DIAGNOSTIC IMPLICATIONS OF A COLD HIP ON ISOTOPE BONE SCANNING IN THE PAEDIATRIC PATIENT

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ABSTRACT

Background: Diagnosing a child with hip pain or limping is challenging. Isotope bone scanning is often utilised to diagnose or exclude septic arthritis where diagnostic difficulty is encountered.
Objectives: The aim of this study was to determine the diagnostic implications of a cold hip on bone scan, as well as the overall accuracy of bone scans in the setting of septic arthritis of the hip.
Methods: A retrospective review of all patients who underwent bone scans for suspected septic arthritis of the hip, over a 10-year period, was performed. All patients that demonstrated a cold hip were included. Demographic and clinical data were extracted from medical records. Patients with septic arthritis and a cold hip were compared to those who had different diagnoses to determine indications for surgical intervention. Sensitivity and specificity data analyses of all patients that underwent a bone scan to diagnose or exclude hip septic arthritis were performed.
Results: We included 59 patients of whom 29 demonstrated a cold hip on bone scan. Septic arthritis was present in 17 (58%) of patients who had a cold hip. There was a significant difference in clinical and haematological variables between patients with septic arthritis and those with other diagnoses. The sensitivity and specificity of a cold hip on bone scan for the diagnosis of septic arthritis were 81% and 68% respectively. The positive predictive value was 59% and the negative predictive value 87%. The overall sensitivity and specificity of bone scan to diagnose hip septic arthritis was 95% and 66% respectively.
Conclusion: A cold hip on bone scan is diagnostic of septic arthritis of the hip in the presence of typical clinical and haematological features of infection. The strength of this investigation lies in its high sensitivity and negative predictive value and its ability to exclude the diagnosis of septic arthritis.

Key words: Bone Scan, septic arthritis, Cold hip, Avascular necrosis, Paediatric

INTRODUCTION

Septic arthritis is a common cause of hip pain in children and should always be actively excluded when a child presents with hip pain or limping (1). The diagnosis can usually be made from physical signs, symptoms, and infective blood markers, but in the very young patient, determining the exact site and nature of pathology can be very difficult, and advanced imaging is often required. The Kocher Criteria (2) is a valuable clinical tool in the differentiation of septic arthritis from transient synovitis of the hip, it is unable to distinguish osteomyelitis from septic arthritis and the use of further imaging is still advised (3).

Isotope bone scanning is useful in cases where diagnostic difficulty remains despite clinical, radiographic and/or ultrasonographic examination. A cold hip on bone scan is highly suggestive of septic arthritis of the hip or, less often, decreased perfusion of the hip due to non-infective causes (4).

At our institution, bone scan is the investigation of choice to diagnose or exclude septic arthritis of the hip in patients with equivocal clinical and haematological findings, yet the diagnostic

accuracy of this investigation, specifically in the setting of hip septic arthritis, has not been firmly established.

The purpose of this study was to determine the diagnostic implications of a cold hip on bone scan, the overall accuracy of bone scan to detect septic arthritis of the hip, as well as the indications for arthrotomy in the presence of a cold hip.

MATERIALS AND METHODS

Approval to perform the study was obtained from our Institutional Human Research Ethics Committee (HREC: 426/2020).

The Department of Nuclear Medicine's database was searched for all patients that had undergone a bone scan during the 10-year period starting from January 2009 to December 2019.

Blood pool, two-hour delayed images of the whole body, and selected static images were recorded according to the EANM guidelines (5). In selected cases, pinhole images or a Single Photon Emission Computed Tomography (SPECT), were recorded. The dose of 99mTc MDP was scaled according to body surface area using the relevant EANM paediatric dose card (6).The children were imaged on a Phillips™ Axis Dual Head camera (previously known as Picker and then Marconi) until April 2015. Thereafter, all children were imaged on a Discovery™ 670 NM/CT Pro GE camera. All images were acquired using a low energy high resolution collimator.

