significantly affected by this selection. Indeed, for some factors, notably sex, it is a better selection of the 223 cases than the original selection of 177 measured cord lengths. However, there seems to be a deficiency of mothers over the age of 35 years, and of children born before 38 weeks of pregnancy.

From Table III it can be seen that the duration of the third stage of labour does not significantly affect the length of the cord. Two of the sums of squares were significantly small. This is reasonable, since two other sums of squares were quite large, though not significantly so.

A linear regression was performed of cord length on each factor in turn, and none of the factors was found to be significant. Sex seemed to affect the cord length most, male children having slightly longer cords.

TABLE III.—Analysis of Variance Table for Multiple Linear Regression of Cord Length

Source	Degree of Freedom	Mean Square	P
Regression on sex	1	63.266	0.30 > P > 0.10
Regression on weight of mother after above factor	1	31.025	0.30 > P > 0.10
Regression on height of mother after above factors	1	0.022	0.99 > P > 0.975
Regression on length of child after above factors	1	4.875	0.70 > P > 0.50
Regression on duration of pregnancy after above factors	1	4.822	0.70 > P > 0.50
Regression on weight of child after above factors	1	21.418	0.50 > P > 0.30
Regression on parity after above factors	1	6.875	0.70 > P > 0.50
Regression on age after above factors	1	0.013	0.99 > P > 0.975
Regression on duration of 3rd stage of labour after above factors	1	2.217	0.90 > P > 0.70
Residual	74	28.311	

Other Results

Since a linear regression of cord lengths on duration of pregnancy was not statistically significant, there is no evidence that cords grow in length after 28 weeks of pregnancy.

A linear regression of height of child on duration of pregnancy was done for each sex in order to test the hypothesis that girls stop growing after the 38th week of pregnancy while boys continue to grow. The regression was significant in both cases; thus both boys and girls continue to grow throughout the pregnancy. The slope of the regression line was slightly greater for boys than for girls, though the difference was not significant.

In 200 mothers (89.7% of the cases) the blood groups were recorded and the figures for each group were compared by means of the χ^2 test with the corresponding ABO figures for the United Kingdom (Dobson and Ikin, 1946) and Rh figures (Mollison *et al.*, 1952). χ^2 was not significant in both instances. ($0.10 < P < 0.25$). Thus the Cambridge data do not differ from national figures.

In 82 out of the 84 complete records, blood groups were recorded. When compared with the ABO and Rh frequencies the χ^2 test was again not significant in both cases ($0.25 < P < 0.50$).

Summary and Conclusions

Maternity records were collected of mother and child and of umbilical cord length at a Cambridge hospital and the data were analysed. It was found that normal gestation and delivery can occur with any length of cord between 7 and 48 in. (17.8 and 121.9 cm.).

In the sample of population examined, which is probably fairly typical of the population in this country,

there is no evidence that any of the factors which were thought to be relevant are related to cord length.

Though our results are largely negative, we present this paper for two reasons. First, it demonstrates how, from a small number of easily collected data, it is possible by statistical analysis to arrive at fairly definite conclusions. Secondly, we feel that the data collected and analysed may be used for comparison with data from other populations.

It is interesting that the analysis shows that while male and female children continue to grow throughout pregnancy there is no evidence of growth in cord length after 28 weeks. This is not surprising, as the placenta begins to degenerate about this time.

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REFERENCES

- Denman, T. (1816). *An Introduction to the Practice of Midwifery*, 5th ed., p. 330. London.
 Dobson, A. M., and Ikin, E. W. (1946). *J. Path. Bact.*, **58**, 221.
 Fox, H. (1929). *J. Mammal.*, **10**, 37.
 Gardiner, J. P. (1922). *Surg. Gynec. Obstet.*, **34**, 252.
 Gibberd, G. F., *et al.* (1956). *Queen Charlotte's Text-book of Obstetrics*, 9th ed., p. 171. Churchill, London.
 Mollison, P. L., Mourant, A. E., and Race, R. R. (1952). *Med. Res. Coun. Med.*, No. 27.
 Starck, D. (1957). *Z. Säugetierk.*, **22**, 77.

