BRITISH MEDICAL JOURNAL

LONDON SATURDAY JUNE 14 1958

MANAGEMENT OF THE UNDESCENDED TESTIS

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The management of the undescended testis is still a controversial subject, mainly because few long-term studies of the late results of treatment are available. To have secured the testis in its proper position in the scrotum is not an adequate criterion of success. It is necessary to follow the patient over a number of years to discover whether the testicle remains there and functions normally.

The literature concerning the management of the undescended testis was previously reviewed and an analysis made of the results of treatment in 139 cases (Bishop, 1945). That series has now been extended, and a further follow-up study is reported here, with particular reference to the prognosis regarding fertility.

Material

The present series consists of 209 cases (72 with both testicles undescended and 137 with only one testicle undescended). A number of other cases have been rejected, either because the initial position of the undescended testicles was not adequately recorded or because there were insufficient details concerning the methods and results of treatment. Since the failure of descent is bilateral in a number of cases, and since the position of the testicles may vary from case to case, it is considered better to analyse the effects of treatment, so far as anatomical results are concerned, in terms of individual testicles rather than in terms of cases.

The cases have been classified as follows, according to the position of the testicle: (1) canalicular, (2) extracanalicular, (3) retractile, (4) superficial inguinal, and (5) impalpable. The first group (canalicular) is self-explanatory. The second (extracanalicular) consists of all testicles that have emerged from the canal but have not reached the scrotum. This may well be a mixed group, including both superficial inguinal testicles and testicles of which the cords are not quite long enough to enable descent into the scrotum; in practice it is often difficult to distinguish between these two types. The third group (retractile) comprises all testicles which, though undescended when first examined, can be manipulated into the scrotum. Some of these will remain in the scrotum after manipulation; others will not, and may therefore be testicles of which the cords are too short; they are, however, classified here as retractile, to minimize the possibility that spontaneous descent may be falsely attributed to treatment. The

fourth group (superficial inguinal) consists of testicles the cords of which are presumably of adequate length and which have emerged from the canal but have doubled back on themselves to enter the "superficial inguinal pouch." The fifth group (impalpable) is again probably a mixed one, including abdominal testicles, testicles that have completely failed to develop, and testicles situated in the canals but impalpable.

Methods

Patients in whom the spermatic cords were thought to be too short to allow normal testicular descent were treated with chorionic gonadotrophin. The total dose ranged from 260 to 40,000 international units, with an average of approximately 12,000 units; the dose at each injection ranged from 100 to 1,500 units and was most commonly 500 units; and the duration of treatment varied from 1 to 12 months, with an average of four months. The question of dosage has been fully discussed by Bishop (1945), and it was concluded that a dose of 500 units twice weekly for periods of up to six months is suitable in most cases, and that it is seldom worth while continuing for longer than this if satisfactory results have not been achieved.

Patients were treated surgically if there was evidence of mechanical obstruction to the descent of the testicle, if the testicle had deviated to the superficial inguinal pouch or to another ectopic position, or if endocrine therapy had failed. All patients were referred to the same surgeon (Mr. S. H. Wass) for orchidopexy.

The age at which treatment was begun varied between 5 and 20 years. It has been our policy to treat all boys with undescended testes before puberty, whenever possible. The ideal age for treatment is thought to be 9 or 10 years.

Patients were re-examined on one or more occasions beyond the age of expected puberty, and in 52 cases information was obtained about subsequent fertility. This information was obtained at least 10 years after the initial treatment in all cases.

The anatomical results were assessed according to the final position of the testicles and their size and consistency. The analysis of these results was based exclusively on cases in which puberty had already been established and not on the immediate post-operative condition. Androgenic development was assessed on the basis of sexual hair distribution, voice change, measurements

of arm span and lower and upper body segments in relation to height, and the occurrence of erections and emissions. Fertility was estimated on the basis of examination of seminal specimens in 37 cases; in a further 15 cases information was obtained concerning parenthood. Seminal examinations were made wherever possible, and three separate specimens were obtained at intervals of not less than one week. In a few cases a single specimen with a good count was accepted as an adequate criterion of fertility. The specimens were examined so far as possible within three hours of production, and were analysed with regard to the volume of the specimen, the number of sperms per millilitre, and the motility of the sperms.

