Chapter 5

Clinical feasibility of two-step streptavidin/111In-biotin scintigraphy in patients with suspected vertebral osteomyelitis

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**Abstract.** *Purpose.* Streptavidin accumulates at sites of inflammation and infection as a result of increased capillary permeability. In addition to being utilised by bacteria for their own growth, biotin forms a stable, high affinity non-covalent complex with avidin. The objective of this investigation was to determine the diagnostic performance of two-step streptavidin/$^{111}$In-biotin imaging for evaluating patients with suspected vertebral osteomyelitis. *Methods.* We evaluated 55 consecutive patients with suspected vertebral osteomyelitis (34 women and 21 men aged 27–86 years), within 2 weeks after the onset of clinical symptoms. Thirty-two of the patients underwent magnetic resonance imaging (MRI) and 24, computed tomography (CT). DTPA-conjugated biotin was radiolabelled by incubating 500 ug of DTPA-biotin with 111 MBq of $^{111}$In-chloride. Two-step scintigraphy was performed by first infusing 3 mg streptavidin intravenously, followed 4 h later by $^{111}$In-biotin. Imaging was begun 60 min later. *Results.* Streptavidin/$^{111}$In-biotin scintigraphy was positive in 32/34 patients with spinal infection (94.12% sensitivity). The study was negative in 19/21 patients without infection (95.24% specificity). The corresponding results for MRI and CT were 54.17% and 35.29% (sensitivity), and 75% and 57.14% (specificity), respectively. All statistical parameters of diagnostic performance (Youden’s J index, kappa measure of agreement with correct classification, accuracy, sensitivity, specificity, positive likelihood and negative likelihood) were clearly better for streptavidin/$^{111}$In-biotin scintigraphy than for either MRI or CT. *Conclusion.* Streptavidin/$^{111}$In-biotin scintigraphy is highly sensitive and specific for detecting vertebral osteomyelitis in the first 2 weeks after the onset of clinical symptoms, and is potentially very useful for guiding clinical decisions on instituting appropriate therapy.

*Keywords:* Vertebral osteomyelitis – Two-step streptavidin/$^{111}$In-biotin scintigraphy – Imaging modalities – Diagnostic performance

**Introduction**

Vertebral osteomyelitis is an infectious process that affects primarily the intervertebral disc and the adjacent osseous tissue. Although the bone is very resistant to infections, once micro-organisms (mostly *S. aureus* and *S. epidermidis*) have invaded the bone, either haematogenously or via direct extension, they are not easily eradicated. In immunodepressed and elderly patients such infections are life threatening, and early diagnosis and treatment are of the utmost importance. Blood cultures are often negative, thus emphasising the need for early diagnosis. Computed tomography (CT) [1] and magnetic resonance imaging (MRI) [2–4] are generally non-diagnostic in the first 2 weeks of the disease [5], which, in cases of delayed diagnosis and/or improper treatment, may have serious consequences,
including death (11%) or residual disability [6]. Bone scintigraphy has been widely used for examination of patients suspected of having osteomyelitis. The bone scan typically becomes positive within 24–48 h after the onset of symptoms, and multiphase scanning may increase its specificity [7, 8]. However, the structural complexity of the spine and the frequent presence of degenerative/arthritic changes may hamper the interpretation of bone scintigraphy, so that other radionuclide imaging methods are often necessary. Most of the radiopharmaceuticals proposed to complement the diagnostic value of the bone scan in patients with suspected vertebral osteomyelitis are either non-specific (radiolabelled nanocolloid, non-specific human IgG, antigranulocyte antibodies) [9–13] or not widely available (chemotactic and antimicrobial peptides, [18F]FDG) [14–20]. Radiolabelled autologous leucocyte imaging, useful for diagnosing osteomyelitis of the appendicular skeleton [21, 22], is of little value in patients with suspected vertebral osteomyelitis [23–31]. Although 67Ga-citrate scintigraphy is very sensitive in vertebral osteomyelitis, it entails a non-negligible radiation burden and requires an interval of up to 72 h between injection and imaging. Because of its poor resolution, 67Ga-citrate scintigraphy is usually combined with a conventional bone scan [32, 33]. These considerations motivated us to investigate the diagnostic performance of the streptavidin/111In-biotin two-step protocol, which has been found to be a promising approach for imaging infection in both animal [34] and human [35–37] studies. Streptavidin (a 65-kDa protein) is administered and allowed to accumulate at sites of infection, presumably as a result of locally increased vascularity and vascular permeability. 111In-biotin, which is administered 4 h later, accumulates at the inflamed/infected focus because of its extremely high affinity for streptavidin (K_d=10−15). Any 111In-biotin not bound to streptavidin is excreted by the kidneys, while any streptavidin/111In-biotin complex not bound at the site of infection is excreted by the liver. It is unlikely that the accumulation of streptavidin is specific for bacteria, which instead do possess some avidity for biotin per se; in fact, pyruvate carboxylase, a key metabolic pathway for producing energy by ATP cleavage, is biotin dependent [38]. It is difficult, however, to discriminate the fraction of biotin that concentrates at sites of disease because of its binding to localised streptavidin from the fraction that localises because of direct utilisation by growing bacteria. While our previous experience with avidin scintigraphy or streptavidin/111In-biotin scintigraphy [37] included patients with suspected osteomyelitis affecting a variety of skeletal sites, the present study explored the utility of this technique for detection of early vertebral osteomyelitis in a large consecutive series of patients. 