RESULTS OF TENOTOMY OF THE TENDO ACHILLIS IN INTERMITTENT CLAUDICATION

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Operations carried out solely for the relief of symptoms without rectifying in any way the underlying cause of those symptoms have never been widely practised by British surgeons. With the exception of procedures to alleviate the misery of advanced malignant disease, purely symptomatic surgery tends to be regarded as quackery, and those who practise it to be relegated to the fringe of, if not well within, the underworld of surgery. It is illogical, however, to deny a patient relief of his discomfort simply because the underlying cause is either unknown or impossible to rectify.

Intermittent claudication is an excellent example. With the exception of the very few patients suitable and fit for arterial reconstruction there is little to offer the mass of sufferers from this crippling symptom. Sympathectomy has its place as a limb-preserving procedure, but it contributes little, as a rule, to the relief of their exercise pain. An attempt was made in 1947 to relieve exercise pain confined to the gastrocnemii by division of the branches of the popliteal nerves supplying these muscles. This operation, however, proved unsatisfactory for several reasons. It was necessary to be certain that the soleus was not involved in the production of pain; isolation of the branches to the gastrocnemii was not always an easy matter; and finally it was necessary to keep the patient in bed for several days, as a result of which venous thrombosis in the paralysed

muscle-bellies was a frequent and trying complication. In order to widen the scope so as to include the soleus and minimize the period of recumbency, it was decided to try defunctioning the calf muscles by tenotomy of the tendo Achillis. The complete relief of pain and the very slight degree of disability resulting from this procedure seemed at first to have solved the problem. It was soon found, however, that the selection of patients suitable for this minor procedure was by no means easy. This short paper, somewhat overdue, we fear, is based on our experience of this operation in 72 patients.

Technique of Subcutaneous Tenotomy of the Tendo Achillis

This simple operation is much easier to demonstrate than to describe. With the patient under general anaesthesia, the limb, flexed to a right angle at the hip and knee, is held firmly by an assistant standing on the outer side (see Fig.). The assistant grasps the forefoot with one hand to maintain dorsiflexion and supports the calf with the other. The limb is held firmly in the correct position by clamping it between the upper arm and the

Position of leg and assistant for tenotomy of tendo Achillis.

body. The skin in the area of operation is prepared in the usual way and isolated by sterile towels. The assistant, who plays a vital part in the success of the operation, dorsiflexes the foot to render the tendo Achillis taut. The surgeon stands opposite the assistant, on the inner side of the limb, and inserts the tenotome immediately in front of the tendon about 1 in. (2.5 cm.) above

the os calcis, where the tendon is narrowest and almost cylindrical. By division at this level the bursa between the tendon and the bone is avoided. The tendon is then gradually divided by a sawing movement, the assistant steadily increasing dorsiflexion of the foot to keep the tendon taut. At the moment of division of the final strands of the tendon the assistant must relax pressure on the foot or the skin may split. The gap between the divided ends of the tendon is compressed between gauze swabs for a few moments to control bleeding. The assistant then dorsiflexes the foot again in order that the surgeon may verify the completion of division. If any fibres are found to be undivided, the tenotome is reinserted and division completed. A firm crêpe bandage is then applied over a pressure dressing of gauze and wool.

Aftercare

The key to success lies in careful post-operative management and the patient's intelligent co-operation. The patient must be urged to walk as soon as possible and to concentrate on walking with a normal gait. After 24 hours the wound is inspected, and if satisfactory the patient is encouraged to walk. At first it is wise to sit the patient on the edge of his bed with his feet on the

floor, gradually increasing the pressure on the tenotomized foot until he feels confident enough to stand up. He should be supported until he feels comfortable and is able to stand normally. He should be encouraged to repeat this manoeuvre by himself until he feels quite stable before trying to walk. It is very unwise to try to make him walk until he can stand with confidence. The nervous patient may not get further than repeating the exercise of standing by his bed on the first day. As soon as he is able to stand comfortably and maintain his balance walking should be encouraged, at first with support, then alone with the aid of a stick. In a day or two he should be able to walk unaided. The first few steps are usually painful, but as the stiffness wears off the pain rapidly eases. Walking should be painless and the patient able to resume his normal life within a week or so after operation.