A count of more than 20 million sperms per ml., with a good motility index has been accepted as normal (MacLeod and Gold, 1951, 1953). The motility was expressed by an arbitrary scoring ranging from 0 to 3: 1 represents poor motility, meaning that only about one-third of the sperms are sluggishly motile; 2 indicates good motility; and 3 is excellent, meaning that almost all the sperms are progressively motile. We have considered a motility of 1.5 or more as normal.

Results

The results of endocrine therapy and of surgery are summarized in Table I. It shows that 35 testicles descended spontaneously, 20 of them being retractile testes. These

TABLE I.—Results of Endocrine Therapy and Surgery

Initial Position of Testicle	Total No. of Patients	No. of Undesc. Testes	Spontaneous Descent	Treatment with Chorionic Gonadotrophin			Surgical Treatment		
				No. of Testicles Treated	Complete Descent	Failure of Descent	No. of Testicles Treated	Complete Descent	Failure of Descent
Canalicular ..	62	81	2	74	47	27	27	26	1
Extra-canalicular ..	49	68	8	57	40	17	17	17	0
Retractile ..	26	36	20	16	14	2	2	2	0
Superficial inguinal ..	42	63	1	26	3	17	59	59	0
Impalpable ..	30	33	4	20	6	20	15	7	8
Total ..	209	281	35	193	110	83	120	111	9

patients were usually seen between the ages of 5 and 9 years, and it was thought advisable to keep them under observation until the age of 10. When seen again at that age the testicles were found to have descended spontaneously. Descent occurred in 58% of the group treated with chorionic gonadotrophin. Finally, a group of patients were referred to the surgeon because it was thought that they would not respond to endocrine therapy. These include cases in which there was mechanical obstruction to descent and the testicles were located in an ectopic position. It is obvious that endocrine therapy is not indicated in these cases.

As may be expected, descent is more easily brought about the nearer the testicle is to the scrotum at the start of treatment. It will be seen that 63.5% of canalicular testicles, 74% of extracanalicular, and 87% of retractile testicles came down with hormonal treatment. Chorionic gonadotrophin acts by lengthening the spermatic cord and cannot rectify a mechanical abnormality whereby a testicle has migrated into the wrong position. This explains why only three of the superficial inguinal group came down, the probability being that these were misdiagnosed.

Practically all testicles in the first four groups could be brought into the scrotum at operation, but a completely satisfactory result (that is to say, normal position, size, and consistency) was obtained in only 65% of the surgically treated cases that were followed up.

At first sight it appears from a study of Table I that endocrine therapy failed to bring down 27 canalicular

testicles, but when these 27 testicles were subsequently operated upon all but one were successfully brought into the scrotum. If that were the case it would be a strong argument in favour of surgery in this group and there would seem to be no need to submit these patients to endocrine therapy at all. It should, however, be emphasized that, as pointed out in the previous paragraph, only 65% of the testicles in the first four groups showed a completely satisfactory result on follow-up examination. Furthermore, some of the 27 testicles in the first group were found to be mechanically obstructed when operated upon, and therefore could not have responded to endocrine therapy.

Table I also shows that 6 out of 26 impalpable testicles descended completely under the influence of chorionic gonadotrophin, while 7 out of 15 impalpable testicles were located and placed in the scrotum at operation. There is therefore every reason for giving endocrine therapy a fair trial before carrying out an exploratory operation in such cases. Some, if not all, of the testicles in this group which can be brought into the scrotum are probably concealed canalicular testicles.

