AMNIOTIC ARTHROPLASTY FOR TUBERCULOSIS OF THE HIP

A PRELIMINARY CLINICAL STUDY

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Arthroplasty of the hip using an interposed multi-layered cap of amniotic membrane is reported in 28 patients with tuberculous arthritis. The disease had been present from one to seven years, and five patients had multiple discharging sinuses. Follow-up was from 30 to 46 months.

Amniotic tissue caused no inflammatory reaction, or obvious rejection, and 25 patients were free of symptoms, with a good range of movement and a stable joint. The three failures were caused by dislocation, fracture of the femoral neck and extra-articular bone formation respectively. Amniotic arthroplasty seems to be capable of providing a painless, mobile and stable joint in patients with tuberculosis of the hip.

The hip joint is important, not only for walking, but also for the squatting, kneeling or bowing required by custom and tradition in Indian society. Tuberculosis of the hip has crippled many patients in Asia and elsewhere. New antituberculous drugs have made direct surgery possible and this has varied from debridement or excision of the joint to arthrodesis.

In the West, tuberculosis has declined in the past few decades, and arthrodesis has provided one satisfactory solution for the infected hip. Few attempts have been made to provide painfree movement and stability of the joint. Wilkinson's (1957) joint debridement procedure failed in adults and was only partially successful in children. The Girdlestone excision arthroplasty sacrificed stability for movement but resulted in a grotesque gait and marked limb shortening.

Katayama, Itami and Marumo (1962) attempted to retain movement in tuberculosis of the hip. They combined joint debridement with the interposition of fascia or OMS membrane (woven fabric catgut compressed into a thin membrane and chemically strengthened by immersion in chromic solution). The results were not encouraging, and the procedure was given up. Interposition of soft tissues had been widely employed in non-infective conditions and included the use of fascia (Campbell 1924), skin (Kallio 1957) and peritoneum (Kuznetsov 1962). Persistently poor results were obtained and the procedures were discarded.

Biological tissue would be ideal for interposition arthroplasty, provided that it did not elicit any host reaction and was capable of functional adaptation. The clinical

application of fetal membranes presents interesting possibilities and there have been more than 20 articles on the subject since 1970, though reports on their use in joints are rare. Davis (1910) first reported the use of fetal membrane for skin covering, while Stern (1913) and Sabella (1913) used amniotic membrane for burns and ulcerated skin. They both reported no infection, relief from pain and an increased rate of epithelialisation.

Brindeau (1934) and Burger (1938) used amnion in forming an artificial vagina. De Roth (1940) reported its successful use in conjunctival defects and Douglas (1952) investigated fetal membrane as an allograft for large wounds. In 1962, Masee *et al.* confirmed that fetal membranes produced few, if any, adhesions when used in the abdomen as a replacement for parietal peritoneum. Trelford *et al.* (1975) used amnion as a biological dressing for full thickness wounds while Ninman and Shoemaker (1975) recommended amniotic membrane for the treatment of burns. Volkov in 1973 reported the use of amniotic membrane in congenital dislocation of the hip.

Vishwakarma, Krishnan and Khare (1980) reported experiments on the interposition of amniotic membranes in dog joints, artificially made arthritic by destruction of the articular cartilage and complete synovectomy and capsulectomy. The findings were interesting: the range of movement achieved was comparable to normal, a cleft in the plane of movement appeared in the multi-layered amniotic cap after two months, and there was progressive formation of fibrous tissue in the peripheral layers. Functional metaplasia was apparent from the appearance of fibrocartilage which indicated adaptation to stress. Another finding was that synovial-like tissue lined the walls of the cleft; its origin remained uncertain. There were no rejection phenomena or inflammatory responses.

This animal study encouraged the trial of interposition arthroplasty of the hip for tuberculosis, using a cap

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0301 620X/86 1013 \$2.00

of amniotic membrane with the twin objectives of eradicating the disease and providing a painless, stable and mobile hip.

MATERIAL AND METHODS

The study was conducted at the Central Institute of Orthopaedics, Safdarjang Hospital, New Delhi, from 1980 onwards, on 28 patients with tuberculosis of the hip, all of whom had an amniotic arthroplasty. The diagnosis of tuberculosis was based on clinical and radiological findings and laboratory investigations. It was confirmed by histopathology but not by bacteriology. Larson's (1963) hip disability rating scale was used to assess function before and after operation.