After division the ends separate, forming a gap of about 2 in. (5 cm.), which is maintained by use of the leg. After a few months the gap is bridged by a band of tissue—probably tendinous, though its histology has never been investigated—which thickens. Moderately strong plantar flexion becomes possible. This band does not usually contract and does not approximate the cut ends, so the tendon is permanently lengthened. If the patient is kept in bed the ends remain in apposition and heal without lengthening.

Complications of the Operation

Early complications are haematoma with persistent leakage of serosanguineous fluid from the wound, leakage of clear bursal fluid, and infection. With these complications walking is delayed. Phlebitis in the defunctioned muscles may follow, leading to further delay in ambulation and reunion of the tendon without lengthening. This occurred in two patients amongst our 41 complete failures.

A more usual cause of immediate rejoining of the tendon without lengthening was the refusal of the patient to persevere in his walking after the operation. This applied to three of the four patients on whom tenotomy was carried out while they were out-patients. As supervision did not extend to their post-operative exercises, these were not performed, and the tendon immediately rejoined. Two other patients took to their beds after their return home and a junction occurred. All these patients were of rather low intelligence, in whom the desire to walk was not supported by sufficient determination.

The principal late complication is a sore heel. About 40% of the patients complained of some degree of discomfort in the heel. Discomfort in walking due to a tender heel seems to come on about three to four weeks after the resumption of normal activity. A plastic foam pad under the heel gives relief, and the discomfort gradually diminishes, usually disappearing completely in a few months. In two patients the tenderness was persistent and severe. Complete relief followed division of the posterior saphenous nerve in the back of the calf. In some cases the area of tenderness in the heel is localized and an x-ray film reveals a typical calcaneal spur. It seems probable that the discomfort is caused by the rather "pounding" gait after tenotomy in patients who have lost some of the normal fatty pad on the plantar surface of the heel. Recovery after some months is due to rejoining of the tendon, leading to a more normal "springy" gait and less trauma to the heel.

After operation the patient walks with a limp; but this improves as the tendon rejoins with lengthening.

Results

Tenotomy of the tendo Achillis was carried out in 72 patients, in 10 of whom both tendons were divided. The majority fell into the 55-64 age-group (Table I). They were all severely handicapped by claudication and were mostly grade 3 or late grade 2 (Boyd *et al.*, 1949).

TABLE I.—*Ages of the 72 Patients Tenotomized*

Age in years ..	33-45	45-54	55-64	65-74
No. of patients ..	1	5	52	14

TABLE II.—*Results of Tenotomy*

	Unilateral	Bilateral	Total
Complete relief ..	14	2	16 (22%)
Initial relief with late failure ..	14	1	15 (21%)
Immediate failure ..	34	7	41 (57%)
Total ..	62	10	72

TABLE III.—*Causes of Failure*

	Unilateral	Bilateral
Late failure after initial relief ..	14	1
Intermittent claudication in other leg ..	6	
Osteoarthritis ..	4	1
Intermittent claudication in same leg due to rejoined tendon ..	4	
Immediate failure ..	34	7
Amputation of either leg ..	6	
Osteoarthritis ..	4	2
Intermittent claudication in other leg ..	12	
Thigh .. same ..	4	2
Anterior tibia ..	1	
Tendon rejoined ..	6	1
Instability ..		2
Painful state ..	1	

Complete relief of pain, enabling the patient to walk without discomfort as far as he desired, resulted in 16 patients (22%) (Table II), including two in whom both tendons had been divided. The longest period of relief was 10 years, the patient walking without pain until her recent death. The average length of the follow-up to the patient's death, to the onset of ischaemia requiring amputation of one or other leg, or to the present day is 4.5 years.

Temporary relief lasting not less than a year occurred in a further 15 patients, including one in whom both tendons had been divided. Failure in these cases was due to the onset of intermittent claudication in the other leg in six patients, and in the tenotomized leg in four patients whose tendons rejoined and, by gradual shortening, eventually had inadequate length to prevent use of the muscle (Table III). The other five patients developed pain due to osteoarthritis, with limitation of walking.