Materials and methods

Patients
Between 1995 and 2001, 55 consecutive patients, suspected of having spinal osteomyelitis, underwent streptavidin/\(^{111}\)In-biotin imaging within 2 weeks after the onset of back pain, fever, neurological deficits, increased erythrocyte sedimentation rate and/or positive blood cultures. The patients comprised 34 women and 21 men, and had a median age of 55.5 years (range 27–86 years). Fifteen patients had undergone neurological spinal surgery because of a herniated intervertebral disc between 6 and 8 weeks before the onset of symptoms. Suspected sites of infection were lumbar spine (n=33), L5–S1 (n=9), thoracic spine (n=7), sacro-iliac joints (n=5) and cervical spine (n=1). All patients underwent physical examination, routine blood tests, conventional X-ray, MRI and/or CT and streptavidin/\(^{111}\)In-biotin scintigraphy within 2 weeks after the onset of clinical signs and symptoms. In particular, 14 patients were evaluated by MRI only and six by CT only, while 18 patients underwent both CT and MRI. Twenty-four of the 32 patients evaluated by MRI and 17 of the 24 evaluated by CT were eventually classified as having vertebral osteomyelitis. The scintigraphic study was performed before (n=17) or during (n=38) antibiotic therapy and prior to any surgical procedures planned for the near future. Infection was considered present when tissue cultures of samples obtained via biopsy or surgery grew bacteria (16 patients) or when a purulent mass was observed at surgery (seven patients). If no tissue samples were obtained or no operation took place, infection was considered present after a positive response only to antibiotic therapy until the symptoms disappeared (11 patients), or absent on the basis of clinical follow-up for at least 12 months (21 patients). Full recovery from vertebral osteomyelitis, or follow-up in patients without infection, was based on a combination of clinical and blood chemistry [5, 6, 39]. Thus, in all patients the disease status was defined independently from the scintigraphic study and other imaging modalities. This study was approved by the Internal Review Board for medical ethics of the University Hospital of Pisa, and all patients were enrolled after giving their written informed consent. Biotin labelling Diethylene triamine penta-acetic acid (DTPA)-conjugated biotin \([\text{\(\text{\(\Omega\)}-bis(biocytna-mide)\)}}\], purchased from Sigma (St Louis, Mo., USA), was diluted in sterile acetate buffer 0.2 \(M\), pH 5.5. Aliquots containing 500 \(g/ml\) of DTPA-biotin were then prepared and stored at 4°C for subsequent labelling with \(^{111}\)In. Just prior to administration, a 500 \(g\) DTPA-biotin aliquot and \(^{111}\)In-chloride (111 MBq) were mixed at room temperature for 15 min, and labelling efficiency was assessed by ascending chromatography as described previously [37]; labelling efficiency was always \(\geq 98\%\), and the preparation therefore required no purification. Streptavidin/\(^{111}\)In-biotin protocol Streptavidin purified from fermentation filtrates of Streptomyces avidinii cultures was purchased from Società Prodotti Antibiotici (S.P.A., Milan, Italy) as sterile, pyrogen-free aqueous solution with a concentration of 5 mg/ml. The protocol employed in this study included
premedication of the patients with prometazine (50 mg i.m.) 30 min before infusion of i.v. 3 mg of streptavidin diluted in 10 ml of physiological saline solution, over 60 s. Such premedication was adopted in order to prevent possible adverse reactions to i.v. infusion of a heterologous protein. All patients were closely monitored for 30 min following this administration. Four hours later, $^{111}$In-DTPA-biotin was injected i.v. as a single bolus (about 111 MBq linked to 500 µg as described above). Patients were imaged between 60 and 120 min after the injection of $^{111}$In-biotin. Planar anterior and posterior images of sites of suspected infection were acquired using a digital large field of view gamma camera (Camstar, General Electric Corp, Milwaukee, WI, USA), equipped with a medium-energy collimator, using 20% energy windows centered around the 173 and 247 keV energy peaks of $^{111}$In (matrix 128x128 pixels, usually with a 1.33 electronic zoom factor). Images were acquired for three million counts each; the kidneys, bladder and liver were shielded when necessary. Lateral views were obtained as needed.

