is much less certainly established. While dramatic early improvement has been seen many times, the long-term results have been disappointing. We do not think that a definite advantage will be shown over the results that can be obtained with intravenous heparin drips.

FIG. 4.—Typical renal biopsy appearance. Note distension and vacuolation of renal tubular cells and marked reduction of tubular lumen. (Haematoxylin and eosin. $\times 110$.)

Summary

Three cases of profound oliguria following courses of low-molecular-weight dextran are reported. Two patients had

generalized vascular disease but no other evidence of renal involvement. All were given adequate fluids during treatment and none suffered episodes of hypotension. Renal biopsy material was obtained from each case, and a florid form of "osmotic nephrosis" was noted in each. There was no evidence that oliguria was due to intraluminal aggregations of dextran; rather it seemed that either luminal compromise by greatly distended tubular cells or cellular impairment by contained dextran was responsible. The value of low-molecular-weight dextran in such cases is uncertain, but it is obvious that prolonged courses should be employed with the utmost caution if they are to be used at all.

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Low Incidence of Osteoarthritis in Hip and Knee after Anterior Poliomyelitis: A Late Review*

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Although it has long been suspected that weight-bearing joints in limbs affected by poliomyelitis do not develop osteoarthritis, only three references have been found in the literature which support this impression (Capener, 1956, 1961; Robins, 1959). A study has therefore been undertaken to establish whether osteoarthritis does or does not develop in the joints of lower limbs affected by poliomyelitis "polio joints." If the impression proved correct it was hoped that the factors which protect these joints would become apparent, and from an analysis of these factors the effect of callipers on the severity of joint-degeneration might be estimated.

Method

On the advice of a statistician we planned to examine the hips and knees of 100 patients over the age of 35 who had suffered an attack of anterior poliomyelitis at least 10 years previously.

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So far as was possible patients were selected who had only one lower limb very severely paralysed, but who walked regularly and who constantly wore one long-leg calliper. Many of these patients also had some paralysis in the stronger leg. This enabled a comparison to be made between the stronger and the weaker leg of the same individual.

As a further control the radiographs of a similar number of unselected people that had been taken during a field survey conducted by the Arthritis and Rheumatism Council in the Leigh Area were examined (Kellgren and Lawrence, 1958). This allowed a comparison to be made between the joints of the weaker and stronger legs, and also between each of these and the radiographic appearances of a random group of control joints.

An attempt was made to assess the degree of weight-bearing activity of each patient, and in all the patients any history of joint symptoms, injuries, or operations was obtained. Examination included an assessment of the muscle-power of the trunk and legs as well as measurements of joint movements. The presence or absence of ligamentous instability was noted.

It was decided to concentrate on the hip- and knee-joints because these have the highest incidence of osteoarthritis in

normal subjects. Antero-posterior non-weight-bearing radiographs of both hips and both knees were made on each patient, and these radiographs, together with the control films, were read in random order by two observers. Each film was assessed for the presence of osteoarthritis according to the scale published by Kellgren and Lawrence (1957), but it was difficult to fit some of the polio-joint radiographs into this classification. An assessment of six criteria (diminution of joint space, osteophytes, sclerosis, and cysts; bone shape; and subluxation) for each joint was therefore made, and a joint was regarded as osteoarthrotic if two of the first four of these criteria were present or if there was significant osteophytosis.

To obtain a simple system for grading the degree of residual muscle-function each muscle group was assessed separately according to the Medical Research Council (1943) scale. The grades so obtained for each of the basic movements of each joint were then added together and scaled from 0 (flail) to 4 (normal power).

Material

Ninety-eight patients who fulfilled the necessary criteria were studied. Most of these selected patients had developed poliomyelitis in infancy, as the result of which one leg was weaker than the other. They were all over 35, and their sex and age distribution is shown in Table I. It was possible to match the radiographs of our patients as regards age and sex with those of unselected people in the Leigh series, with the exception of females under 45 whose hips had not been radiographed (Table I).

TABLE I.—Sex and Age Distribution

Age Group	Lower-limb Polio Patients		Controls (Leigh Series)	
	Male	Female	Male	Female
35-44 years	10	17	8	0
45-54 "	11	21	12	21
55-64 "	10	15	10	14
65+ "	9	5	9	5
Total	98		79	

It might be argued that these 98 patients with polio were specifically referred to the Royal National Orthopaedic Hospital because they had osteoarthritis in the stronger leg. If this was so they would only be one side of the question, and, though it would not affect the comparison between the stronger and the weaker side, it would affect the comparison with a control population. In fact many of these patients have been on the records of the Royal National Orthopaedic Hospital for many years, frequently since their acute attack of poliomyelitis.

