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Ultrasonography in hip disease in children

Intra-articular synovial effusion was visualized in different juvenile hip diseases by ultrasonography; 166 hips from 149 children were examined. Joint aspiration of 97 hips confirmed that ultrasonography was more sensitive than conventional radiography in diagnosing effusion. The magnitude of the ultrasonic joint space correlated well with the clinical severity of the disease, the volume of synovial fluid, and the intra-articular pressure. Considerable widening of the ultrasonic joint space was seen in transient synovitis, septic arthritis, reactive arthritis and arthritis with urticaria; moderate widening was seen in some patients with Perthes disease, and symmetrical joint space in patients with nonspecific arthralgia. We conclude that ultrasonography is valuable in the diagnosis and follow-up of synovial effusion of the hip in children.

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Ultrasonography has proved useful in visualizing structures with a high content of fluid such as popliteal cysts (McDonald & Leopold 1972, Beals et al. 1980), and there are also some reports on its use in the diagnosis of congenital hip dislocation (Graf 1980) and synovial effusion of the hip (Seltzer et al. 1980, Wilson et al. 1984, Wingstrand & Egund 1984). Preliminary observations in our patients showed that ultrasonography was more accurate than radiography in diagnosing synovial effusion of the hip (Jäppinen et al. 1984).

We have studied the value of ultrasonography in the diagnosis of painful hip in children.

Patients and methods

This prospective study was performed in 149 children with 166 episodes of hip pain. One hundred and six (71 per cent) were boys and 43 (29 per cent) girls between the ages of 6 months and 16 years. Of the patients 114 were diagnosed at the Aurora Hospital and 35 at the University Children's Hospital during the period May 1982–December 1983.

The criteria were limp without history of severe trauma, painful and limited motion of the hip or suspicion of hip joint affection based on radiographic appearance ("capsular swelling", widened joint space or signs of necrosis or osteomyelitis in the proximal femur). Table 1 gives the diagnoses based on clinical and radiographic appearance, hip aspiration, haematologic, serologic and synovial fluid examinations, and bacterial cultures from the throat, blood and synovial fluid.

All the patients were clinically examined by two of the authors (PK and IK). The range of joint motion (A.A.O.S. 1969) was recorded for both hips.

The radiographic examination included both hips in anteroposterior and Lauenstein views. Any radiographic "capsular swelling" (RCS) was recorded.

Ultrasonography was performed immediately after the radiographic examination and before any therapy was started. A further examination was made 2 weeks later. The patients were placed in a supine position with the hips in symmetrical neutral extension, abduction and rotation. A real-time linear ultrasonograph (Model Hitachi EUB-22 with 3.5 MHz transducer) was used at the Aurora Hospital and a sectoscanner (Model ATL MK-300 with 5–7.5 MHz transducer) at the Children's Hospital. The

Table 1. Clinical diagnoses in 149 children with hip disease

	Patients	Hips
Transient synovitis		
Unilateral	90	97
Bilateral	6	12
Perthes disease	9	10
Osteomyelitis	9	9
Septic arthritis	5	5
Reactive arthritis	2	3
Arthritis & urticaria	2	2
Other[a]	26	28
Total	149	166

[a] 1 muscular distension, 1 physeolysis, 1 juvenile rheumatoid arthritis, 2 polymyositis, 3 insertion tendinitis and 20 cases of nonspecific hip pain without restriction of joint movement.

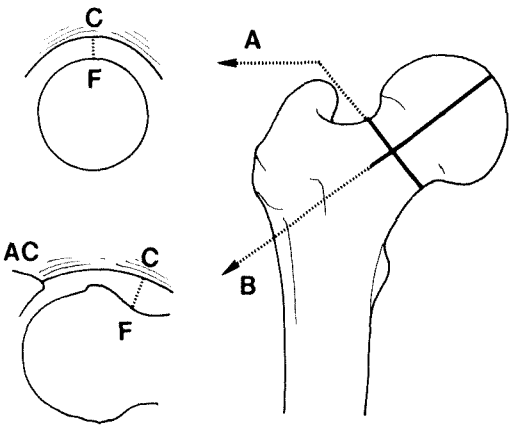

Figure 1. Ultrasonographic examination of the hip joint. The distance between the anterior wall of the joint capsule (C) and the anterior surface of the femoral neck (F) was recorded in both transverse (A) and longitudinal (B) planes. Any blurring of the capsular image was recorded. AC = acetabular rim.