**Image interpretation**

All scintigraphic images of the spine were independently interpreted by two readers who had no knowledge of the results of other tests or of the final diagnosis, but who were familiar with the pattern of physiological radioactivity distribution in a typical streptavidin/$^{111}$In-biotin study. This is characterised by quite homogeneous diffusion in the soft tissues and fast renal clearance, with ensuing preferential accumulation in the kidneys and urinary bladder. Some tracer accumulation is also observed in the liver, without, however, appreciable hepatobiliary clearance. Uptake in the bone marrow is faint and barely discernible from background radioactivity. The streptavidin/$^{111}$In-biotin scan was considered positive when distinct focal uptake of radioactivity, regardless of intensity, was observed in the spine. Criteria for diagnosing vertebral osteomyelitis by MRI were: (a) low signal intensity on T1-weighted images (turning to high signal intensity on T2-weighted images) adjacent to the endplates delimiting the affected site (intervertebral disc or vertebral body), and (b) on T1-weighted images, gadolinium-enhanced signal of the endplates delimiting the affected site with diffuse enhancement of the intervertebral disc. The criteria for CT were: (a) multiple osteolytic lesions of the vertebral bodies, (b) phlogistic reactions of the perivertebral soft tissues with obliteration of the loosely woven adipose tissue and (c) oedematous or purulent effusion in the peridural space.

**Statistical analysis**

Statistical analysis included a series of tests designed to assess the reliability of diagnostic examinations [40]. The Youden’s Index (J$^*$), was employed to estimate the overall diagnostic performance of streptavidin/$^{111}$In-biotin scintigraphy. The Youden’s J$^*$ index is based on the observed rates of false positive and false negative results,
and estimates the probability of correct classification of a diagnostic test: 0 denotes a test with no diagnostic value, while 1 denotes a test with maximum diagnostic accuracy. The diagnostic performance of streptavidin/\(^{111}\text{In}\)-biotin scintigraphy was also evaluated in terms of accuracy, sensitivity, specificity, positive predictive value, positive likelihood ratio, negative predictive value and negative likelihood ratio. The positive likelihood ratio relates the probability of a test being positive in a person with the disease to the probability of the test being positive in a person without the disease. As such, it indicates how much more likely it is to obtain a positive test in the group with the disease versus the group without the disease. Conversely, the negative likelihood ratio indicates how much more likely it is to obtain a negative test in the group without the disease versus the group with the disease. As a consequence, while the maximum numerical value of the positive or negative predictive value is 1 (or 100%), the numerical value of the positive or negative likelihood ratio can be much higher than 1. The “kappa” value was also employed, to assess agreement of the diagnostic classification as achieved by the streptavidin/\(^{111}\text{In}\)-biotin scan with the final classification of patients as with or without vertebral osteomyelitis, independently from the results of imaging. Statistical significance in the difference of patients’ classification based on streptavidin/\(^{111}\text{In}\)-biotin scintigraphy in terms of overall accuracy vs the other imaging modalities employed (MR and CT) was assessed by the McNemar’s test, which allows to test the equality for proportions of binary response rates (affected or non-affected). The StatXact software was used for all statistical computations (Version 4).

