specificity for predicting any positive diagnosis or tumor (Tables 3 and 4). Male gender was a significant predictor for a positive diagnosis ($p = 0.004$) but not a predictor for tumor ($p = 0.58$).

Pain profile

Of the 87 patients complaining of constant pain, 29 had a positive diagnosis made. Of the 129 patients complaining of intermittent pain, 18 patients had a positive diagnosis but only one of these 18 patients had a diagnosis of a tumor. Of the 10 patients diagnosed with tumors, nine had constant pain and the other patient with an osteoid osteoma had night pain. The presence of constant pain was statistically significant for both positive diagnoses ($p = 0.0007$) and tumor ($p = 0.001$) (Tables 1 and 2).

Night pain was a complaint in seven of 10 patients diagnosed with tumors ($p = 0.000001$); however, it was not a significant factor in predicting an overall positive diagnosis ($p = 0.19$). Ten of 47 patients with a positive diagnosis had night pain and seven of these patients were diagnosed with tumors.

TABLE 3. *The usefulness of patient characteristics in predicting a positive diagnosis: any positive diagnoses*

	Sensitivity	Specificity	Positive predictive value	Negative predictive value
Age <10	0.15	0.83	0.20	0.78
Male gender	0.60	0.63	0.31	0.84
Constant pain	0.64	0.65	0.34	0.87
Night pain	0.21	0.86	0.30	0.80
Radicular pain	0.30	0.83	0.33	0.81
Duration <3 mo	0.38	0.71	0.27	0.80
Thoracic pain	0.25	0.73	0.25	0.78
Abnormal neuro	0.11	0.94	0.36	0.79
Absence of scoliosis	0.87	0.28	0.25	0.89

Abnormal neuro, abnormal neurologic examination.

TABLE 4. *The usefulness of patient characteristics in predicting a diagnosis of tumor: positive tumor diagnoses*

	Sensitivity	Specificity	Positive predictive value	Negative predictive value
Age <10	0.30	0.85	0.09	0.96
Male gender	0.50	0.59	0.05	0.96
Constant pain	0.90	0.62	0.10	0.99
Night pain	0.70	0.87	0.21	0.98
Radicular pain	0.40	0.83	0.11	0.95
Duration <3 months	0.60	0.70	0.09	0.97
Thoracic pain	0.40	0.74	0.07	0.96
Abnormal neuro	0.20	0.94	0.14	0.96
Absence of scoliosis	0.70	0.32	0.04	0.94

Abnormal neuro, abnormal neurologic examination.

Radicular symptoms were noted in 44 patients and 14 of these patients had a positive diagnosis with four patients having a tumor diagnosed. Radicular symptoms showed trends but were not significantly associated with either a positive diagnosis ($p = 0.07$) or with tumors ($p = 0.10$) (Tables 1 and 2).

The duration of symptoms was 6.5 months for the tumor patients and 13 months for the other patients ($p = 0.21$). In patients presenting with <3 months' duration of symptoms, there was a statistically higher incidence of tumors ($p = 0.04$).

The primary region of pain was lumbar in 159 patients (73.3%), thoracic in 36 patients (16.6%), and thoracolumbar in 22 patients (10.1%). The region of pain was not significantly associated with either a positive diagnosis ($p = 0.83$) or of tumor ($p = 0.33$) (Tables 1 and 2).

Physical examination

The neurologic examination was noted to be abnormal in 14 patients. Six patients had purely sensory findings, two had purely motor findings and one patient had an absent ankle reflex. The remaining five patients had mixed motor, sensory, and reflex findings. Five of these 14 patients had a diagnosis made for their back pain. Two of these patients had tumors, one benign neurofibroma and the other a leptomeningeal medulloblastoma, and both of these patients had motor weakness and sensory deficit. An abnormal neurologic exam was not statistically predictive for a positive diagnosis ($p = 0.39$) and only showed a trend for a diagnosis of tumor ($p = 0.07$) (Tables 1 and 2).