greatest distance between the anterior surface of the femoral neck and the wall of the anterior joint capsule was regarded as the ultrasonographic joint space (UJS), which was measured in millimetres in longitudinal and transverse planes (Figure 1). Only the values of the longitudinal projection were used for the final analysis, because they soon proved more reliable than those of the transverse projection, which was found to be more sensitive technical errors. Any lack of sharpness or thickening of the anterior joint capsule of the diseased hip compared to the healthy side seen in the monitor during the examination was recorded. The finding was called ultrasonographic capsular blurring (UCB).

The difference between the values of each diseased and symptom-free hip (UJS-DIFF) was calculated. In the six bilateral cases this difference was calculated from the values of the actual UJS and the control value of the same hip after recovery.

In total, 97 hips were aspirated because of suspected synovial effusion based on radiographic and ultrasonographic evidence or suspected septic arthritis or osteomyelitis. The same anterolateral aspiration technique was used by the same author (PK) in every case. The volume of fluid (SFV) was recorded. Intra-articular hydrostatic pressure was measured in 72 hips (Kallio & Ryöppy 1985).

For statistical analysis the *t*-test was used, and the means are given with ± 1 standard deviation.

Results

A conspicuous feature of synovial effusion of the hip in ultrasonography was widening of the "joint space" between the anterior surface of the femoral neck and the wall of the anterior capsule (Figure 2). The means of UJS-DIFF in reactive arthritis, septic arthritis, transient synovitis, osteomyelitis and Perthes disease differed ($p<0.001$) from non-specific arthralgia (Table 2).

The means of UJS in diseased and symptom-free hips in patients with transient synovitis or

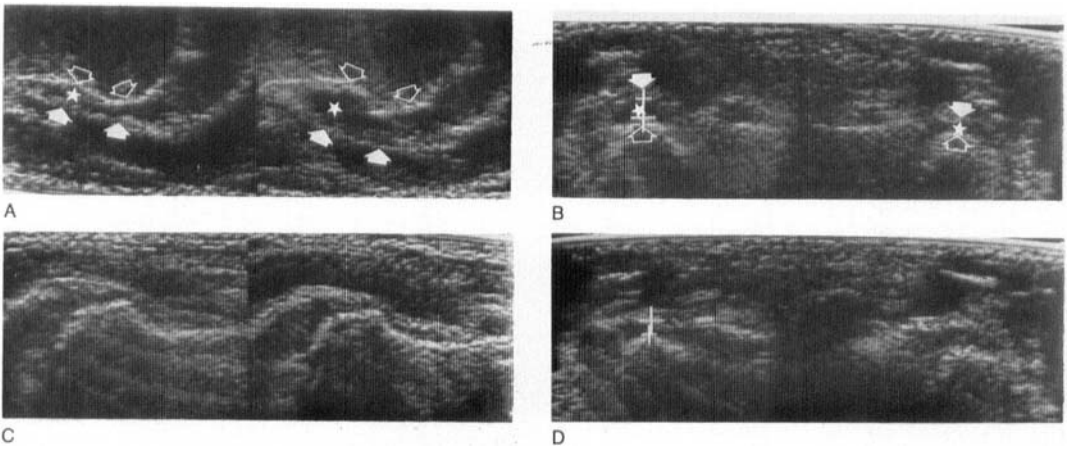

Figure 2. A case of transient synovitis (male, 6 years) of the right hip with widened synovial space both in the longitudinal (9/4 mm, A) and transverse (5/3 mm, B) planes. 4.2 ml fluid was aspirated and an intra-articular pressure of 22 kPa (165 mmHg) in forced extension and 2.6 kPa (20 mmHg) in flexion was recorded. The synovial space was symmetrical (3/3 mm, C, and 4/5 mm, D) at re-examination after bed rest for 10 days. The blurring of the right capsule was seen in both projections of admission and still in the longitudinal plane of re-examination. The synovial space is indicated by a star, the anterior capsule by two solid arrows and the femoral head and neck by two framed arrows. The crosses in the two transverse projections were used for measuring the width of joint space.