**Results**

There were 34 cases of spinal osteomyelitis among the 55 patients studied: one cervical, three thoracic, 23 lumbar, three lumbosacral, and four sacro-iliac joints. Thirteen of these 34 patients had recently undergone neurological spinal surgery. Among the 21 patients without spinal osteomyelitis, two had recently undergone neurological spine surgery and one was later diagnosed as having a metastatic spine lesion causing a compression fracture. In all patients except the one with metastatic disease, symptoms disappeared after a combination of therapy with non-steroid anti-inflammatory drugs, bed rest and lumbosacral brace. As previously reported for scintigraphic studies based on a similar two-step pretargeting approach [36, 37], no early or delayed adverse effects of any type occurred following i.v. injection of streptavidin in patients undergoing the procedure. Table 1 displays the results obtained with the various imaging modalities (not all procedures were employed in all patients). In 32/34 patients with spinal osteomyelitis, the streptavidin/\(^{111}\text{In}\)-biotin scanning demonstrated markedly increased accumulation of radioactivity at the infected site (94.12% sensitivity, Fig. 1).
Table 1. Results of streptavidin/\(^{111}\)In-biotin initial scanning (n=55) and of other imaging modalities in patients in whom vertebral osteomyelitis was strongly suspected

<table>
<thead>
<tr>
<th>Imaging results</th>
<th>(\text{SA/}^{111}\text{In-B (n=55)})</th>
<th>MRI (n=32)</th>
<th>CT (n=24)</th>
</tr>
</thead>
<tbody>
<tr>
<td>True positives</td>
<td>32</td>
<td>13</td>
<td>6</td>
</tr>
<tr>
<td>False positives</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>True negatives</td>
<td>20</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>False negative</td>
<td>2</td>
<td>11</td>
<td>11</td>
</tr>
</tbody>
</table>

\(\text{SA/}^{111}\text{In-B, Streptavidin/}^{111}\text{In-biotin scintigraphy} \)

Table 2. Results of statistical analysis on the diagnostic performance of streptavidin/\(^{111}\)In-biotin scintigraphy, MRI and CT (95% confidential intervals are shown in parentheses, when applicable). \(\text{SA/}^{111}\text{In-B, streptavidin/}^{111}\text{In-biotin scintigraphy; PPV, positive predictive value; NPV, negative predictive value} \)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>(\text{SA/}^{111}\text{In-B} )</th>
<th>MRI</th>
<th>CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yeouden's (J)</td>
<td>0.8940 (0.773–1.014)</td>
<td>0.2920 (–0.069–0.652)</td>
<td>–0.0760 (0.507–0.256)</td>
</tr>
<tr>
<td>Kappa</td>
<td>0.8850 (0.621–1.150)</td>
<td>0.2120 (–0.078–0.503)</td>
<td>–0.0570 (0.376–0.262)</td>
</tr>
<tr>
<td>Accuracy</td>
<td>0.9455 (0.885–1.005)</td>
<td>0.5938 (0.434–0.764)</td>
<td>0.4167 (0.219–0.614)</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>0.9412 (0.862–1.020)</td>
<td>0.5417 (0.342–0.741)</td>
<td>0.3529 (0.126–0.580)</td>
</tr>
<tr>
<td>Specificity</td>
<td>0.9524 (0.861–1.043)</td>
<td>0.7500 (0.450–1.050)</td>
<td>0.5714 (0.205–0.838)</td>
</tr>
<tr>
<td>PPV</td>
<td>0.967</td>
<td>0.8667</td>
<td>0.6667</td>
</tr>
<tr>
<td>NPV</td>
<td>0.9061</td>
<td>0.3529</td>
<td>0.2667</td>
</tr>
<tr>
<td>Positive likelihood</td>
<td>19.7650 (2.913–134.089)</td>
<td>2.1670 (0.617–7.603)</td>
<td>0.8240 (0.282–2.402)</td>
</tr>
<tr>
<td>Negative likelihood</td>
<td>16.1906 (2.913–134.089)</td>
<td>1.6360 (0.506–2.955)</td>
<td>0.8830 (0.425–1.835)</td>
</tr>
</tbody>
</table>