The youngest patient was aged 10 years and the oldest 70 years (mean 27 years), with only five over 40 years of age. The duration of the disease ranged from one to seven years. Details are given in Table I. Five patients had discharging sinuses with superadded bacterial infection before operation. The organism was *Pseudomonas aeruginosa* in three cases, *Escherichia coli* in one and *Klebsiella* sp in the fifth. One patient had a healed sinus. Twenty-four patients had fibrous ankylosis with absent or restricted movement and four had bony ankylosis. The degree of radiological destruction ranged from mild in 5 cases and moderate in 11, to severe in 8 cases, with complete disorganisation in 4 patients.

Follow-up was from 30 months to 46 months. Anti-tuberculous drugs which included streptomycin, INAH, ethambutol, thiacetazone and rifampicin were given for three weeks before operation. Preliminary traction was used in some cases with fibrous ankylosis to help correct the deformity.

Preparation of the amniotic cap. The amniotic cap was prepared according to a technique which has been standardised at this centre. Fresh placentae were collected from the maternity centre and washed in running tap water for 10 minutes. Amnion was separated from the chorion, and amniotic membrane, denuded of mucus, was collected in a beaker containing normal saline. Layers were then cut into squares and piled on a glass mould the size of a femoral head. There were 50 to 60 layers in each cap, the mesenchymal surface of the membrane always facing the glass mould. The amniotic cap was dried at ambient temperature for six to eight hours and a purse-string suture was then applied (Fig. 1). The dried cap was sterilised in 1% β -propiolactone for two hours before operation, according to the technique of LoGrippe *et al.* (1957). Repeated bacteriological studies revealed the efficacy of the β -propiolactone as a sterilising agent.

Technique of operation. In adults the hip joint was exposed by a posterior approach; in children an anterior approach was used to avoid contamination of the wound by faecal matter. The iliopsoas tendon was routinely divided. Trochanteric osteotomy with subsequent distal transfer of the trochanter was used in cases with bony

ankylosis to allow a better exposure, and also in cases of total destruction of the head and neck of the femur to improve abductor power and, in some cases, to avoid impingement of the trochanter on the edge of the acetabulum.

The femoral head and the acetabulum were then reamed to expose healthy bleeding cancellous bone. The femoral head was shaped in a valgus direction and the acetabulum in cephalad and medial directions to produce some medial displacement of the reconstructed joint (Fig. 2). Care was taken to obtain smooth surfaces and reasonable congruity. Total synovectomy and capsulectomy were essential parts of the technique, the most crucial stage of the operation being the excision of the anterior and medial capsule and synovial membrane. Care was needed to avoid injury to the femoral vessels. The posterior and superior rim of the acetabulum were excised to the extent that part of the head was uncovered when the limb was in neutral position.

Fig. 1

Fig. 2

Figure 1—A cap including 50 to 60 layers of amniotic membrane being prepared on a glass mould. Figure 2—Diagram to show the medial displacement of the hip at operation. The heavy lines show the postoperative position.

The prepared amniotic cap was then placed over the femoral head and anchored loosely to the neck with a purse-string catgut suture. In cases with total destruction of the head and neck (Cases 3, 4 and 9), a Colonna type of reconstruction was performed, the abductors being transplanted distally and the proximal shaft, covered with an amniotic cap, being placed in the acetabulum. In Case 20, also with total loss of the femoral head and neck, reconstruction was attempted by osteotomising the greater trochanter and placing the medial portion together with an iliac bone graft into the acetabulum, interposing an amniotic cap. All small bony fragments were then removed by cleansing with saline solution and suction. The wound was closed in layers with suction drainage for 48 hours. The limb was supported in a Thomas splint in abduction.

Postoperative care. Static quadriceps exercises and active ankle and toe movements were started as soon as the patients recovered from anaesthesia. On the fourteenth day, after the removal of stitches, passive hip exercises were started three times daily in all directions except adduction; this facilitated the formation of a cleavage

between the layers of the amniotic cap (Vishwakarma *et al.* 1980). Patients were also encouraged to perform active hip exercises.

The splint was removed after four weeks and resisted active exercises were started. During the fifth week patients started walking with crutches, taking no weight on the affected limb. They were discharged from hospital after six weeks and continued antituberculous drugs at home for periods ranging from 4 to 18 months, usually 6 to 10 months. Partial weight-bearing was allowed at 18 weeks and full weight-bearing after 20 weeks. Crutches were discarded after 24 weeks.