Results

The incidence of osteoarthritis demonstrated radiographically in the hip- and knee-joints of the weaker limbs (3.1% hips and 5.1% knees) was considerably lower than that in the stronger limbs (10.2% hips and 12.3% knees) and in the control patients (7.6% hips and 17.1% knees) (Table II). Exclusion from the series of the 17 younger females whose radiographs could not be matched with controls did not significantly alter the relationship.

Among the hip- and knee-joints of the polio patients there were 22 which had been injured, accidentally or surgically, or in which some other factor normally considered to predispose to osteoarthritis was present. These included 14 joints (two stronger and 12 weaker) which in spite of predisposing factors had not developed osteoarthritis. The radiographs of these 14 joints, however, did suggest considerable wear and tear, though the changes did not fulfil our criteria of osteoarthritis.

The effect of excluding all such predisposed joints, as well as those of the younger female patients, is also shown in Table II. It emphasizes the striking discrepancy in the incidence of primary osteoarthritis in the weaker and stronger limb—namely, 0% and 11.4% in hips, and 1.4% and 12.7% in knees.

TABLE II.—Incidence of Osteoarthritis

	Hips			Knees		
	Total	Osteoarthritis		Total	Osteoarthritis	
		No.	%		No.	%
<i>Whole Series</i>						
Weaker ..	98	3	3.1	98	5	5.1
Stronger ..	98	10	10.2	98	12	12.3
Controls ..	158	12	7.6	158	27	17.1
<i>Excluding 17 Female Polio Patients under 45</i>						
Weaker ..	81	3	3.7	81	4	4.9
Stronger ..	81	9	10.1	81	11	13.6
Controls ..	158	12	7.6	158	27	17.1
<i>Excluding Predisposed Joints and Younger Female Patients</i>						
Weaker ..	74	0	0	71	1	1.4
Stronger ..	79	9	11.4	79	10	12.7

It was also possible to demonstrate an association between osteoarthritis and residual muscle-function in knees (whether of the weaker or stronger limb). Osteoarthritis occurred in 15.7% of 70 knees with full muscle-power, in 7.3% of 82 with some paralysis, and in none of 44 flail joints (Table III). Thus the contrast between the 44 completely flail knees without osteoarthritis and the 11 affected joints among 70 normally powered knees was striking.

TABLE III.—Reduced Muscle Function and Osteoarthritis (of Weaker and Stronger Limbs)

Residual Muscle Function	Knees			Hips		
	No. of Joints	Osteoarthritis		No. of Joints	Osteoarthritis	
		No.	%		No.	%
4 (normal)	70	11	15.7	67	6	9
2 } (weak)	15 } 82	2 } 1	7.3	15 } 123	0 } 7	5.7
3 }	38 } ..	3 } 0	0	61 } ..	6 } 0	0
1 }	29 } ..	0 } ..	0	47 } ..	1 } ..	0
0 (Flail)	44	0	0	47	0	0

There was a similar but less strong association in hips. Osteoarthritis was found in 9% of 67 hips with full muscle-power, in 5.7% of 123 with some paralysis, and in none of six flail joints (Table III).

An attempt to isolate the effects of residual muscle function from the contrast between the weaker and the stronger side was made by considering the joints on the stronger side only (which had an appreciable incidence of osteoarthritis). Osteoarthritis was found in 16.4% of 67 normally powered knees and in 3.2% of 31 with reduced or absent muscle function (Table IV). However, no association with residual muscle function was apparent in the hips on the stronger side. Osteoarthritis was found in 9.8% of 61 normally powered hips and in 10.8% of 37 hips with reduced muscle function (Table IV). Since there were only four very weak and no completely flail hips, there may nevertheless be a relation which these data have not revealed.

TABLE IV.—Residual Muscle Function and Presence of Osteoarthritis (Stronger Limb)

Residual Muscle Function	Knees			Hips		
	No. of Patients	Osteoarthritis in Stronger Knee		No. of Patients	Osteoarthritis in Stronger Hip	
		No.	%		No.	%
4 (normal)	67	11	16.4	61	6	9.8
3 }	8 } 31	0 } 0	3.2	13 } 37	0 } 4	10.8
2 } (weak)	16 } ..	0 } 1	0	20 } ..	4 } 0	0
1 }	5 } ..	0 } ..	0	4 } ..	0 } ..	0
0 (Flail)	2	0	0	0	0	0

N.B. 11 out of 67 knees in the stronger limb and with full muscle-power had osteoarthritis.

