Acta Orthop Scand 57, 211–215, 1986

Computed tomography and ultrasonography for diagnosis of hip joint effusion in children

Nineteen consecutive children with transient synovitis of the hip were examined for intracapsular joint effusion using computed tomography (CT) and ultrasonography (US). The two techniques were highly correlated in measurements of the anterior displacement of the joint capsule, indicating both to be reliable diagnostic tools. Such an effusion is clinically important because of the increase in intracapsular pressure with ensuing disturbance in the vascular supply to the proximal femoral epiphysis, as demonstrated experimentally and clinically in transient synovitis.

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The diagnosis of hip joint effusion in children is clinically important because increased intracapsular pressure may obstruct the blood supply to the proximal femoral epiphysis (Kloiber et al. 1983, Wingstrand et al. 1985a) The condition is difficult to diagnose by conventional radiography (Brown 1975). We have evaluated computed tomography (CT) and ultrasonography (US) in the diagnosis of hip joint effusion in children.

Patients and methods

Nineteen consecutive cases of transient synovitis were admitted for examination; there were 15 boys and four girls, mean age 7 (3–12) years. After conventional radiography of the hip in AP and frog-leg projections, CT of both hips, immediately followed by US, was performed within 12 hours after admission. In five children the examinations were repeated, for a total of 25 US and CT examinations.

During the examinations the child was placed in the supine position with the hips in a few degrees of flexion, obtained with a pillow under the knees. This position was comfortable and could be reproduced in most of the children. No sedatives were necessary.

The CT examinations were performed with a Philips Tomoscan 300 or Toshiba TCT 80 A, with a slice thickness of 6 and 5 mm, respectively. Guided by palpation, the first scan was obtained at the proximal level of the greater trochanter, and a maximum of three scans through the femoral neck and head were obtained.

The distance from the ventral aspect of the neck of the femur to the ventral aspect of the iliofemoral capsular ligament was measured directly on the CT display (Figure 1). The measurements were performed at a window level and width of 150 and 400, respectively, the figures being obtained from a series of measurements on a phantom simulating the anatomic conditions of the neck. This phantom was made from tubes of polyacetale (POM) and polyamide (PA 6) inserted into each other; their CT numbers were respectively 330 and 70.

Because the spatial orientation of the femoral neck within the scanning plane may distort the true distance, a correction was made: The x and y coordinates of the center of the femoral neck (Q) of the most distal scan and those of the center of the head (P) were recorded, and the distance between the scans was used as the z coordinate (Egund & Palmer 1984). The orientation of the vector $\bar{v}$ between the two centers was calculated, and the relation between the measured distance D and the true distance d was obtained from the equation

$$d = D \cdot \sqrt{1 - \frac{v_y^2}{|\bar{v}|^2}}$$

$$v_y = Q_y - P_y$$

$$|\bar{v}| = (Q_x - P_x)^2 + (Q_y - P_y)^2 + (Q_z - P_z)^2$$

US was performed with a scanner using a 7.5 or 10 Mhz sector transducer (Technicare Autosector or Diasonics DRF 12). Both hips were scanned from the ventral aspect of the hip in the plane of the axis of the femoral neck (Figure 2), whereby the femoral neck, metaphysis, physis, epiphysis, and acetabular rim were clearly identified (Figure 1). The US examinations were performed by two observers only.

Joint aspiration was performed in nine patients preceded by intracapsular pressure recordings with the technique described by Wingstrand et al.