Scoliosis was diagnosed in 54 patients with an average Cobb angle of 15° (range, 10–50°). Twenty patients had a curve of >20°. Patients without scoliosis, contrary to our expectation, had a statistically significant higher rate of positive diagnosis ($p = 0.04$).

Chart documentation of hamstring tightness and straight leg raising was inconsistent. Hamstring tightness was documented in only four patients, one of whom had a diagnosis of spondylolysis made at a later date. The presence of a positive ipsilateral straight leg raise was documented in only six patients, one of whom had a diagnosis of a herniated disc made at a later date.

In summary, the following factors were more likely to be associated with any positive diagnosis: constant pain ($p = 0.0007$) and male gender ($p = 0.004$). The factors not associated with positive diagnoses in this group of patients was the age at presentation, presence of night pain, duration of symptoms, an abnormal neurologic examination, and the location of the pain. Isolating tumor from all positive diagnoses, the presence of night pain ($p = 0.000001$), the constant nature of the symptoms ($p = 0.001$), and a duration of symptoms of <3 months ($p = 0.04$) were significant positive predictors. Nine of 10 patients diagnosed with tumors had constant pain and the other patient with an osteoid osteoma had night pain. The factors not associated with diagnosis of tumor were age at presentation, gender, presence of scoliosis, an abnormal neurologic examination, radicular symptoms, and the location of the pain. None of the patient characteristics had high values of sensitivity and specificity for predicting the presence of a positive diagnosis (Table 3). For the subset of patients with tumors, only night pain had reasonable sensitivity and specificity (Table 4). However, if only patients with either constant pain and/or radicular symptoms had received extensive investigations (other than plain radiographs), only one patient with a positive diagnosis (a patient with a herniated disc) in this series would have been missed. Thus, a selective strategy of investigating patients with these characteristics would have reduced the number of patients receiving further investigation from all 217 to 119.

Diagnostic imaging

All patients underwent plain radiographs and SPECT. Overall, SPECT demonstrated a sensitivity of 0.57, a specificity of 0.89, a positive predictive value of 0.59, and a negative predictive value of 0.88. In the 47 patients who were given a diagnosis, only nine patients with normal radiographs had the diagnosis made on bone scan, 24 patients had the diagnosis based on bone scan and abnormal plain radiographs (in whom before the bone scan, the abnormality on the radiograph was thought to be an unlikely explanation for their pain), 14 patients had normal radiographs and bone scans in whom the diagnosis was made based on other investigations (nine of 31 patients who had magnetic resonance imaging (MRI) and four of 32 patients who had computed tomography [CT]). There were 13 instances of nonspecific changes on SPECT and three on plain films in which no final diagnosis was made. SPECT was serendipitously positive for hydronephrosis in one patient.

Plain radiographs demonstrated a spondylolysis in 10 of 15 cases with the final diagnosis of spondylolysis. SPECT was positive in 12 of 15 cases of spondylolysis and the remaining three cases with a negative SPECT had a positive radiograph. There were two additional cases with a final diagnosis of "presumed" spondylolysis by symptoms that were both negative by plain radiograph and SPECT. Intraosseous spinal tumors were positive on both SPECT and plain radiographs in three cases. One case of an osteoid osteoma was detected on SPECT in the presence of a negative plain film. One case of eosinophilic granuloma was evident on plain film with a negative SPECT.

MRI was used in 31 patients (14%). It was diagnostic in nine cases in which the standard radiographs were negative. In the five cases of extraosseous spinal cord tumors, the MRI was positive in the presence of negative plain films and SPECT. Three of these patients had normal neurologic examinations including the one patient with an astrocytoma.

CT and CT myelography were used in 31 patients and were diagnostic in four patients. CT was diagnostic in one case of a negative MRI in a case of spondylolysis. CT myelography did not demonstrate any advantage over MRI in this group of patients.

