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NATURAL HISTORY OF AVASCULAR NECROSIS FOLLOWING TRAUMATIC HIP DISLOCATION IN CHILDHOOD

A Review of 145 Cases

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One hundred and forty-five cases of traumatic hip dislocation in children, complicated with avascular necrosis, were reviewed. Necrosis involved the capital epiphysis and the growth plate, and the resulting changes followed different patterns. These changes in younger children were mostly dependent on the disturbance of the growth plate, and resembled Calvé-Perthes' disease in most of its features. In older children necrosis of the femoral head occurred, as in adults. Analysis of long-term results suggests that the frequency of deformities is extremely high, and a significant incidence of degenerative joint disease can be anticipated.

Key words: avascular necrosis; children; hip; hip dislocation

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Previous studies discussing the radiological patterns of avascular necrosis (AN) following traumatic hip dislocation in childhood (THDC) for the most part contain conflicting opinions. A few authors have stressed the incidence of certain growth disturbances of the proximal extremity of the femur (PEF) following THDC (Glass & Powell 1961, Gouin 1961, Hovelius 1974); however no report linking these disturbances with AN has been presented.

Interference with the blood supply of the PEF in a child should result in AN, not only of the epiphyseal ossific nucleus, but also of the growth plate (GP) (Duriez 1977, Pous & Dimeglio 1977, Kalamchi & MacEwen 1980). On this basis, the observations to be included under the term AN should be those with radiologic signs of necrosis of the ossific nucleus, or with changes indicating necrosis of the GP, or both.

A previous report on THDC by the author included four cases complicated with AN, as defined in this paper (Barquet 1979). Since then one further case has been recorded by us. In addition, a review of the literature, together with personal communications, has permitted the compilation of a large number of well documented cases.

The purpose of this retrospective review is to outline the natural history of AN following THDC on the basis of our observations and those previously reported.

PATIENTS AND RESULTS

Including the author's observations, a total of 145 cases of AN following THDC in patients under 16 years have been collected (Table 1). This review involves all the available roentgenographic information included in the records of these patients.

Roentgenographic patterns

The radiological changes indicating AN secondary to THDC followed different but constant patterns, which could be related to the sites and amount of involvement

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Table 1. A total of 145 collected cases of avascular necrosis following traumatic dislocation of the hip in children*

Author	Year	Cases	Author	Year	Cases
Elmslie, R.	1919	1	Altav, H.	1962	7
Sundt, H.	1920	2	Funk, F.	1962	2
Rehbein, M.	1922	1	Ruffoni, R.	1962	1
Fairbank, H.	1923	1	Ulloa, I.	1962	4
Bergman, E.	1931	1	Ricci, F. et al.	1963	1
Nicolaysen, K.	1931	1	Liuboshits, N. et al.	1964	2
Elmslie, R.	1932	1	Bonvallet, J.	1965	1
Pouzet, F.	1932	2	Fernández, E.	1965	1
Phemister, D.	1934	1	Titze, A.	1965	2
Blumensaat, C.	1936	1	Giglio, H. et al.	1966	1
Cuche, M.	1937	2	Byram, G. et al.	1967	1
Funsten, R. et al.	1938	1	Scialpi, G. et al.	1967	1
Goldenberg, R.	1938	1	Helal, B. et al.	1967	1
Paltrinieri, M.	1938	1	Chapchal, G.	1968	1
Birch-Hirschfeld, A.	1939	1	Donaldson, W. et al.	1968	2
Kleinberg, S.	1939	1	Rigault, P. et al.	1968	1
Mutschler, H.	1939	1	De Paoli, P. et al.	1968	1
Watson-Jones, R.	1940	1	Hipp, E.	1969	6
Banks, S.	1941	1	Matsubara, T. et al.	1976	2
Bohler, L.	1942	1	Fina, C. et al.	1970	2
Quist-Hanssen, S.	1945	1	Boitzy, A.	1971	1
Urist, M.	1947	1	Lam, S.	1971	1
Lezama, L.	1950	1	Kanan, S. et al.	1972	2
Paus, B.	1951	1	Pearson, D. et al.	1973	1
Zarotti, F.	1951	1	Pollen, A.	1973	1
Mau, C.	1953	1	Coleman, S.	1974	1
Barbieri, M.	1955	1	Hovelius, L.	1974	1
Jensen, H.	1955	1	Rana, M.	1974	2
Ruiz, V.	1955	1	Schwartz, D. et al.	1974	1
Scholder, C.	1955	2	Chotigavanichaya, C.	1975	7
Picchio, A.	1956	1	Labaziewicz, L.	1976	1
Bohler, J.	1957	1	Macfarlane, I. et al.	1976	2
Jantzen, P.	1958	1	Nerubay, J.	1976	1
Jonasch, E.	1958	1	Canale, S. et al.	1977	5
Cros, A.	1959	1	Rogala, P. et al.	1977	1
De Wulf, A.	1959	1	Hidalgos, A.	1978	2
Seewald, R.	1960	1	Soares, L.	1978	3
Davalli, C.	1961	1	Barquet, A.	1979	4
Freeman, G.	1961	2	Guillaume, E.	1979	2
Glass, A. et al.	1961	13	Lavianos, I.	1979	1
Gouin, J.	1961	1	Weigand, H. et al.	1979	1
Haliburton, R. et al.	1961	1	Epstein, H.	1980	3
Piggot, J.	1961	1	Barquet, A.	1981	1