Table 1. Observations in 19 children with transient synovitis of the hip

A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	8	F	L	30	10	36.4	Yes	6.4	4.6	7.0	4.6	–	–
2	6	M	R	3	–	37.5	No	7.3	4.6	7.6	4.6	–	–
3	3	M	L	3	15	37.8		9.3	6.7	11.5	6.2	–	–
								7.4	5.6	7.9	6.0	–	–
4	5	F	R	½	7	37.6	No	8.7	5.6	8.9	5.7	–	–
5	12	M	L	21	3	–	No	8.9	5.1	8.9	5.6	–	–
								9.6	5.8	9.8	6.0	–	–
6	4	M	R	3	15	37.0	Yes	8.3	4.6	8.6	4.5	–	5.0
								7.3	3.8	7.2	4.5	–	–
7	6	M	L	14	18	36.9	No	11.4	5.1	12.0	4.7	–	5.5
								8.6	5.1	9.1	4.7	–	–
8	6	M	L	7	10	36.8	No	7.6	6.0	7.2	5.0	–	–
9	5	F	R	½	12	37.0	No	6.7	5.1	6.8	5.1	–	–
10	9	M	L	4	44	36.6	No	11.0	5.7	11.7	6.2	–	–
11	3	M	L	1	13	36.9	No	9.4	5.1	9.7	5.1	–	–
12	5	M	L	1	7	36.9	No	10.0	6.0	11.2	6.0	–	–
13	5	M	R	4	26	37.9	No	9.8	5.0	11.0	5.3	–	3.0
14	5	F	L	1	5	37.2	Yes	7.1	5.0	8.0	5.4	15.2	2.5
15	12	M	L	1	5	36.4	No	10.4	7.3	10.0	5.6	11.0	5.5
16	4	M	R	1	4	36.8	No	9.0	4.8	9.1	4.7	12.1	2.8
17	6	M	L	1	15	38.2	No	8.1	6.2	8.2	6.3	14.5	1.6
								7.3	6.4	7.4	6.1	–	–
								6.3	5.6	6.6	6.1	–	–
18	3	M	R	2	3	37.6	No	5.6	4.0	5.8	4.3	10.5	0.5
19	10	M	R	2	7	37.5	Yes	12.2	5.4	12.9	5.0	11.8	7.5

A=Patient number. B=Age (yrs). C=Sex (M=male, F=female). D=Left/right symptomatic hip. E=Duration of symptoms at time of admission (days). F=ESR (mm/hour). G=Body temperature (C). H=Previous episode of transient synovitis? I=CT measurement, symptomatic hip (mm). J=CT measurement, *non*symptomatic hip (mm). K=US measurement, symptomatic hip (mm). L=US measurement, *non*symptomatic hip (mm). M=Intracapsular pressure with the hip in extension-neutral position (kPa). N=Aspirated volume (ml).

Comments: Complete data concerning intracapsular pressure were published by Wingstrand et al. (1985b), where case numbers 2, 3, 4, 5, and 7 correspond to patient numbers 15–19, respectively, in this table.

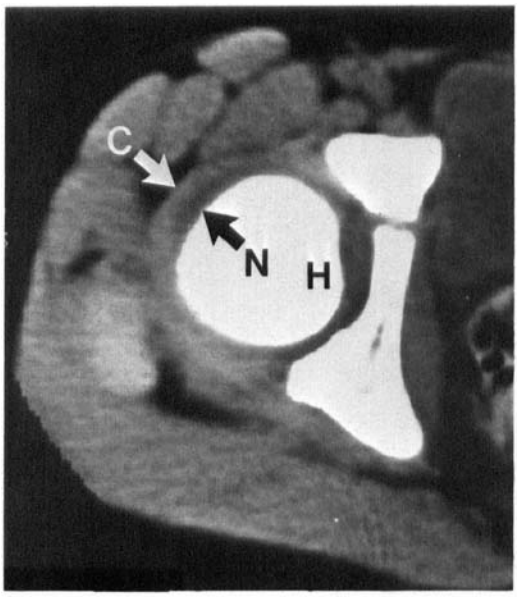
(1985b). In three patients (Cases 13, 17, 18), aspiration was performed before the first CT and US measurements.