All patients that underwent a bone scan to rule out or diagnose septic arthritis of the hip were included. In addition, all patients that demonstrated a cold hip on bone scan, regardless of the indication for the scan, were included. Patients were excluded if their medical records were unavailable or incomplete.

Data was collected on demographic variables, clinical presentation and indication for bone scan, laboratory investigations, bone scan findings and eventual diagnosis. Routine blood investigations included a Full Blood Count (FBC), Erythrocyte Sedimentation Rate (ESR) and C-Reactive Protein (CRP) (Table I).

Table 1

Presenting variables of all 59 patients included in the analysis

Presenting variable (median; IQR)	All patients (n=59)	Septic arthritis (n=20)	Not septic arthritis (n=39)	P-value
Age in months	46 (16;102)	25 (10;26)	57 (21;116)	P=0.034
Temperature (°C)	37.1 (36.4; 38.5)	37.6 (36.4; 38.7)	37 (36.4; 38.5)	P=0.74
White cell count ((x10^9/L)	13.1 (9.5; 18.2)	15 (11; 19.3)	12.6 (9.4; 17.1)	P=0.27
ESR (mm/hr)	51 (28; 75)	50 (41; 75)	52 (25; 74)	P =0.55
CRP (mg/dL)	129 (38; 198)	138 (74; 184)	126 (27; 200)	P= 0.37

Patients who demonstrated a cold hip on bone scan were grouped together to determine the eventual diagnosis in each, and which number had a final diagnosis of septic arthritis. Presenting variables for this group were analysed to determine differences between those with and without septic arthritis.

For the sensitivity and specificity analysis, all the patients that underwent bone scan, where the indication for the scan was a painful hip or a limp, and an elusive diagnosis, were included. The diagnosis of septic arthritis was made in the presence of frank pus in the joint and/or bacteriological or histological confirmation of septic arthritis.

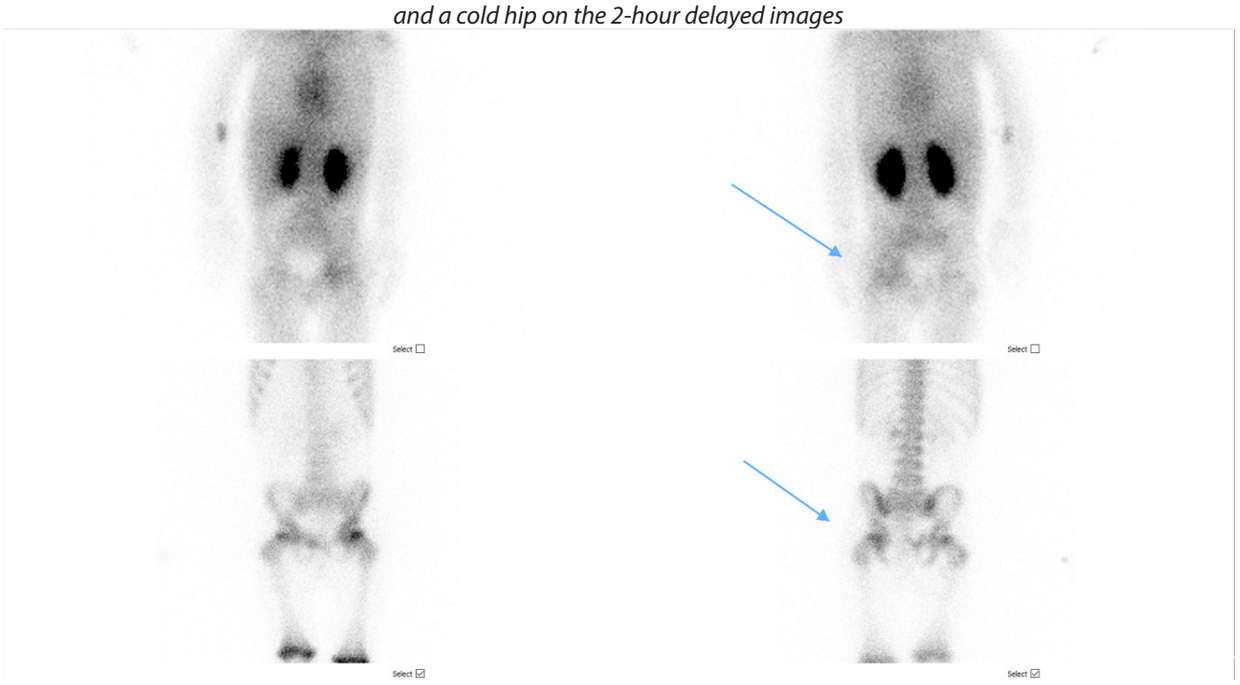
Statistical analysis was performed using Stat Tools tool pack in Microsoft™ Excel. Data was presented as medians and interquartile ranges for continuous variables. The unpaired Wilcoxon-Rank test was used to assess the relationship between various independent variables. Where appropriate, statistical significance was set at $p<0.05$.