There were 41 patients who never benefited from the operation, seven of whom had bilateral operations. In patients tenotomized bilaterally one failure was due to the patient going to bed on returning home, when the tendons rejoined. Two were due to the inability of the patient to balance while walking or standing. A further two had intermittent claudication in the thigh after the operations. Two developed arthritic pain. In the 34 unilateral operations, six patients failed to benefit because of the onset of gangrene in one or other leg shortly after the operation. In 12 cases intermittent claudication was revealed in the other leg, and five had intermittent claudication in the leg operated upon, either in the thigh or the anterior tibial group of muscles. One patient had a painful state of the foot and ankle which was due to too tight bandaging after tenotomy but which did not lead to amputation. Four developed arthritic pain. A further six

failures have already been discussed, being due to the immediate rejoining of the tendon.

Discussion

Though only 22% had lasting relief, a further 21% had a worth-while respite of a year at least. Of the 41 patients who did not benefit, five were probably unsuitable owing to their mental outlook and non-persistence with walking. Six immediate failures due to the precipitation of osteoarthritis were the results of poor selection. In another 17 patients intermittent claudication in the same or the other leg was the cause of failure and also reflects upon the selection. We now feel that bilateral tenotomy should only rarely be done and therefore a further six patients should be added to the list of failures. This totals 24 patients out of 41 who probably should never have been tenotomized. It has been suggested that the success of tenotomy is due to slowing of the patients' walking pace. Those whom we have operated on have all been persons whose pain was so severe that their pace had already been slowed to the minimum compatible with useful activity. The improvement which occurs is a real one.

The overall picture strongly suggests that tenotomy has a place in the palliative treatment of intermittent claudication provided that patients suitable for the operation are very carefully selected.

Selection of Patients

No hard-and-fast rules can be laid down. The selection must be entirely individual. The nature and purpose of the operation must be carefully explained to the patient, and so must the possibility of disappointment and the reasons for it.

Success depends very largely on the patient's intelligent, determined, and courageous co-operation. Only subjects with the right outlook should be considered. The claudication must be confined to the calf and should be grade 3 in our clinical grading. In clinical grade 3 the exercise pain increases rapidly in severity until the patient is forced to stop. Owing to the marked tendency to spontaneous improvement in patients who have had a recent thrombosis of a main vessel, grade 3 patients with a recent onset of claudication should not be operated on until their non-improvement is certain. The nutritional state of the limb must be good enough to give no grounds for anxiety in the near future.

Aortico-iliac thrombosis which is causing only calf claudication may, if the patient is tenotomized, lead to thigh and buttock claudication. Patients with this lesion should therefore be excluded.

The two main causes of disappointment we found after tenotomy were intermittent claudication in the opposite limb or in other muscle groups in the same limb, and osteoarthritis.

Reference to the causes of failure (Table III) shows that almost half the patients with unilateral tenotomies (27 out of 48) suffered immediately or later from claudication in the opposite limb or in the same limb. Approximately one-fifth of the patients with segmental thrombosis will suffer a second thrombosis in the same or the opposite limb within five years from the onset of their claudication. This hazard of later thrombosis is unavoidable, but every effort must be made to exclude those patients in whom claudication in the thigh or other leg is almost certain to occur. It is often very difficult to assess the degree of impairment of the

circulation in the opposite limb and whether or not it is severe enough to be likely to cause discomfort at an uneconomic distance. The only certain way to solve the problem of whether either leg will be responsible for immediate failure after tenotomy is by employing the Hunterian method. The patient is walked until he is halted by claudication in the leg on which tenotomy is contemplated. Claudication is then abolished by blocking the nerve supply to the gastrocnemius and soleus with lignocaine and the patient is walked again. With relief of pain in the group on which tenotomy is under consideration, the behaviour of the limbs on exercise can be studied.