Table 2. Ultrasonographic joint space difference (UJS-DIFF) (mean ± SD) and synovial fluid volume (SFV) (mean ± 1 SD) and the frequencies of positive ultrasonographic capsular blurring (UCB) and radiographic capsular swelling (RCS) in the different diagnostic groups

Clinical diagnosis	UJS-DIFF	UCB	RCS	SFV
Transient synovitis	2.4±1.5	57/69	71/89	2.5±1.7
Bilateral transient synovitis	1.6±1.0	4 /12	0 /12	1.9±2.0
Perthes disease	1.7±1.6	4 / 4	3 / 9	0.7±0.8
Osteomyelitis	1.2±1.9	0 / 4	0 / 9	1.3±1.5
Septic arthritis	2.4±1.5	2 / 4	1 / 5	2.2±2.0
Reactive arthritis	3.0±3.0	1 / 1	2 / 2	6.2±0.3
Arthritis	3.0±3.0	1 / 1	2 / 2	6.2±0.3
Arthritis & urticaria	3.0±4.2	2 / 2	0 / 1	7.6±5.3
Other	0.1±0.3	1 /23	4 /23	0.1±0.1

Table 3. Diagnostic accuracy of radiographic capsular swelling (RCS), ultrasonographic capsular blurring (UCB) and ultrasonographic joint space difference (UJS-DIFF) in synovial effusion of the hip in the 97 hips with joint aspiration. Synovial fluid volume (SFV) of 0.4 ml or more or a UJS-DIFF of 2 mm or more were regarded as pathological.

	SFV		
	Normal	Pathological	Total
RCS			
Normal	10 (0.6)	20 (0.3)	30 (0.3)
Pathol.	6 (0.4)	59 (0.7)	65 (0.7)
Total	16 (1)	79 (1)	95 (1)
UCB			
Normal	10 (0.7)	16 (0.3)	26 (0.3)
Pathol.	5 (0.3)	44 (0.7)	49 (0.7)
Total	15 (1)	60 (1)	75 (1)
UJS-DIFF			
Normal	12 (0.7)	13 (0.2)	25 (0.3)
Pathol.	6 (0.3)	66 (0.8)	72 (0.7)
Total	18 (1)	79 (1)	97 (1)

other forms of arthritis differed ($p<0.001$) when calculated separately for transient synovitis ($p<0.001$) and septic arthritis ($p<0.05$) (Figure 3). A difference was also found in patients with Perthes disease ($p<0.01$), whereas no difference was found in patients with nonspecific arthralgia and reactive arthritis.

The sensitivity and specificity (66/79 and 12/18 respectively) were better for UJS-DIFF than for RCS (59/79 and 10/16) when the pathological limit of UJS-DIFF was 2 mm or more (Table 3). If the limit of pathological UJS-DIFF was lowered to 1 mm, the sensitivity rose to 77/79. The diagnostic value of UCB was equal to that of RCS.

A positive correlation was found between UJS-DIFF and SFV ($r=0.4566$, Figure 4) and

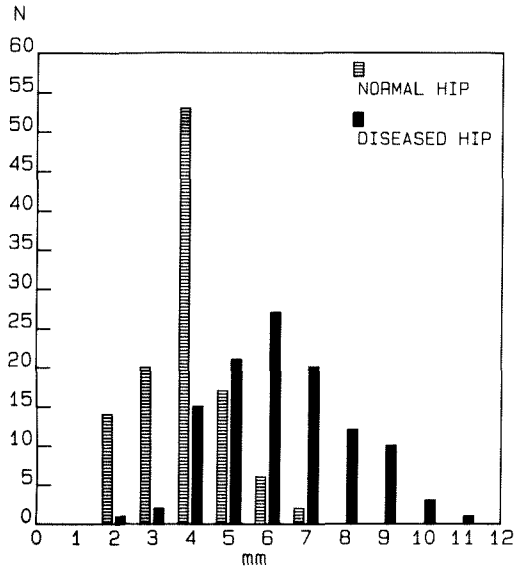

Figure 3. Distribution of ultrasonographic joint space (mm) of normal and diseased hips in 112 patients (N) with synovitis or arthritis.