* A full list of references to Table 1 is available from the author on request.

of either the GP or the femoral head, or both. When referred to the age of the patients, each pattern appeared to fall naturally into two distinct periods of childhood. Therefore these changes were correlated to two different age groups as follows.

Group I – Younger children (less than 12 years old). The initial change in the capital epiphysis was the radiographic appearance of increased density. This was followed by different degrees of flattening, but a definite fragmentation was not documented in every instance.

Figure 1. Fifteen years after traumatic dislocation of the hip reduced 72 hours after the injury in a 9-year-old boy. Shortening and widening of the femoral neck, with enlargement and diminution in height of the head. No alteration of the neck – shaft angle. These changes would mainly result from central and symmetrical damage to the growth plate.

The last stage was that of re-ossification. The varied roentgenographic appearance reflects the different degrees of severity of the avascular disease.

The early roentgenographic signs of damage to the GP were usually subtle, and consisted of defects at the metaphysis. These were followed by retardation of longitudinal growth of the femoral neck, leading to different degrees of shortening. Certain typical patterns of GP damage could be found, viz. medial, lateral or central damage to the GP, including diffuse damage to the plate with the predominant lesion being on its medial or lateral side. Whatever the pattern, a constant finding was widening of the femoral neck. This process progressed until skeletal maturity. Medial damage led to shortening on this side of the neck, with consequent varus angulation. Involvement of the lateral site led to valgus angulation of the neck. Central damage led to a symmetrical growth disturbance, with shortening of the neck as a whole, but without significant alteration of the neck-shaft angle (Figure 1). Diffuse damage to the GP with a predominating lesion on the medial or lateral side was frequent and led to asymmetrical shortening of the neck and a varus or valgus angulation (Figure 2).

A correlation between the changes of the GP and those of the femoral head could be found. If damage to the ossific nucleus and the GP had been mild, the femoral head regained its normal shape and height. Whenever damage to the GP led to widening and shortening of the femoral neck, the development of the head was also abnormal, showing a clear parallelism

Figure 2. An example of diffuse damage to the growth plate, predominating on its lateral side. Asymmetrical widening and shortening of the femoral neck has led to valgus angulation. The femoral head has grown in accordance with its modified base, and coxa magna has resulted. This complex deformity was documented 6 years after open and delayed reduction of a traumatic hip dislocation in a 7-year-old boy.

Figure 3. Thirty-seven months after traumatic dislocation of the hip in a 14-year-old girl. Frontal view showing that changes of avascular necrosis in older children are restricted for the most part to the femoral head, resembling those occurring in adults.

with the GP changes, and this applied not only to widening but also to diminution in height. If damage to the GP was moderate, then widening predominated over shortening, and the shape of the femoral head was the same as that seen in coxa magna (Figure 2). However, if damage to the physis was significant, shortening was the most apparent change, and the femoral head lost its spherical shape, undergoing flattening, as seen in coxa plana. It seemed that the head, or a part of it, had lost in height what it had gained in width.

These growth disturbances were dynamic; they progressed and even modified during the skeletal growing period. Acetabular development followed the alternating deformity of the femoral head, probably as a result of their adaptative interrelation.

Group II – Older children (12–15 years). In this age group the incidence of growth disturbances was very mild; changes were restricted, for the most part, to the femoral head, resulting, in some cases, in slight or moderate deformities of the femoral neck (Figure 3).

Thus the roentgenographic changes in older children appeared somewhat similar to those occurring in avascular necrosis of the femoral head in adults.