RESULTS

Following exclusions, 59 patients were included, of whom 29 patients had a cold hip on bone scan (Figure 1). The mean age of the patients was 60 months (range 2-170 months).

Figure 1

Example of a patient with septic arthritis of the right hip demonstrating decreased tracer uptake in the blood-pool images and a cold hip on the 2-hour delayed images



The diagnoses of the 29 patients who demonstrated a cold hip are summarised in Table 2. Septic arthritis was present in 17 (58.62%) patients.

Table 2

Final diagnosis in patients with a cold hip on bone scan

Diagnosis	No. (%)
Septic arthritis	17 (58.6)
Perthes disease	5 (17.2)
Transient synovitis	2 (7.1)
Avascular necrosis (not Perthes)	1 (3.4)
Slipped Upper Femoral Epiphysis (SUFE)	1 (3.4)
Proximal femur osteitis	1 (3.4)
Non-ossifying fibroma	1 (3.4)
Simple bone cyst	1 (3.4)
Total	29

Among those patients with a cold hip on bone scan, there was a statistically significant difference in clinical and haematological variables between patients who had septic arthritis, and those that did not (Table 3).

Table 3

Presenting variables in the 29 patients that demonstrated a 'cold hip' on bone scan

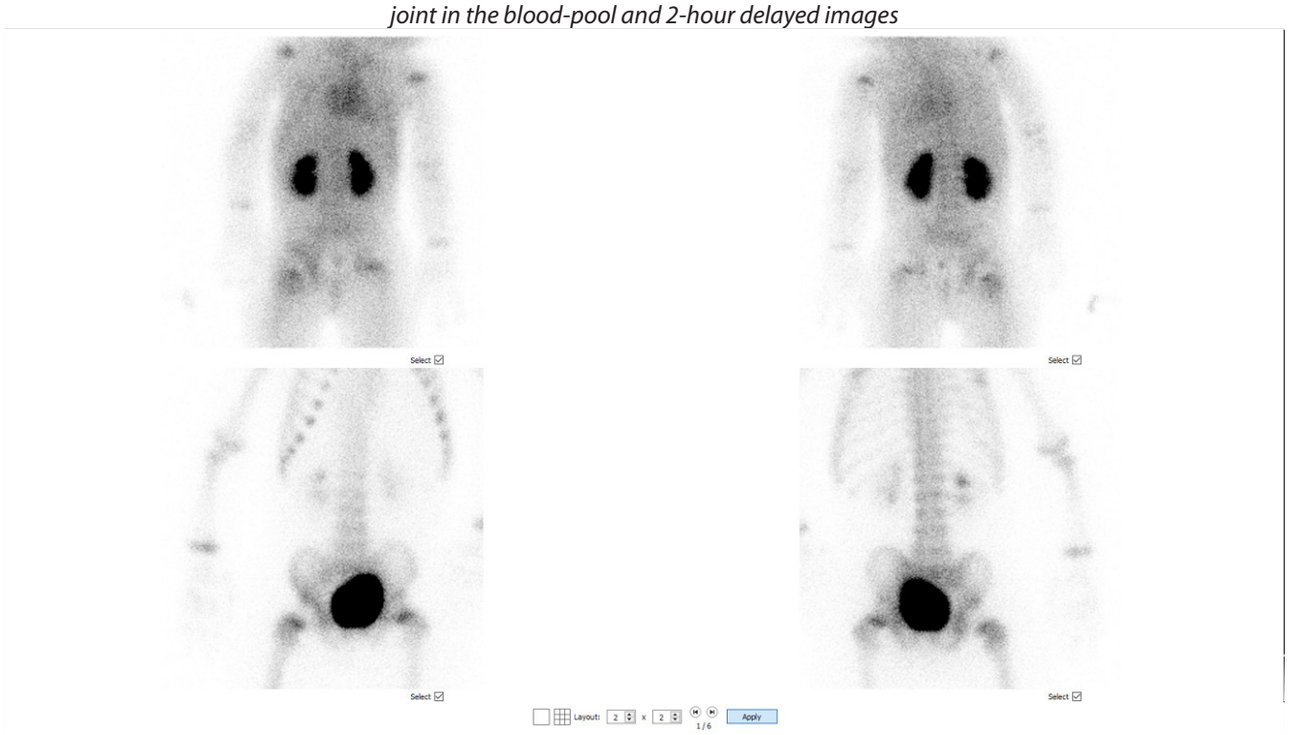
Variable	All patients	Septic arthritis	Not septic arthritis	P-value
Temperature (°C); (IQR)	36.8 (36, 38.1)	37.7 (36.5, 38.8)	35.5 (35.4, 37.2)	0.018
WCC (x10^9/L) ; (IQR)	15.3 (9.2, 17.9)	18.23 (9.9, 20.9)	10.58 (7.2, 13.3)	0.031
ESR (mm/hr); (IQR)	45 (23, 67)	59.64 (40, 75)	25 (3.8, 43.3)	0.011
CRP (mg/dL); (IQR)	125 (24.4, 192.7)	162.4 (42, 309)	47.89 (15.8, 96.9)	0.022