RESULTS

The wound healed by primary intention in all but two cases, in which superficial infection was controlled by antibiotics. In no case was there recurrence of the disease during follow-up. The results were evaluated by the Larson hip disability rating scale (Tables I and II). The operation was a success in 25 patients, who had no pain

and gained a good range of movement. All 25 could manage their daily chores, 22 of them could squat, 24 could sit cross-legged, and all of them could relax comfortably on chairs. There was an average 0.5 cm increase in shortening after operation. Bone condensation was seen radiographically in 21 cases, but in four patients (Cases 2, 4, 14 and 22) there was minimal resorption, which, surprisingly, did not compromise the result. Radiographs of four patients, with postoperative clinical photographs of one of them, are seen in Figures 3 to 14.

Failures. One patient (Case 3) had a dislocation after a Colonna type of arthroplasty. Another patient (Case 26), an elderly man with long-standing tuberculosis and secondary infection of the hip, did not gain a satisfactory range of movement postoperatively; at a revision operation he sustained a fracture of the neck of the femur which failed to unite. The third failure (Case 23) suffered re-ankylosis from massive extra-articular bone formation. None of the three failures was caused by the amniotic element of the arthroplasty.

Table I. The clinical findings before operation in 28 patients having an amniotic arthroplasty for tuberculosis of the hip

Case	Age (years)	Sex	Duration of disease (years)	Larson score			Fixed flexion* (degrees)	Range of flexion (degrees)	Shortening (cm)	Total Larson score
				Pain	Function	Gait				
1	18	M	3	0	6	4	40	0	5	10
2	10	M	3	0	6	4	70	0	4	10
3	15	M	3	10	12	6	80	0	4	28
4	20	M	4	0	6	6	10	10-70	7	19
5	18	M	7	0	6	4	50	50-80	3	16
6	32	M	4	0	6	4	15	0	1	20
7	29	M	4	0	14	8	60	60-80	3	23
8	45	M	1	10	15	4	20	20-70	1	38
9	25	M	2	0	8	6	30	30-100	4	19
10	24	F	1	10	15	8	30	30-60	1	36
11	60	M	4	10	12	6	30	30-90	1	37
12	34	M	3	10	12	6	45	0	2	30
13	40	F	1	10	14	6	40	40-90	2	37
14	23	M	7	10	12	4	45	0	3	26
15	16	F	3	0	12	4	15	0	3	22
16	15	M	2	10	12	4	60	60-90	2.5	29
17	20	M	2	30	4	4	120	0	4	38
18	16	F	2	10	14	6	15	0	2.5	38
19	29	M	4	10	14	6	60	60-90	2	35
20	26	M	5	20	6	4	80	0	3.5	30
21	16	F	7	0	15	6	80	0	4	21
22	16	M	4	0	14	6	60	0	1.5	22
23	14	F	3	0	6	4	60	0	4	10
24	29	M	2	0	14	6	50	50-70	2.5	22
25	60	M	4	10	12	6	40	0	2.5	30
26	70	M	7	0	6	4	50	0	3	10
27	14	M	3	0	12	8	60	0	2	22
28	22	M	2	0	6	4	40	0	1	12

* All except four patients had a fixed adduction or abduction deformity; all except eight had a fixed rotational deformity. There was no free abduction/adduction or rotational movement in any patient before operation

DISCUSSION

Amniotic arthroplasty aims to provide painfree movement and stability for the tuberculous hip joint. Arthrodesis of the hip does not suit patients in the East, because social customs necessitate squatting, kneeling and sitting cross-legged. Other possible operative procedures might well have helped to eradicate the disease but might not have succeeded in providing a painless, mobile and stable hip with safety.

Of the 28 cases in this series followed for more than 30 months, 25 were successful, and primary healing took place even where discharging sinuses were present before operation. This seems even more significant since the dosage of antituberculous drugs after the patient was discharged tended to be irregular. This was partly because the patients were free of symptoms and believed that they had been cured.