Clinical outcome

Of the 170 patients with no diagnosis, 132 (78%) were contacted by phone. In 12 cases, the parent insisted on responding for the child. In none of the patients had a subsequent diagnosis been made and no further testing had been done. Thirty-eight patients (29%) reported little or no pain, 73 (55%) reported moderate pain, and 21 (16%) patients reported quite bad to unbearable pain at the time of clinical follow-up. Thirty-eight (29%) patients complained of night pain. Forty-four (33%) patients complained of pain that occurred every day, and 21 (16%) patients complained of the pain severely limiting their activities of daily living. Results of the Roland and Morris disability score (no disability equals 0 and maximum disability equals 24) demonstrated 42 (32%) patients with scores from 0 to 3, 39 (30%) patients had scores from 4 to 7, and 51 (39%) patients had scores of ≥8. There was no correlation between age or gender on outcome.

DISCUSSION

Back pain is quite common in children particularly during adolescence (3,12,15,25,31). Salminen found that 18% of 14-year-old children reported significant back pain in the past year. Other authors confirmed an incidence of back pain between 11 and 33% in school-age children. Despite the high prevalence of pediatric back pain, Turner et al. (34) stated that it accounted for only 2% of all nontrauma pediatric referrals.

The symptom of back pain in childhood has been regarded by a number of authors to require detailed investigation that they have believed will often lead to a diagnosis of organic pathology (10,17,19,30,34). Bone scan is frequently recommended as the preferred test after radiographs have been performed (18). Little notice has been given in the orthopedic literature regarding the nature and prognosis of back pain in childhood to substantiate the statement that most children will have a definable and treatable cause for their back pain. Many children undergo studies with the obvious morbidity and cost incurred (16,21). Turner et al. (34) reported that in their pediatric patient population, as many as 50% of patients presenting with back pain had “serious spinal disease.” They found that clinical findings were unreliable and that plain radiographs were the best diagnostic test. CT myelography was the most sensitive test in that series, which predated the use of MRI. Hensinger (17) and similarly King (19) found that in their patient populations, as many as 85% of children presenting with back pain had an objective and often treatable cause. Hensinger stated that often the diagnosis was not obvious and that several visits were required.

We studied a pediatric patient population with back pain in whom a diagnosis was not readily apparent. Thus, the patients included in our study would have excluded many of those children with causes obvious from their history or radiographs such as trauma or spondylolisthesis. This may partially explain the lower rate of positive diagnoses in this study compared with prior studies. However, this group of patients was of greatest interest to us because this is the population that will often undergo detailed investigation with numerous imaging studies including bone scan. SPECT has been routinely done at The Hospital for Sick Children in patients with back pain and no obvious diagnosis. As a tertiary care referral center, our institution would tend to have a bias for children with more severe pain and with higher prevalence of positive diagnoses. Thus, because this study probably excludes those patients with symptoms not severe or prolonged enough to warrant a referral and subsequent bone scan, the percentage of patients in this series with a positive diagnosis is probably higher than for those patients seen in community practices.

We found that 78% of children in this study had no discernible cause for their symptoms. The use of clinical markers such as constant pain and night pain should alert the clinician to possible underlying pathology. No patient had a spinal neoplasm without either constant and/or night pain. This emphasizes the importance of eliciting the severity of the pain when evaluating a child with back pain. Although duration of symptoms was statistically lower for the positive diagnosis group of patients, it is not clinically useful because no absolute number of years could be used to differentiate the positive from the negative group. The abnormal neurologic examination showed only a statistical trend associated with underlying pathology that may be owing to the small number of tumors in this series. Many of the patients had only subjective mild sensory abnormalities or asymmetry of their reflexes, which probably explains why these children had “neurologic abnormalities” but no diagnosis was found. Certainly the presence of gross neurologic deficit, particularly motor deficits, should alert the clinician to perform further tests. Finally, the presence of scoliosis in this patient population was associated less often with underlying pathology than if the patient had no scoliosis at all. This finding is consistent with research that demonstrates that 32% of 244 patients with scoliosis had back pain (27). Therefore, typical scoliosis in itself (excluding those with neurologic abnormalities and atypical curve patterns) may be a cause for back pain (27).