Osteoarthritis.—It is not surprising to find degenerative changes in joint cartilage in the age period in which degenerative changes in arteries are most often present. Osteoarthritis in the knee-joint is not uncommonly a co-partner with arteriosclerosis in limiting a patient's activity. A minor degree of arthritis may pass unnoticed in a patient whose walking is severely reduced by intermittent claudication. If, however, the claudication is relieved, permitting increased activity, the hitherto quiescent arthritis may become an even more intractable disability than the claudication. It is very disappointing to find that the calf pain which hitherto limited walking to 200 yards (183 metres) is replaced by an equally crippling discomfort at 300 yards (274 metres). The risk of such an occurrence is particularly great after tenotomy of the tendo Achillis on account of the slight degree of instability of the knee following defunctioning of the gastrocnemius. Tenotomy may convert a subclinical degree of osteoarthritis of the knee-joint, hitherto painless, into a crippling disability by depriving the joint of the postural support of the gastrocnemius muscle. One-third of our late failures were due to osteoarthritis. In some patients the onset of osteoarthritis is unpredictable, but probably half of our failures due to osteoarthritis could have been avoided by more careful selection.

Bilateral Tenotomy.—Owing to the possibility of instability and thigh pain we feel that this should very rarely be done. It should certainly not be done with only a short interval between the two operations. We feel that a possible indication may be the late occurrence of calf pain in the other leg of an already tenotomized patient, whose previously sectioned tendon has rejoined sufficiently to allow him some moderately powerful plantar flexion on that side.

Angina, Emphysema, and Bronchitis.—Disappointment after alleviating exercise pain in the calf muscles is not infrequently due to breathlessness from bronchitis or emphysema, or anginal pain limiting activity. As it happens, we have no examples of either of these conditions in our series of tenotomies, though this unfortunate sequel has been seen after relief of claudication by other means. Great care, therefore, should be taken to exclude, so far as possible, patients in whom there is a risk of these conditions limiting activity.

In practice the decision for or against tenotomy is made by weighing the likelihood of further arterial insufficiency against the patient's desire to walk and his willingness, after being fully informed of the hazards, to accept the risks of failure. With careful selection our recent results have been more pleasing. In our last eight patients, five have had complete relief, with an average follow-up period of three years. There were no immediate failures; but we had three late failures,

due to osteoarthritis in two and to intermittent claudication in the other leg in one.

Summary

Our experience of subcutaneous tenotomy of the tendo Achillis for the relief of intermittent claudication in 72 patients is discussed.

The technique of this simple procedure is described and the complications of the operation are discussed.

The results, tabulated under three headings, were: (a) complete relief in 16 (22%), including two bilateral tendon sections; (b) temporary relief—minimum of one year—in 15 (21%) including one bilateral tendon section; and (c) immediate failure in 41 (57%) including seven bilateral tendon sections.

The causes of failure are discussed in detail. Immediate failures were due to intermittent claudication elsewhere in the same leg or in the opposite leg; these constitute approximately 50% of the failures. The remaining 50% were divided almost equally between early union of the divided tendon without lengthening, onset of ischaemic changes leading to amputation, and osteoarthritis.

We feel that this high failure rate (57%) could have been greatly reduced by better selection; 34 out of 41 probably should never have been tenotomized.

The principles of selection are discussed and the difficulties outlined.

In our opinion this operation has a definite though limited place in the management of intermittent claudication.

REFERENCE

Boyd, A. M., Ratcliffe, A. Hall, Jepson, R. P., and James, G. W. H. (1949). *J. Bone Jt Surg.*, 31B, 325.

INCIDENCE OF INTUSSUSCEPTION AND CONGENITAL HYPERTROPHIC PYLORIC STENOSIS IN EDINBURGH CHILDREN

BY

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Recent comparison of the incidence of acute intussusception in Newcastle upon Tyne (Court and Knox, 1959) and in Birmingham (MacMahon, 1955) has shown a marked difference between the incidence in the two cities, while the incidence of congenital pyloric stenosis in Newcastle upon Tyne (Davison, 1946) and Birmingham (MacMahon *et al.*, 1951) shows a striking similarity. Before any conclusion can be drawn from these figures it will be necessary to carry out similar surveys in other centres, and with this in view a survey has been made of such cases occurring within the City of Edinburgh during the period 1950 to 1958.

Method

The method used is similar to that employed in the previously reported series (Davison, 1946; Spence and Court, 1950; MacMahon, 1955)—the total number of children with an Edinburgh address admitted to any of the children's units within the city during the nine-year period 1950 to 1958. Again, as in the previous series,