The procedure was false negative in two patients, both of whom had spinal tuberculosis. In 21/22 patients without vertebral infection, streptavidin/\(^{111}\)In-biotin scanning was true negative (Fig. 2). The procedure was false positive in only one patient, who had a metastatic spine lesion (from a previously unknown lung cancer) (95.24% specificity). Consistent with what has been reported in the literature [5, 6], MRI and CT exhibited poor sensitivity for the detection of early vertebral osteomyelitis (54.17% and 35.29%, respectively). Ten of the 11 cases of spinal osteomyelitis that were false negative on MRI were detected with streptavidin/\(^{111}\)In-biotin scintigraphy. One case of spinal osteomyelitis which was false negative on streptavidin/\(^{111}\)In-biotin scintigraphy was correctly diagnosed on MRI. Ten of the 11 cases of spinal osteomyelitis that were false negative on CT were true positive on streptavidin/\(^{111}\)In-biotin scintigraphy, while the 11th patient was also false negative on the streptavidin/\(^{111}\)In-biotin scan. The results of statistical analysis on the diagnostic performance of streptavidin/\(^{111}\)In-biotin scintigraphy are reported in Table
2, which also shows, for the purpose of comparison, the corresponding statistical parameters for CT and MRI. Streptavidin/\(^{111}\)In-biotin scintigraphy was characterised by clearly higher values in all statistical parameters than either MRI or CT, both of which had a very low negative predictive value. The positive and negative likelihood ratios of streptavidin/\(^{111}\)In-biotin scintigraphy were about nine-fold and 18- to 24-fold higher than the corresponding values of MRI and CT, respectively. As a consequence, the kappa value of streptavidin/\(^{111}\)In-biotin scintigraphy (0.885) indicated excellent agreement with the final classification of patients, whereas both MRI (0.212) and CT (−0.057) demonstrated very weak correlations with final diagnoses. The McNemar test showed that the overall accuracy of the streptavidin/\(^{111}\)In-biotin scan in classifying patients as having or not having vertebral osteomyelitis was significantly higher than that of CT (two-sided \(p=0.0325\)), while it was at borderline statistical significance versus MRI (two-sided \(p=0.0522\)).

