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Hyperpressure in juvenile hip disease

Intra-articular pressure was measured in 94 hips in 81 children with Perthes' disease and various forms of synovitis of the hip. The pressure was elevated in Perthes' disease (3.4 kPa), transient synovitis (17.3 kPa), septic arthritis (20.2 kPa), reactive arthritis (28.0 kPa) and arthritis with urticaria (32.3 kPa). In transient synovitis the mean pressure was only 2.3 kPa in flexion, while a mean of 26.6 kPa was seen in the neutral position and in internal rotation. In children with synovial effusion of the hip, the position of immobilisation should therefore be in flexion of 30–45 degrees with slight external rotation. The neutral position or extension, even with simultaneous traction, may endanger the circulation of the femoral head.

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The synovial fluid effusion encountered in transient synovitis of the hip in children has been suggested as a possible etiologic factor of Perthes' disease (Spock 1959, Jacobs 1971). Increased intra-articular pressure (Tachdjian & Grana 1968, Barz & Torklus 1976, Barta et al. 1978, Kemp 1981) has been suggested as mediator because of the vascular anatomy of the proximal femur (Trueta 1959, Chung 1976).

A decrease in the circulation of the capital femoral epiphysis has been produced experimentally in puppies by increasing the intra-articular pressure, as measured by radioisotope or vascular dye uptake (Tachdjian & Grana 1968, Basset et al. 1969, Kemp 1981, Launder et al. 1981, Lücht et al. 1983). Perthes-like histological changes have also been reported in the hips of puppies after tamponades of 20–80 mmHg (3–11 kPa) for 4–8 h (Kemp 1981), 5 kPa for 12 h (Woodhouse 1964), 8 kPa for 10 h (Singleton & Jones 1979), and 27 kPa for 10 h (Tachdjian & Grana 1968).

No data are available on the normal intra-articular pressure of the human hip *in vivo,* but the pressure of hips after tamponade has been shown to depend on the position of the joint both in patients with fractured femoral neck (Soto-Hall et al. 1964) and in cadavers (Eyring & Murray 1964), with the highest pressures in internal rotation and extension. Soto-Hall et al. (1964) found values of 9 and 10 kPa in two patients with "idiopathic synovial effusion" with the hip in neutral position. Values of 3–9 kPa (Kloiber et al. 1983) and 7 kPa (Wingstrand & Egund 1984) were recently reported in hips with transient synovitis, but the positions of the joints during measurement were not given.

We wanted to collect basic information about intra-articular pressure in the most common juvenile hip diseases to see if the data offered some theoretical basis for treatment.

Patients and methods

The patients were aged from 6 months to 16 years, and they were treated at Aurora Hospital and Children's Hospital from May 1982 to December 1983. They all had pain in the hip region, limp, restricted movements of the hip or suspicion of synovial effusion based on radiographic and ultrasonographic (Jäppinen et al. 1984) data. The final diagnosis was based on radiographic appearance, result of hip aspiration, hematologic and serologic examinations and bacterial cultures from throat, blood, urine and synovial fluid.

Intra-articular pressure was measured in 94 hips in 81 children (Table 1); bilateral hip aspiration and pressure measurements were made in four cases. Normal pressure measurements were obtained from both hips in a patient with acute polymyositis first diagnosed as bilateral hip synovitis.

One case of transient synovitis and another of septic arthritis were excluded because no synovial fluid could be obtained and no pressure increase was noted, despite clinical, radiographic and ultrasonic evidence of synovial effusion. Two secondary pressure measurements after partial synovial aspiration were included for analysis of the pressure position and pressure-volume relationships only; these were cases of transient synovitis and arthritis with urticaria.

Diagnostic aspiration was made after admission and before any therapy was started. The equipment consisted of an 18-gauge needle and a 10-ml syringe joined by a three-way stopcock, and connected to the arterial pressure transducer (Model OLLI 224) by a plastic tube and another three-way stopcock. The system was hermetically filled with saline. The same antero-lateral aspiration technique was applied in all