Results

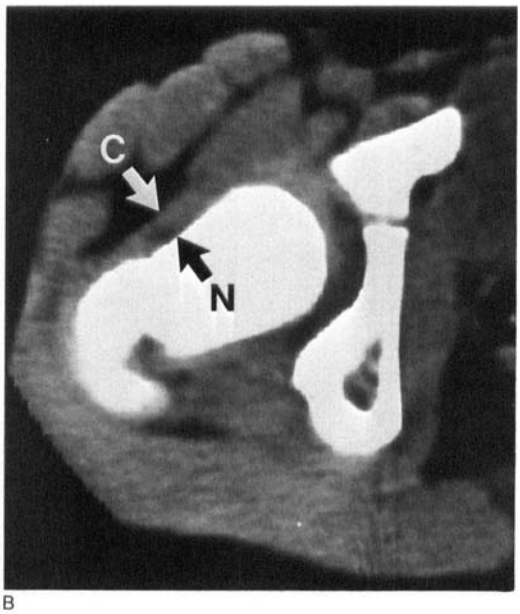
Clinical data and observations in the 19 children are listed in Table 1. In the 19 nonsymptomatic hips, the 25 CT and US images of the relation between the ventral aspect of the neck of the femur and the capsule followed each other equidistantly (Figure 1); the correlation between CT and US measurements in the nonsymptomatic hips proved to be good ($r = 0.77$). Thus, the CT measurements varied between 3.8 and 7.3 mm (mean 5.4 ± 0.8 S.D.) and the corresponding US measurements between 4.5 and 6.3 mm (mean 5.3 ± 0.7 S.D.). At the level of the femoral head, these distance values were slightly lower. The discrepancy between the CT and US measurements of the nonsymptomatic hips exceeded 1.0 mm in only one case, corresponding to the largest pixel size used on the display.

Intracapsular effusions were found by both CT and US in all 25 examinations of the 19 symptomatic hips. The effusion distended the capsule anteriorly, with the largest displacement along the neck of femur distal to the metaphysis (Figure 3). On CT examinations most effusions could also be observed lateral to the head and at the medial and posterior aspect of the neck (Figure 4). Capsular distension was less pronounced at the level of the head; moreover, large effusions were never observed at the lateral aspect of the femoral neck.

The CT measurement of capsular displacement in the symptomatic hips was 5.6–12 mm (mean 8.5 ± 1.7 S.D.). The corresponding US measurement was 5.8–13 mm (mean 9.0 ± 1.9 S.D.). Thus, there was a good correlation be-



A



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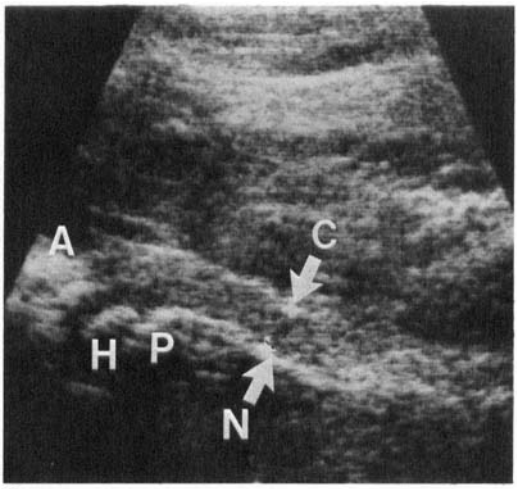


C

Figure 1. CT in a proximal (A) and more distal (B) level of the neck of the femur and US (C) of a normal hip. The following anatomic structures are identified: acetabular labrum (A), head of femur (H), growth plate (P), neck of femur (N), and joint capsule (C). The distance from the anterior aspect of the joint capsule to the neck of the femur is recorded. The capsule follows the neck equidistantly.

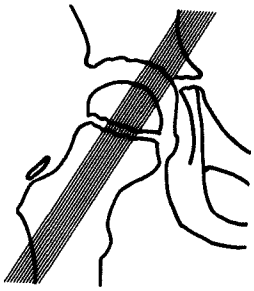


Figure 2. The direction of the US beams from the anterior aspect along the neck of the femur.