Trelford *et al.* (1975) and Walker, Cooney and Allen (1977) demonstrated clinically the healing effect of amnion as a dressing for pyogenic wounds, but gave no

explanation. Vishwakarma, Krishnan and Khare (1981) found that for infected bedsores and degloving injuries of the limbs, dressing the wounds with amnion not only controlled infection but also resulted in the rapid appearance of healthy granulation tissue covering exposed bone, which soon made the wound suitable for a split-thickness skin graft. The possibility that the specific antibacterial substance lysozyme (Fleming 1932) was present in amniotic membrane was considered by Robson, Samburg and Krizek (1972) but they concluded that this was not so. Gruss and Jirsch (1978) have shown that amniotic membrane applied to infected and contaminated wounds decreases the bacterial count. The presence of a weak antibody-like substance in amniotic fluid has recently been demonstrated and there is a strong possibility that it is elaborated in the epithelium of amniotic membrane (Galask and Synder 1970; Sachs and Stern 1979).

Induction experiments have shown that human amnion can induce the formation of epithelial cells in the

Table II. The results after operation in 28 patients having an amniotic arthroplasty for tuberculosis of the hip

Case	Follow-up (months)	Larson score			Fixed flexion† (degrees)	Range (degrees)					Shortening (cm)	Total Larson score
		Pain	Function	Gait		Flexion	Extension	Abduction	Adduction	Rotation		
1	46	35	25	8	—	100	20	40	30	50	4	84
2	46	35	25	8	—	100	20	40	20	30	5	83
3	46	30	25	6	20	Hip dislocated					5	64
4	44	35	25	8	—	90	20	40	20	30	4	83
5	44	35	28	8	—	100	20	30	30	40	4	86
6	44	35	24	8	—	90	15	30	30	30	1.5	83
7	43	35	28	8	—	110	20	40	30	40	3.5	87
8	42	35	28	10	—	100	20	30	30	50	2	91
9	43	35	30	8	—	110	20	40	20	40	3	89
10	40	35	30	10	—	100	15	30	30	40	1.5	92
11	40	35	28	10	—	110	15	40	30	40	2	91
12	40	35	30	10	—	110	15	40	30	50	3	90
13	38	35	30	10	—	90	10	30	30	40	2.5	92
14	38	35	28	10	—	100	15	40	20	40	3.5	88
15	37	35	28	8	—	110	20	45	30	50	4	87
16	37	35	30	10	—	110	15	40	30	50	3	91
17	37	35	28	8	—	90	20	30	30	40	4	86
18	36	30	24	10	—	90	15	40	20	40	3	79
19	36	35	30	10	—	110	15	40	30	40	3	90
20	35	30	20	6	10	70	0	30	20	20	4	69
21	35	35	28	8	10	90	0	20	30	20	4.5	82
22	35	35	25	10	—	120	20	40	30	40	2	88
23	34	30	14	6	10	Extra-articular ankylosis					4	58
24	33	35	30	10	—	100	20	40	30	50	3	91
25	32	35	28	10	—	110	20	30	20	40	3	88
26	31	20	14	4	20	Fracture of neck of femur					4	46
27	30	35	28	10	10	90	0	40	30	40	3	88
28	30	35	28	10	—	100	20	40	30	40	2	91

† After operation only two patients had a fixed deformity in the coronal plane

Fig. 3

Fig. 4

Case 22. Radiographs of the right hip before and 35 months after operation, showing a well-formed joint space. Clinical photographs of the patient squatting and sitting cross-legged after operation.

Fig. 5

Fig. 6

Fig. 7

Fig. 8

Fig. 9

Case 9. Radiographs of the left hip. Figure 7—Before operation, showing total destruction of the joint. Figures 8 and 9—At 6 months and 43 months respectively after a Colonna-type arthroplasty with an amniotic cap.

Fig. 10

Fig. 11

Case 12. Radiographs before and 40 months after amniotic arthroplasty. A well-marked joint space has developed.

Fig. 12

Fig. 13

Fig. 14

Case 13. Radiographs of the left hip. Figure 12—Before operation. Figures 13 and 14—At 20 months and 38 months respectively after operation. Note the joint space, the contour of the femoral head and the new bone formation at the lateral border of the acetabulum.

chorio-allantoic membrane of the fertilised chicken egg (Sawyer, Abbott and Trelford 1972) and this method indicates one avenue of research. Induction phenomena have not been seen in the clinical situation as yet, but the complexities of the amnion cell suggest that it may have multiple functions. Vishwakarma *et al.* (1980) observed the formation of joint-type tissues when multilayered amniotic cap was interposed, and this indicates that the human amnion may be capable of inducing the formation of diverse tissues.