Table 1. Diagnoses in 81 children with hip disease

	Patients	Hips
Transient synovitis	65	74
Perthes' disease	8	9
Septic arthritis or osteomyelitis	4	4
Reactive arthritis (Yersinia)	1	2
Arthritis with urticaria	2	3
Normal	1	2

cases by the same investigator (PK). General anesthesia was used. The intra-articular location of the needle was confirmed by aspirating a few drops of the fluid, which were then reinjected; by gently touching the anterior surface of the femoral neck or head, the needle was retained in the joint. The correct location was indicated by continuous pressure recording; if the needle moved out of the joint or its point became covered by synovial folds, this was seen immediately by a sudden drop in pressure or an absence of pressure-change after joint movements. The pressure was measured in a sequence of different joint positions according to A.A.O.S. (1969). The patient lay in a supine position on the table, which was the position of initial pressure (I) with both hips in slight spontaneous flexion and neutral rotation. Secondly, an assistant pulled on the extremity with force but without moving the patient (IT). Neutral extension (N) was applied by pressing the knee firmly onto the table, after which the joint was forced to internal (NIR) and external rotations (NER). The hip was flexed to 45 degrees (F) and traction (FT) was then applied as in IT. When still flexed, the hip was fully internally and externally rotated (FIR and FER), after which it was allowed to adopt the initial position. Finally, all obtainable synovial fluid was aspirated and the volume recorded.

The pressure changes were recorded graphically on a chart recorder (Model OLLI 206) with a scale of 0–40 kPa (0–300 mmHg). In cases with minimal pressure increases, as in patients with Perthes' disease, a scale of 0–4 or 0–20 kPa was used. If the values clearly exceeded 40 kPa, then these were read as 40 kPa. Loss of pressure during the procedure as a sign of leakage was found in only a few cases in which the values of the last positions were excluded.

Statistical analysis was carried out using BMDP programs; the significance levels were calculated by the *t*-test.

Results

As compared to normal, the intra-articular hip pressure was elevated in all the conditions studied (Table 2). It was very high in reactive arthritis and arthritis with urticaria, intermediate in transient synovitis, and relatively low in Perthes' disease.

In transient synovitis the pressure was higher ($p < 0.001$) in all other positions except F and FT compared with the initial position (Table 3); the pressure was lowest in flexion ($p < 0.001$). In Perthes' disease the position-related pressure differences were less dramatic; in all the patient groups the differences were greater if the initial pressure was high. No pressure increase was found during joint movements in the two normal hips; in fact, the neutral zero pressure seemed to become negative during extreme rotations.

The volume of synovial fluid in transient synovitis (2.4 ± 0.2 ml) differed ($p < 0.001$) from that of Perthes' disease (0.4 ± 0.2 ml). A positive correlation for the whole material was seen between synovial fluid volume and intra-articular pressure; the highest correlation ($r = 0.6729$) was obtained in forced extension (Figure 1); the r-value was 0.4506 for transient synovitis alone.

In transient synovitis the intra-articular pressure dropped with duration of symptoms (Figure 2). The opposite trend was seen in septic arthritis, and no difference was seen in Perthes' disease. In transient synovitis no changes were found in the amount of aspirated fluid

Table 2. Intra-articular pressure as mean kPa (SEM) in various juvenile hip diseases in three hip positions and the calculated mean of the pressure. See text for explanation of position symbols

Clinical diagnoses	Position of the hips			Average
	I	N	F	
Transient synovitis	8.6 (0.7)	17.3 (1.1)	2.3 (0.2)	9.8 (0.6)
Perthes' disease	2.4 (0.5)	3.4 (1.0)	2.6 (1.5)	2.8 (1.0)
Septic arthritis	8.9 (3.0)	20.0 (9.9)	1.3	10.1 (4.3)
Reactive arthritis	16.0 (1.3)	28.0 (2.7)	4.0	16.0
Arthritis & urticaria	23.0 (17.0)	32.3 (7.7)	5.7 (4.3)	20.3 (9.7)

Table 3. Intra-articular pressure in different positions of the hip in transient synovitis and Perthes' disease. See text for explanation of position symbols

Position of the hip	Transient synovitis			Perthes' disease		
	kPa	SEM	n	kPa	SEM	n
I	8.6	0.7	73	2.4	0.5	9
IT	5.9	0.7	29	2.9	0.4	5
N	17.3	1.1	68	3.4	1.0	9
NIR	26.6	1.5	62	3.3	0.8	8
NER	21.0	1.6	55	4.4	2.2	8
F	2.3	0.2	60	2.6	1.5	6
FT	1.7	0.2	20	1.0	0.4	4
FIR	13.8	1.5	53	3.0	0.4	4
FER	6.3	0.9	50	2.4	0.8	4

when duration of symptoms was taken into account.

Discussion

In transient synovitis the intra-articular pressure may reflect different stages of synovial irritation or various phases of the disease. For example, a low pressure may reflect minor synovitis, or it may reflect an initial phase of the disease or recovery from it, or both these factors may operate simultaneously. We found that the pressure was highest during the first 3 days after onset of symptoms, which is in agreement with the clinical course of most cases of this disease. As the loss of pressure was not associated with the decrease of synovial effusion, it may, perhaps, be due to changes in the compliance of the capsule.