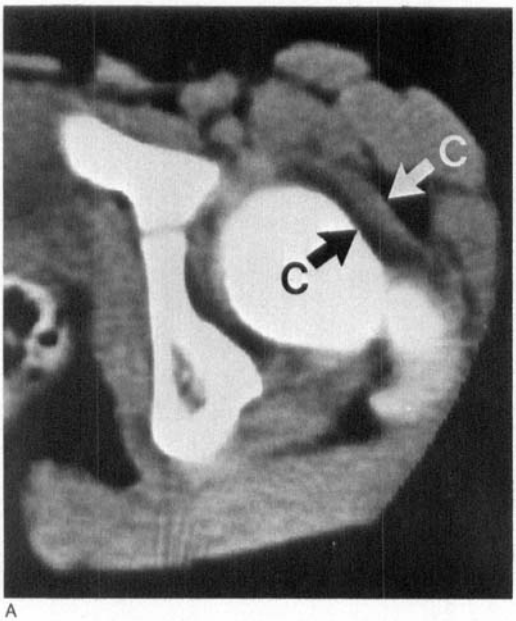
tween the measurements in the symptomatic hips obtained by CT and US (r = 0.96, k = 1.09) with respect to the distance between the anterior aspect of the neck and the capsule, the difference being within 1 mm in all except three examinations (Figure 5).

Aspiration was performed in nine consecutive patients, yielding on an average 3.8 ml (0.5–7.5) of fluid. The mean preoperative capsular distension in these patients, measured as the difference between the symptomatic and non-symptomatic hips, was 5.1 mm. A positive correlation was found between capsular distension and volume of fluid aspirated (k = 0.74, r = 0.8).

Discussion

Experimentally and clinically increased intracapsular pressures have been shown to produce ischemia of the proximal femoral ephiphysis (Woodhouse 1964, Lucht et al. 1983, Kloiber et al. 1983, Wingstrand et al. 1985b).

Conventional radiographic examination does not provide sufficient information about effusion of the hip joint (Brown 1975, Resnick & Niwayama 1981). Alternative diagnostic measures would be CT, with additional radiation to the patient, or diagnostic aspiration of the hip, which in this age group requires general anesthesia.



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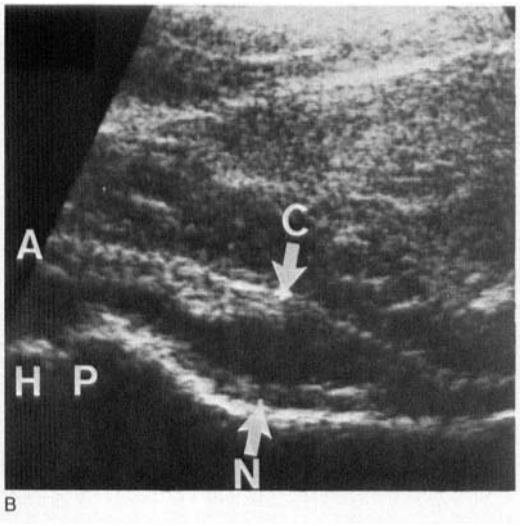
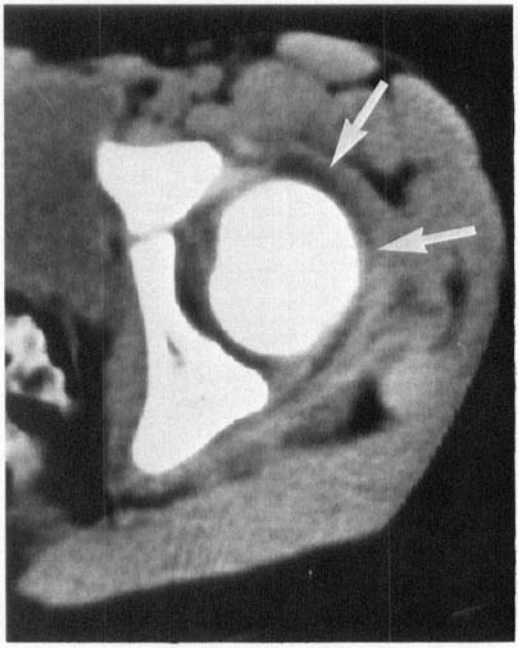
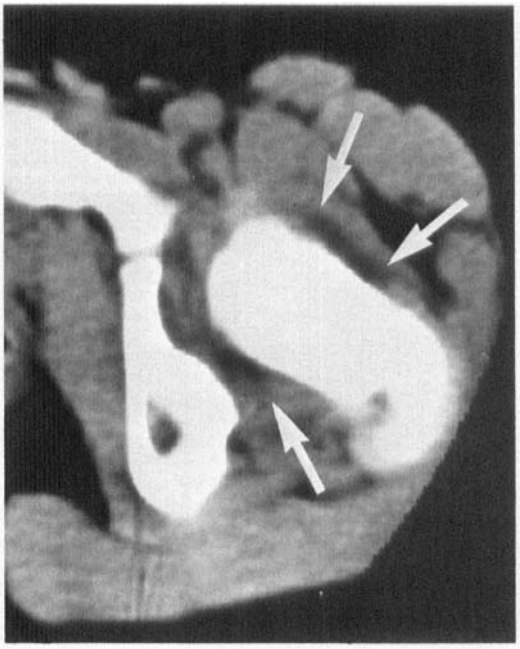