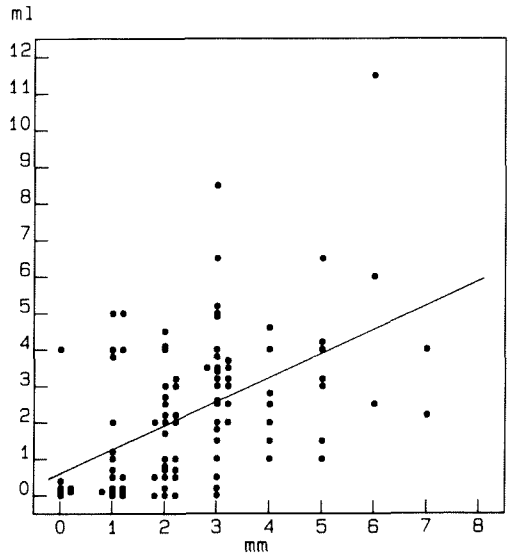

Figure 4. Correlation ($r=0.4566$) between ultrasonographic joint space difference (mm) and synovial fluid volume (ml) in 97 hips with joint aspiration.

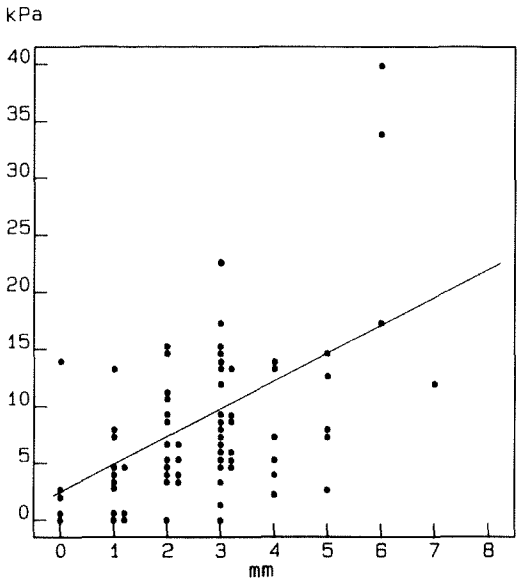

Figure 5. Correlation (r = 0.5227) between ultrasonographic joint space difference (mm) and the intra-articular pressure (kPa) with the hip in slight spontaneous flexion and neutral rotation. (N = 72). The trend was the same for all positions of measurement.

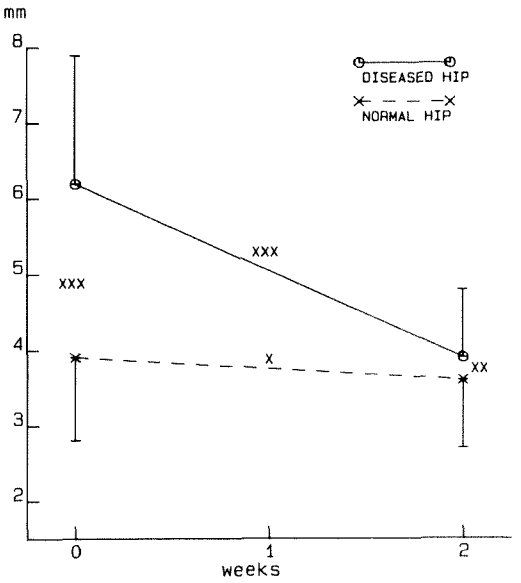

Figure 7. Change of ultrasonographic joint space (mm) during follow-up (weeks) in 102 hips with transient synovitis. ×, ×× and ××× = levels of significance ($p<0.05$, $p<0.01$ and $p<0.001$ respectively).

between UJS-DIFF and the intra-articular pressure (r = 0.5227, Figure 5).

The correlation between the UJS of both diseased and symptom-free hips and the age, height and weight of the patient was poor. In transient synovitis the UJS-DIFF decreased with the duration of the symptoms, as did the intra-articular pressure (Kallio & Ryöppy 1985).