Roentgenographic results

Fifty-three patients in this series were observed for between 2 and 31 years, with a median of 6.5 years. The roentgenographic rating was based on capital morphology and size; cervical length, width and shape; the acetabulum and the joint space. According to these criteria, the observations seemed to fall naturally into the following types:

Type 1: Absence of deformities;

Type 2: Minimal enlargement and no shortening of the head and neck, slight varus or valgus angulation of the neck, normal acetabulum;

Type 3: Enlargement of the head, but maintaining, at least partially, its spherical shape; significant enlargement of the neck with moderate shortening; varus or valgus angulation of the neck; enlarged acetabulum. This is coxa magna;

Type 4: Enlargement and significant diminution of the height of the femoral head; shortening and widening of the femoral neck, with varus or valgus angulation; correlative deformities of the acetabulum. This is coxa plana;

Type 5: Changes resembling those of avascular necrosis of the femoral head in adults, with minimal or no signs of damage to the GP.

These types were designated with an added *a* when the joint space was normal, and with an added *b* if narrowing or obliteration of the joint space was present.

The reviewed cases of younger and older children were analyzed according to these criteria (Table 2).

The evaluation of these results in children aged less than 12 years at the time of dislocation showed the significance of growth disturbances in the pathogenesis of the sequelae: nearly 95 percent of the observations indicated coxa magna or coxa plana. *Restitutio ad integrum* of the PEF, though extremely infrequent –2.65 percent – was also found.

In patients between 12 and 15 years of age, the radiological changes resembled in most cases those of avascular necrosis in adults, with minor or no signs of physeal necrosis. In this group the joint space underwent precocious narrowing or obliteration in a large number of cases (53 percent).

Table 2. Roentgenographic results in 53 collected cases of avascular necrosis following traumatic hip dislocation in children, with a minimum follow-up period of 2 years

Younger children (<12 years old)			Older children (12–15 years old)		
Type	No. of cases	Percent	Type	No. of cases	Percent
1a	1	3	1	0	0
2a	1	3	2	0	0
3a	19	50	3a	2	13
4a	16	41	4a	2	13
4b	1	3	5a	3	20
			5b	8	54
Totals	38	100	Totals	15	100

Interval before diagnosis

Avascular necrosis was diagnosed at varying intervals following dislocation. Diagnosis was made in the first 6 months after the accident in one-third of the observations, in the first year in nearly two-thirds of cases, and in more than 92 percent of cases in the first 24 months following dislocation.

DISCUSSION

AN of the PEF is a most serious complication following THDC, and accounts for the poor prognosis of this injury.

There is controversy concerning the duration of the interval preceding the radiological diagnosis of AN after THDC. The present investigation leads us to suggest that an interval of 2 years should be chosen, at least for statistical purposes. However, this applies to roentgenographic diagnosis. A bone scan performed shortly after dislocation should determine those cases with initial ischemia and would be of diagnostic and prognostic significance (Meyers et al. 1977).

The development of AN after THDC depends on the amount and duration of the vascular involvement of the PEF. Hipp (1969) found that when irreversible occlusion has occurred, necrosis is to be expected, and a relationship between the location of the occlusion and the topography of AN can be anticipated.

Our findings show that in younger children the radiological changes of AN following THDC are similar to those of Calvé-Perthes' disease in most of its features. These changes, as already shown, for the most part result from growth disturbance, and this can be also applied to Perthes' disease.

AN involving the germinal and proliferative layers of the plate is responsible for growth disturbance in this area, mainly retardation or even arrest, and also disorganization of the plate. The main changes are cervical enlargement and shortening. The enlargement results from apposition of cartilaginous columns at the periphery of the physis (Rigal 1961). As shown by Duriez (1977) and Guglielmone (personal communication 1980), the deformities of the femoral head in children undergoing AN correlate with the physeal damage, and the present investigation confirms these opinions. Consequently, this role of the physis is critical in establishing patterns of involvement (Bucholz & Ogden 1978).

Ferguson & Howarth (1935) thought coxa magna to be due to a compensatory increase in the blood supply to the hip joint following an initial ischemic catastrophe. However, we consider that coxa magna is the result of growth disturbance of the PEF developing AN.

The normal development of the acetabulum is affected by these deformities of the PEF, as an abnormal avascular femoral head does not supply adequate mechanical stimulus (Kalamchi & MacEwen 1980).

In older children between 12 and 15 years of age, the potential of the GP has diminished a great deal or is absent. Therefore the radiological changes of AN following THD in this age group will resemble AN of the femoral head in adults.

Altogether, the frequency of sequelae has been extremely high in this series, and a significant incidence of degenerative joint disease in the future life of these children may be anticipated. No therapeutic measures have been shown to definitely influence the natural history of avascular necrosis (Bucholz & Ogden 1978, Kalamchi & MacEwen 1980). Only reconstructive surgical procedures may improve the mechanics of the hip joint. Therefore, periodical evaluation of the hip would help in the planning of adequate treatment for these children, the purpose being the achievement of better long-term results.

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