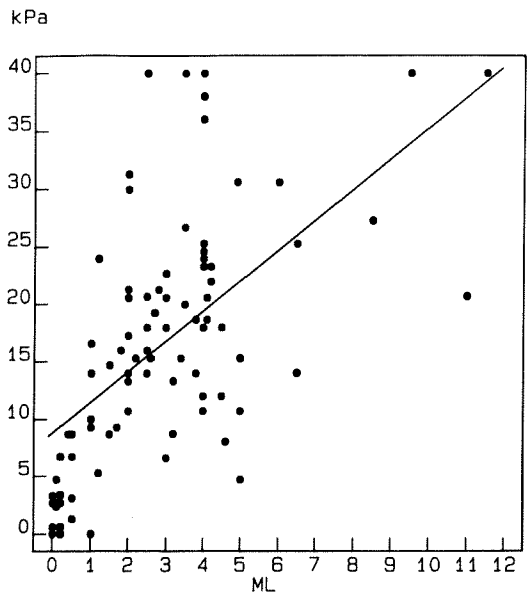

Figure 1. Relationship between intra-articular pressure in neutral position and amount of aspirated synovial fluid in 85 hips with Perthes' disease or various forms of synovitis.

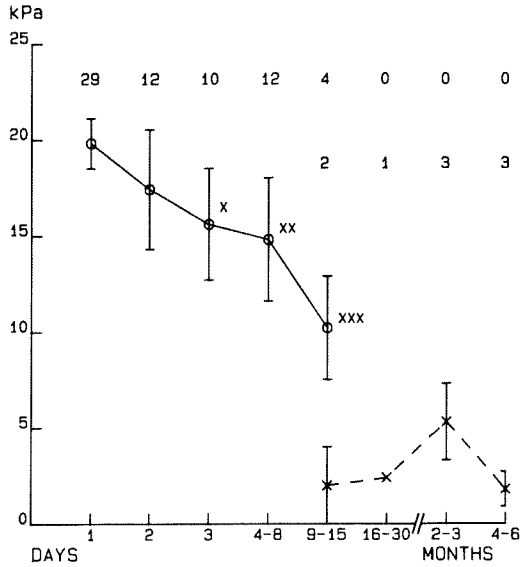

Figure 2. Intra-articular pressure in neutral position N related to time after onset of symptoms (mean ± S.E.M.). Transient synovitis (solid line) and Perthes' disease (broken line); the figures show the number of cases. Statistical differences in transient synovitis were calculated from the values of each period compared with the value of the first day; xxx $p < 0.001$, xx $p < 0.01$, x $p < 0.05$.

The differences between the various juvenile hip diseases were significant only when Perthes' disease was compared with the other forms of synovitis. The pressure in transient synovitis and septic cases seemed to be equal, but the duration of the symptoms may play an important role; the natural course and the period of highest pressure in septic arthritis may differ from those of transient synovitis. The durations of the symptoms in our three septic cases were 1, 2 and 4 days, and the pressures in neutral position were 8.7, 12 and 40 kPa, respectively.

Our finding that the intra-articular pressure in Perthes' disease was lower than in transient synovitis does not rule out the importance of intracapsular tamponade in the development of avascular necrosis: the pressure may have been higher during the preceding stages of the disease. In fact, six of nine pressure recordings were made more than 1 month after the onset of symptoms. The magnitude of a critical intra-articular pressure in terms of the circulation of

the capital femoral epiphysis is still unsolved. Nevertheless, we conclude that the intra-articular pressure in transient synovitis is capable of causing a reduction of blood flow in the femoral head with the hip in the neutral position. The high intra-articular pressure lasts for several days and, as evidenced by animal experiments, the danger of necrosis is thus real. It is, however, a well-known fact that children with hip disease adopt a position of flexion and slight external rotation, which, as confirmed by our data, is that of minimal pressure. It is therefore probable that the decrease of epiphyseal circulation was insignificant in our patients treated with bed rest without skin traction. This is supported by preliminary observations that none of our 75 hips has developed Perthes' disease.

The exact position of the hip should be recorded in clinical and experimental studies of the parameters possibly affected by intra-articular pressure. The blood flow of the proximal femoral epiphysis measured by radioisotope uptake (Kloiber et al. 1983) will be greatly influenced by the position of the hip with synovial effusion.

In the treatment of synovial effusions of the hip in children, the position of immobilisation should be 30–45 degrees flexion with slight external rotation. Immobilisation with the hip in the neutral position should be condemned as harmful because the intra-articular pressure in this position is high, even in traction. Traction with the hip in the painless position of flexion does not seem to offer any significant advantage.

Acknowledgements

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