**Discussion**

Our data indicate that scintigraphic imaging using streptavidin as a pretargeting agent and \(^{111}\)In-biotin as the radiotracer is very sensitive for detecting spinal osteomyelitis within the first 2 weeks after the onset of clinical symptoms. This is an important observation, considering that conventional radiology is most often negative in the first 4–5 weeks after the onset of clinical signs [41]. CT is more reliable, but evidence of osteomyelitis is only obtained when morphological changes such as cortical destruction and/or periosteal proliferation can be observed, or when soft tissue abscesses are visualised [42]. MRI has the advantage of an excellent resolution of soft tissue versus bone. Although MRI has excellent sensitivity and specificity for osteomyelitis in general, widely discrepant values have been reported for vertebral osteomyelitis in the early phase of this disease [5, 6, 42, 43]. Later in the disease evolution, the interface between the vertebral body and the disc is no longer discernible, a definite indication of vertebral osteomyelitis. At this stage, the sensitivity of MRI is high; however, treatment should be instituted before this stage is reached. Considering that destructive changes are absent or minimal at the early stage of disease, it is not surprising that in our study streptavidin/\(^{111}\)In-biotin scintigraphy compared favourably with MRI and CT. It should also be pointed out that antibiotic therapy does not seem to affect the diagnostic performance of streptavidin/\(^{111}\)In-biotin scintigraphy. Furthermore, both CT and MRI only allow the regional visualisation of the body, whereas an infectious process may in fact be widespread. Multifocal sites of infection were observed in two of our patients, one of whom exhibited extensive involvement of the cervical spine from C3 to C5; in the second patient the main infection site was located in the lumbar spine (body of L3), but clinically unrecognised infection was also present at L5–S1. In this regard, scintigraphy is still the method of choice for whole-body evaluation, provided an
adequate radiopharmaceutical is employed. Efforts have been undertaken to
develop nuclear medicine methods that can differentiate sterile inflammation from
bacterial infection. Clearly, this possibility would be of considerable help in various
disorders, including suspected (bacterial) vertebral osteomyelitis. How far streptavidin/$^{111}$In-biotin scanning contributes to an increased disease specificity in
this respect remains uncertain on the basis of the results obtained in the present
study, although the high proportion of true negative (21/22) versus the low
proportion of false positive streptavidin/$^{111}$In-biotin scans (1/22) suggests a certain
specificity for bacterial infections. The only false positive result observed with
streptavidin/$^{111}$In-biotin scintigraphy corresponded to the site of a spinal malignancy.
We speculate that in this case there was grossly altered vascular permeability at the
site where bone biopsy showed a metastatic spine lesion. The two false negative
streptavidin/$^{111}$In-biotin studies deserve some consideration, as both patients had
 tuberculous spinal osteomyelitis. Tuberculous infection is typically chronic in nature,
polymorphonuclear leucocytes are scarce and most of the inflammatory cells are
mononuclear cells (lymphocytes and cells of the monocyte-macrophage series)
proliferating in situ to generate the chronic granuloma. In these situations, there is
little vasodilation, vascular permeability or endothelial activation. It is also well
known that the proliferation rate of the tubercle bacillus is extremely slow compared
with that of the bacteria responsible for pyogenic infections. Thus, the explanation
for the false negative results in the two cases of tuberculous spinal osteomyelitis
may be that the mechanisms of streptavidin/$^{111}$In-biotin scintigraphy (locally
increased vascular permeability and possible utilisation of biotin by growing bacteria)
were absent. In an earlier study [37] we had speculated that the use of streptavidin
would not offer clear advantages over hen egg avidin because of identical biotin-
binding capacity and dissociation constants. However, in this study focussed on
patients with suspected vertebral osteomyelitis we employed streptavidin, despite
the expected antistreptavidin immune response [36, 37]. The rationale for this choice
was based on the longer retention times of streptavidin in plasma compared with
hen egg avidin (terminal $T_{1/2}$ about 3.5 h vs about 30 min) [44]. In fact, due to the
peculiar anatomical situation of blood vessels secluded in an inexpandable space
(bone marrow of the vertebral body), infection of the spine causes high intravertebral
pressure and possible intravascular microthrombosis, rendering it difficult to achieve
preferential accumulation of radiolabelled agents at the infected bone marrow site.
We conjectured that, by injecting a pretargeting agent with longer circulation times in
the blood pool, we could increase the probability of accumulation of such an agent at
the inflamed/infected site. A potential disadvantage of this technique, however, is
that immunogenic reactions may develop in response to subsequent administrations
of the agent. The presence of antistreptavidin antibodies at the very least could lead
to altered biodistribution of the tracer, thereby affecting the accuracy of scintigraphic examination. In order to avoid such possible immunogenic reactions in follow-up studies, knowledge of antibody titres may be helpful [36, 37]. An alternative way to compromise between prolonged permanence in the circulation and lower immunogenicity would be to use a polyethylene glycol (PEG)-modified avidin. In particular, it has been shown that the conjugation of 10-kDa PEG to avidin yields a complex with suitable characteristics for pretargeting protocols [45, 46]. Taken together, the findings of this study emphasise the need for a more reliable method of scintigraphic imaging in vertebral osteomyelitis, a need that seems to be fulfilled by streptavidin/$^{111}$In-biotin scanning. It is also worth mentioning that this procedure entails a low radiation burden (about 0.4 mSv to the whole body and 19 mSv to the target organ, the bladder) [47], which is much lower than that from a $^{67}$Ga-citrate scan (over 20 mSv to the whole body for a typical 185 MBq diagnostic dose).

**Fig 1a-f.** Representative examples of streptavidin/$^{111}$In-biotin scans in six different patients with confirmed vertebral osteomyelitis. **a** focal areas of radioactivity uptake are clearly detectable, in the thoracic spine in one patient and **b-e** in the lumbar spine in all other patients. Kidney and bladder have been masked with lead in order to improve counting statistics from the areas of interest.
In conclusion, we believe that our investigation has demonstrated that streptavidin/\(^{111}\)In-biotin scintigraphy is an efficacious method for the detection of vertebral osteomyelitis in the first 2 weeks after the onset of clinical symptoms. In view of the fact that early recognition and treatment of this condition is of crucial importance, we feel that streptavidin/\(^{111}\)In-biotin scintigraphy will prove very helpful in choice of therapy. Whether or not this novel imaging modality can totally replace MRI and/or CT for the diagnosis of early vertebral osteomyelitis remains to be elucidated in further studies of large population samples.
References