B

Figure 3. CT (A) and US (B) of the symptomatic hip in transient synovitis. For legends, see Figure 1. The effusion distends the capsule anteriorly.



A



B

Figure 4. CT of a hip with effusion (arrows) at the level of the head (A) and the distal portion of the neck (B).

Kramps & Lenschow (1979) showed that hip anatomy could be demonstrated by US, and Wilson et al. (1984) visualized intraarticular fluid collection in 16 patients; they concluded that a difference of greater than 3 mm between the two hips was suggestive of an effusion.

The high degree of correlation between CT and US measurements in our study shows that the capsular sonographic echo used represents the anterior aspect of the joint capsule. The CT and US measurements of capsular distension were in each patient calculated as the difference between affected and nonaffected side.

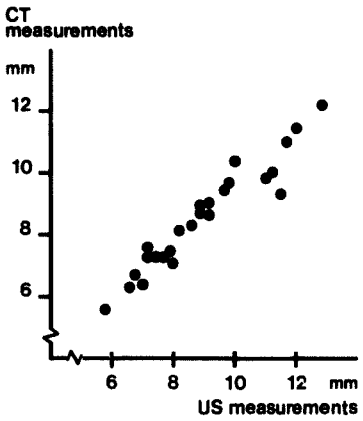


Figure 5. Correlation between 25 US and CT measurements of the capsular displacement in 19 children with effusion of the hip joint.

We cannot, however, conclude with certainty that all nonsymptomatic hips in our patients were not affected. Thus , for the time being, the capsular distances found in these hips should not be considered as representing normal anatomy. This is presently being investigated by us.

We did not attempt to make a direct comparison between CT and US measurements of capsular thickness or width of effusion, for the width of the US echogenic zone obtained from the anterior aspect of the capsule is of a technical nature and, among other factors, depends upon the transducer frequency (Walter 1985).

The tension of the hip capsule is increased in extension and internal rotation and especially in hips with effusion (Wingstrand et al. 1985b) – a condition that may result in an altered distribution of the fluid within the joint. This may exaplain the slight discrepancy between US and CT measurements obtained in those hips with the largest effusion, because the reproducibility of hip flexion and rotation between the two examinations was less accurate in the patients with the most pain.

Similarly, a more pronounced distension of the capsule medial and posterior to the femoral neck was observed in the CT examination (Figure 5), which may also contribute to the discrepancy.

Our investigation shows that CT and US are comparable diagnostic methods for evaluation of effusion of the hip joint in children, and we feel confident that we can diagnose effusions with a capsular distension of 1 mm. Thus, we believe that US should be the method of choice for assessment of joint effusion in transient synovitis of the hip in children.

However, the diagnostic accuracy of US depends on a correct examination technique and knowledge of normal anatomy. CT, on the other hand, requires less individual examination skill and is to be regarded as an excellent alternative method; further, the radiation dose is well within acceptable limits (Bankvall et al. 1982).

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