Another possible explanation of our findings is that the weaker limbs are relatively spared by the natural tendency to throw most of the body weight on to the stronger leg. However, we believe that this interpretation is incorrect, because, even on the stronger side, it was possible to demonstrate a decreasing incidence of osteoarthritis which was directly related to the degree of muscle weakness around the joint.

Because of the close association between severe paralysis and the use of a brace, no definite conclusion regarding the protective value of callipers could be reached, though our figures suggest that they may have some value in protecting flail polio joints.

It was surprising that neither muscular instability of the hip, as manifested by a positive Trendelenburg sign, nor of the knee, when there was combined quadriceps and hamstring paralysis, produced osteoarthritis, though in polio joints osteoarthritis may follow either a sudden alteration of bone shape or acute damage to the articular cartilage (see above). These facts suggest that weak muscles resulting from poliomyelitis have a relative rather than an absolute protective role. It is true that gross abnormalities of bone shape develop after poliomyelitis in infancy, but they arise very slowly and may thus allow time for the protective effect of poliomyelitis to prevent osteoarthritis.

These interpretations are speculative, but it is interesting to consider recent clinical and experimental work on osteoarthritis, some of which also tends to challenge traditional concepts. Sokoloff (1963), reviewing the experimental production of osteoarthritis in mice, found no evidence that obesity or weight-bearing activities were relevant, though both genetic and hormonal influences did seem significant. He also found that osteoarthritis could not be related simply to physiological ageing.

The relation between osteoarthritis and alterations in the vascular pattern in bones and joints, although of importance, has not yet been clearly defined. Harrison, Schajowicz, and Trueta (1953) found evidence of hyperaemia in osteoarthritis, while Shaw (1964a), measuring intramedullary pressures, found the blood-flow to be normal or reduced. B. Helal (personal communication, 1965), using venography, has been able to associate a bone element of pain in osteoarthrotic joints with dilated subchondral venous sinuses and with many extra-osseous venous abnormalities. He found these abnormalities only in primary osteoarthritis.

It is generally accepted that polio limbs have an abnormal vascular pattern. Shaw (1964b) has shown an increase in diaphysal pressure in paralytic osteoporotic tibiae, and it may be that an alteration in the osseous vascular pattern of joints controlled by paralysed muscles is related to the low incidence of osteoarthritis.

It is of interest that Thompson and Bywaters (1962) have reported the protective effects on systemic arthritis which may be conferred by hemiplegia, stressing that rheumatoid arthritis rarely develops in the paralysed side. They also discuss the possibility of some direct change being induced in joint tissues, exerting a protective effect, when the nerve supply to a joint is interrupted. They mention that in degenerative joint disease the protective effect is seen with both upper and lower motor neurone lesions, but they have no information in rheumatoid arthritis about the possible suppression of lesions in limbs when the lower motor neurone has been damaged.

Likewise, recent work (Nissen, 1963, 1964; Harris and Kirwan, 1964) has demonstrated the protective effect of early

high femoral osteotomy (or fracture) in osteoarthritis of the hip. An improvement in the joint often follows early operation.

The gross disorder which occurs in neuropathic joints presents a striking contrast to the radiographic changes seen in polio joints. It is usually taught that the hypertrophic changes seen in Charcot joints occur as a direct result of repetitive trauma in a joint deprived of its normal pain-protective reflexes. It could be argued that flail weight-bearing joints suffer at least as much buffeting due to the inability of their supporting muscles to protect them, and the contrasting results of sensory and motor deprivation remain an enigma.

A comparative experimental study of joints denervated by section of anterior-nerve roots, and others in which the posterior-nerve roots were divided might yield important clues to the pathogenesis of osteoarthritis. In this field Courtright (1964) and Courtright and Kuzell (1965), using *Mycobacterium butyricum* to produce arthritis in rats, have already reported the sparing effect of nerve section.

Summary

This investigation has established that there is a decreased incidence of osteoarthritis in weight-bearing hip- and knee-joints controlled by muscles which have been weakened by anterior poliomyelitis.

It seems probable that residual paralysis following poliomyelitis in some way hinders the development of osteoarthritis.

It is possible that this protection may be related to changes in the osseous vascular pattern near the joints of paralysed limbs.

A review of the relevant literature suggests that protection may occur in other neurological disorders associated with paralysis.

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