The problem of performing excessive studies on children is more than simply the cost, radiation exposure, and patient/family anxiety. Diagnostic tests can give misleading results that can then proceed to unwarranted surgical procedures. For instance, one 10-year-old female patient in our study had persistent low back pain for 6 months. Plain films demonstrated a questionable irregularity at the spinous process at the L4 level. SPECT demonstrated increased activity at that level and a CT scan demonstrated a questionable irregularity. A presumptive diagnosis of osteoid osteoma was made and the patient had resection of the spinous process. The pathology demonstrated mildly reactive bone, no osteoid osteoma, and the patients pain persists unchanged for nearly 7 years after resection. The problem is that not all radiographic findings will be the explanation for the clinical symptoms of back pain. This phenomenon has been documented in adults and is probably similar in children. For example, Baker and McHollick (2) and Fredrickson et al. (14) found a 5% incidence of spondylolysis by the age of 6, and all these children were asymptomatic. Furthermore, Tertti et al. (33) found that MRI detected disc “abnormalities” in 26% of asymptomatic children. Thus, many patients may have their back pain falsely attributed to an anatomic variation. This confuses the confirmation of a definitive diagnosis and may actually increase the yield of positive diagnoses in studies regarding back pain in children. Several of the patients in this series may have had a “positive” diagnosis, such as limb-length discrepancy or congenital kyphosis, which might actually not be the cause of their back pain.

SPECT made the diagnosis in few patients with back pain in this series. The bone scan was positive in only 22% of patients and had low sensitivity and specificity. The main use for bone scan may be in evaluating those patients with spondylolysis and spondylolisthesis where previous studies have shown it to be both sensitive and specific (4). However, in evaluating the possibility of serious underlying pathology, it falls short and adds little to the information gained from plain films. Furthermore, five patients with both normal plain films and SPECT had spinal neoplasm. This occurred in three children without radicular symptoms and with a normal neurologic examination. Therefore, the clinician cannot be assured by a negative bone scan that there is no underlying spinal pathology. MRI has been shown to be useful in the evaluation of the pediatric spine for various intra- and extra-osseous abnormalities (8), and in those patients with constant pain, radicular symptoms, or night pain it may be the preferred investigation. The patients in this study inconsistently received MRI and therefore we are unable to state whether this should be part of the routine assessment of children with back pain. Future research will be necessary to define the role for this investigation including whether it should be the first diagnostic test in those children with normal radiographs.

Many studies documented the high prevalence of paediatric back pain, but relatively little is known about the natural history. We demonstrated that approximately 71% of patients continued to have significant back pain affecting their lives, with 33% reporting daily pain. This suggests that, similar to adults, back pain constitutes a significant morbidity in children. Further research is necessary to evaluate the etiologic factors for ongoing back pain, such as psychological factors, and strategies need to be tested to reduce disability for adolescents with chronic back pain.

In conclusion, of all children in whom the diagnosis was not readily evident on clinical examination or plain film, 78% had no definitive diagnosis. The clinician should use the clinical markers such as constant pain and night pain as the best markers of serious underlying pathology. SPECT should be utilized in the evaluation of symptoms consistent with spondylolysis with negative plain films or to determine whether the lysis is the probable cause of the pain, but provides little other useful diagnostic information. MRI of the spine may be a more useful investigation but requires further evaluation. Finally, a significant number of children with idiopathic back pain will proceed to chronic pain that interferes with their daily activities and significantly affects their lives. Further study is needed to determine whether early intervention in this group of patients will alter the natural history of their pain.

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