More study is needed of the immunology of the amniotic membrane. There was no immunological reaction or rejection phenomenon in any of our patients. Embryonic cells may be immunologically inert because of the absence of antigen which determines histocompatibility (Boyd and Hamilton 1970). Unusual immunology could be due to fetal membrane collagen (Burgeson *et al.* 1976). Attempts to detect antibodies or a cell immune response to amniotic membrane have never succeeded. Study of the fetomaternal relationship has led to the comparison of the status of the fetus with that of a parasite that successfully avoids host rejection (Faulk and Galbraith 1979). A glycoprotein occurring in trophoblast and amniochorion is considered to be important in suppressing detection of the fetus as "foreign" to the mother, by acting on maternal lymphocytes and preventing rejection throughout pregnancy (McIntyre and Faulk 1979). Immunodiagnostic techniques continue to be important in the effort to ascertain the precise action of immunobiologically active glycoprotein of the extra-embryonic tissues. Antigenicity of the amnion, for whatever reason, appears to be low and violent host responses have not yet been demonstrated (Trelford and Trelford-Sauder 1979).

A painless joint with some mobility was achieved in most of our cases. It has been postulated that pain originates mainly from the capsule and to some extent from the muscles. Kellgren (1939) and Kiaer (1950) provided clinical evidence that pain could arise from cancellous

bone, and nerve fibres have been demonstrated in the interior of bone (Gardner 1950). Blood vessels are supplied by nerves, possibly part of the vaso-sensory apparatus. In our cases some pain relief may have followed the release of iliopsoas, quadratus femoris and the short external rotators of the hip; this decreases the compressive forces on the hip joint and improves the distribution of pressure by correcting flexion and adduction contractures. Complete capsulectomy destroys the nerve supply to the joint.

Nerve fibres in the cancellous bone may be neutralised by the metaplastic formation of fibrocartilage at both the articular surfaces (Vishwakarma *et al.* 1980) and a contributing factor may have been the formation of a pseudo-synovial membrane and synovial fluid which kept the new joint lubricated. The average range of movement after operation in the 25 successful cases was flexion 100°, extension 15°, abduction 35°, adduction 25° and rotation 40°.

The basic objectives of the procedure were achieved. Better, quicker results might have been possible, if muscles had not been wasted by chronic disease. Adequate physiotherapy could not be given after the patients were discharged, most of them to their own villages. Excision of the posterosuperior rim of the acetabulum seemed to help achieve increase in abduction and rotation, in addition to the freedom of movement at the joint newly formed by the amnioplasty itself. Vishwakarma *et al.* (1980) have demonstrated experimentally the formation of a near-perfect joint with a capsule. Medialisation of the joint, with valgus reaming of the femoral head and neck, added to the remarkable stability of the reconstructed joints, while the realignment of muscles around the hip improved their function. Law (1962) demonstrated that with the passage of time and the growth of fibrous tissue around the joint, nerve-endings from the surrounding muscles may infiltrate the structures and restore some joint sensation.

Condensation of bone around the acetabulum and

head of the femur was found in all but four cases (Case 2, 4, 14, 22), providing some indirect evidence of a healing process induced by the amnion. In the four cases with some resorption, this was minimal. This also substantiates that the major source of blood supply to the remaining portion of the head and neck is provided through the neck and is not entirely dependent on circulation through the capsule. (Freeman 1978).

An average of 0.5 cm increase of shortening was caused by the operation. This is insignificant and in Cases 4 and 9 gain in length was achieved by trochanteric arthroplasty in the absence of the femoral head and neck. There was also an increase in leg length in cases with a wandering acetabulum when the new acetabulum was created at the original site (Case 1).

The potential of the application of amniotic membrane to surgery is now being realised and is as wide as imagination and experiment can make it. An arthroplasty for tuberculosis which includes joint debridement and the interposition of an amniotic cap not only seems to eradicate the disease but also to induce bone formation and speed up the healing process. Amnioplasty offers a satisfactory solution to the problem of hip joint tuberculosis, especially for patients in the East, where an adequate range of movement is a priority.

This project was supported by a grant from the Indian Council of Medical Research, New Delhi (India).

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