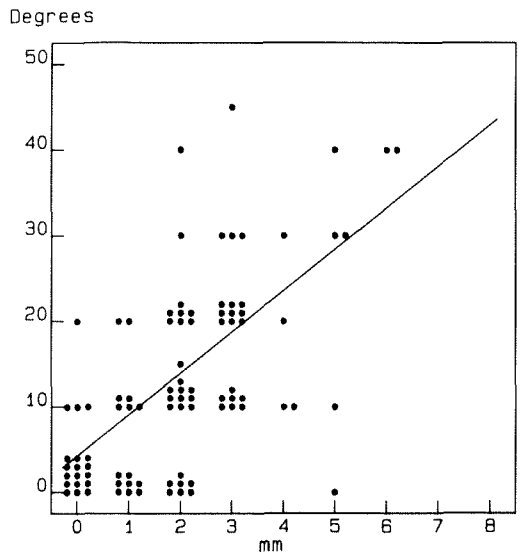

Figure 6. Correlation (r = 0.6356) between ultrasonographic joint space difference (mm) and restriction of hip movement to extension (degrees) in 92 cases with transient synovitis or other types of synovial effusion.

The restriction of joint movement in Perthes disease was as severe as in transient synovitis, but the SFV (0.7 ± 0.8 vs. 2.5 ± 1.7 ml) and the UJS-DIFF (1.7 ± 1.6 vs. 2.4 ± 1.5) were both smaller ($p<0.001$). A positive correlation was seen between UJS-DIFF, and restriction of joint movement in all directions of joint motion when the patients with Perthes disease were excluded. The highest r-value was for restriction of extension (0.64; Figure 6) and for restriction of extension, flexion and rotation together (0.54).

The amount of synovial effusion decreased rapidly in patients with transient synovitis ($p<0.001$) as judged by the UJS measured 2 weeks after admission (Figure 7). However, the UJS was still greater in the diseased hip than in the healthy hip. The reduction in synovial effusion followed the clinical course as most of the patients still had some restriction in range of motion of the joint at re-examination.

Discussion

The patients with Perthes disease did not show as clear a joint space difference as those with transient synovitis, even though the clinical restriction of movement was the same. We conclude that in Perthes disease the restriction of

joint movement was caused by capsular adhesions or cartilaginous incongruence rather than by synovial effusion or high intra-articular pressure as seen in transient synovitis.

A child with bilateral synovitis of the hip is always a diagnostic challenge. The disease is far from common; we found six patients out of 96. In every case radiography gave negative results with symmetrical "capsular shadows", but the absolute width of the ultrasonographic joint space was greater than 6 mm on both sides. Bilateral joint aspiration confirmed the diagnosis.

The ultrasonographic image is formed by a reflection of the ultrasound beam from the borders of tissues of different density. Thus we conclude that the ultrasonographic image of the joint capsule is formed by the surface between the anterior capsule and the muscles in front of it. The image of the femoral neck and head is formed by the surface between the bone or cartilage and the loose synovial layer over them. It is evident that the space we call the UJS is formed by the synovial membrane and the synovial fluid together, because a clear zone (mean 3.9 mm) resembling fluid was seen also in symptom-free hips without synovial effusion. Thus the ultrasonographic border between the synovial space and the joint capsule is actually formed between the layers of the loose synovial membrane and the rigid capsule.

In the normal hip the amount of synovial fluid is minimal; this is supported by the fact that the width of the ultrasonographic joint space is not dependent on the size of the patient. This poor correlation also supports our theory on the origin of the ultrasonographic image of synovial space. Neither the ultrasonographic joint space of the diseased hip nor the amount of synovial fluid correlated with the size of the patient. This confusing result can be explained by the greater laxity of synovial membrane and capsule in younger children in spite of smaller volume of the joint compared to older children.

Although most of our patients were examined with a 3.5 MHz transducer, we recommend 5–7.5 MHz transducers in small children, and 3.5 MHz transducers only for teen-agers or adults in order to get as sharp a view as possible in the monitor. The measurement of joint space in the longitudinal projection proved to be more reliable than in the transverse projection, which was more sensitive for technical errors during the measurement. The ultrasonographic capsular blurring and thickening seen during the examination is a valuable part of arthrosonography for an experienced examiner. This finding obviously indicates tissue oedema around the diseased joint. The exact measuring of this change, for example the thickness of the capsule, has not yet proved satisfactory because of the inadequate sensitivity of the present ultrasonographic equipment.

Ultrasonography is valuable for early diagnosis of arthritis of the hip in children. The method can be used to monitor treatment of transient synovitis and septic arthritis.

Acknowledgements

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