Of the 59 patients included in this study, 21 were diagnosed with septic arthritis, of whom 17 demonstrated a cold hip on bone scan. The sensitivity and specificity of a cold hip on bone scan for the diagnosis of septic arthritis were 81% and 68% respectively. The positive predictive value was 59% and the negative predictive value 87%.

When including patients with imaging findings of septic arthritis preceding the development of a cold hip, such as generalised increased tracer uptake or a 'hot scan' (Figure 2) the sensitivity and specificity for this imaging modality to detect septic arthritis were 95% and 66% respectively.

Figure 2

Example of a patient with septic arthritis of the left hip demonstrating increased tracer uptake on both sides of the hip joint in the blood-pool and 2-hour delayed images



Twenty-two patients underwent an arthrotomy based on clinical suspicion of septic arthritis, confirmed by bone scan findings. Only one patient underwent arthrotomy who did not have septic arthritis of the hip. This was an 11-month-old child with *meningococcal septicaemia,* raised inflammatory markers and increased blood pool activity around the hip on bone scan. No infective organism was isolated form intra-operative samples in this patient, and a diagnosis of reactive arthritis was made.

One patient whose bone scan was not indicative of septic arthritis, did in fact have septic arthritis. The diagnosis was significantly delayed, and the outcome was poor.

DISCUSSION

Decreased or absent perfusion of the femoral head may be caused by a variety of conditions ranging from trauma to infection and malignancy. In the context of Septic Arthritis (SA) of the hip, decreased perfusion is caused by a tamponade effect exerted by the excess fluid or pus in the joint. This manifests as a cold hip on bone scan and is usually reversible once the excess fluid has been evacuated (7,8).

The presence of a cold hip on bone scan should be interpreted within the context of the patient's presenting signs and symptoms. In our study, only 58.6% of patients with a cold hip had a final diagnosis of septic arthritis. There was, however, a statistically significant difference in all four measured variables indicative of infection or inflammation, between patients who did and did not have septic arthritis. Raised inflammatory markers and the presence or history of a fever, in conjunction with a cold hip one bone scan, is an indication for intervention. Due to the high prevalence of tuberculosis in our population, all patients with an indication for intervention undergo arthrotomy in order to obtain synovial samples for TB culture and histology.

The value of the bone scan appears to be in its negative predictive value, or its ability to exclude the presence of infection in cases of clinical equipoise. In our study, the sensitivity and specificity of a cold hip on bone scan for the diagnosis of septic arthritis was 81% and 68% respectively, with a positive and negative predictive value of 59% and 87% respectively. This is in contrast to the findings of Uren *et al.* (9), who diagnosed septic arthritis in only 22% of patients who had a cold hip on bone scan. Despite this relatively low incidence, the authors recommend aspiration or arthrotomy for all patients with this finding.

In the decade covered by this study, a single patient had a normal bone scan in the presence of septic arthritis of the hip. This was a complicated case of post-cardiac surgery systemic sepsis, *serratia marcescens* being the infective organism. Bone scan was performed to exclude non-contiguous infection but was normal. The patient returned two weeks later with clear septic arthritis of the hip. The same organism was cultured.

The usefulness of bone scintigraphy for the detection of infection in children has mostly been studied in the context of osteomyelitis or osteomyelitis and septic arthritis. Tuson *et al.* (10), in a study examining the value of bone scan in detecting bone and joint infection in less accessible sites, found a sensitivity of 92% and a specificity of 40% for this investigation. The authors also quote a 100% Positive Predictive Value (PPV) of a cold hip scan for septic arthritis and osteomyelitis. These results should, however, be interpreted with caution as the study included only patients with an established diagnosis of septic arthritis or osteomyelitis.

Bone scintigraphy may be indicative of septic arthritis of the hip in the absence of a cold hip. Typical scintigraphic findings are increased tracer uptake involving the bony structures adjacent to the joint (8). The appearance of a cold hip is seen in more advanced stages of the disease. In our study, when including patients who had a positive scan for septic arthritis but not a cold hip, the overall sensitivity and specificity of bone scan for the diagnosis of septic arthritis of the hip was 95% and 66% respectively.

Magnetic Resonance Imaging (MRI) has been quoted to be the gold standard for diagnosing bone and joint infections, both in children and adults, with specific changes being seen as early as 24 hours after onset of infection (11-13). If, however, the location of the infection is not known, bone scan is a more appropriate first investigation as it examines the entire body (8,14,15). Once a site is localised, SPECT/CT or MRI can then be performed in order to better define the lesion and identify abscesses that may require surgical drainage. The availability of advanced imaging varies between treatment centres, but in our setting, the use of MRI is limited by availability, the need for sedation or general anaesthesia in younger children, and cost (11,12).

There are some limitations to our study. It is a retrospective study and therefore investigations, other than bone scan, were not performed systematically. Bone scan was not compared to other modalities, such as MRI, to establish its superiority. Our numbers are relatively small, thereby bringing into question the validity of the statistical findings. However, very little has been published on this specific subject and our findings will contribute to the existing body of literature. Prospective, multicentre studies should be considered in future, to determine more conclusively the role of this investigation in the diagnosis of septic arthritis of the hip in children.

CONCLUSION

Our study confirms that bone scintigraphy remains a useful investigation to diagnose or exclude septic arthritis of the hip. The presence of a cold hip on bone scan should alert the treating physician to the possibility of septic arthritis of the hip and should be interpreted within the context of other clinical and haematological findings, such as the well-established Kocher Criteria. The sensitivity and negative predictive value of this investigation in the context of septic arthritis of the hip is very good, but more targeted investigations such as MRI or SPECT/CT should be employed in cases of clinical uncertainty.

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