The results of treatment with regard to subsequent androgenic development are excellent. In only three patients in the whole series was there any gross degree of testicular deficiency.

The results with regard to fertility are set out in Table II. Of the unilateral cases, 93% subsequently exhibited normal fertility. One of the two patients with low sperm counts

TABLE II.—Result in Terms of Fertility

	Unilateral Cryptorchidism	Bilateral Cryptorchidism
Normal sperm count	16 (88%)	13 (65%)
Subnormal	2 (12%)	7 (35%)
Married with children. No sperm count	11	4
Total No. studied	29	24
Total No. with normal fertility ..	27 (93%)	17 (70%)

received no treatment when first seen at the age of 14, and a follow-up study at the age of 25 revealed a small testis on the right and absence of the left testis. The other patient was treated at the age of 7 with endocrine therapy. He received a total dosage of 30,000 units, which is a high dose, and when seen at the age of 25 both testes were in the normal position and of normal size. In both cases the seminal examination revealed a very low sperm count on three occasions.

The group of 24 patients with bilateral undescended testes is more significant in regard to the evaluation of treatment. Table II shows that 70% can be considered to be fertile, this conclusion being based on seminal examination in 20 cases; in the remaining four the evidence depends solely on the fact that the patients had achieved paternity. The details of these 24 cases are given in Table III. Of the 19 fertile patients, 14 were treated with chorionic gonadotrophin alone while five were subsequently operated upon. This stresses the value of giving chorionic gonadotrophin a fair trial, particularly in bilateral cases.

Five patients were found to have a subnormal sperm count: two had complete aspermia and can be considered as sterile, and three had sperm counts below 20 millions per ml. and a motility of less than 1.5. Some of these are borderline cases and can be classified as subfertile. One of these patients is probably fertile, since, in spite of three borderline sperm counts, he is married and has a child. It is important to realize that seminal examination does not provide a clear-cut distinction between "fertility" and "sterility" and that a few "subfertile" men may become fathers.

Age at the time of treatment varied between 5 and 20 years. Most of the patients were treated before puberty, but three received treatment at the age of 14 and two of these are sterile. The third patient had extracanalicular testes, and

TABLE III.—Fertility in Bilateral Undescended Testes

Case	Age Treated	Initial Position of Testis		Chorionic Gonadotrophin	Surgery; Orchiopexy	Androgenic Development	Seminal Specimen			Marital Status	Children
		R.	L.				Volume in ml.	Count in Millions per ml.	Motility		
1	8	S.I.P.	S.I.P.	0	+	N	1.6 1.4 1.2	1.4 1.5 2.5	1 1 1	S	0
2	11	C	C	1,430	-	N	5.4 4.5	33.2 67.7	14 14	S	0
3	5	C	C	18,000	-	N	4.0	58	24	S	0
4	9	S.I.P.	E.C.	7,000	+	N	2.5	41.8	—	S	0
5	11	E.C.	E.C.	22,000	-	N	1.8	27.1	—	S	0
6	7	E.C.	E.C.	8,000	-	N	1.5	30	24	M	0
7	12	E.C.	E.C.	12,000	-	N	1	24.4	24	M	0
8	8	A	S.I.P.	8,000	+	N	0.6 0.5	0 0	— —	M	0
9	8	S.I.P.	C	4,000	-	N	1.8 3.3	12.6 59	2 24	M	0
10	10	C	C	8,000	+	N	—	—	—	M	1
11	10	C	C	15,000	+	N	3.2	98.4	1.5	S	0
12	10	C	C	16,000	-	N	1.5 1.0	139 210	3 3	M	1
13	7	C	C	4,800	-	N	—	—	—	M	1
14	8	C	C	8,000	-	N	0.7 1.0 3.0	45 39.5 19	3 2	M	1
15	7	C	C	13,250	-	N	0.7 1.0 1.2	4.3 12.1 28.6	0.5 1.5 1.5	S	0
16	14	C	C	12,000	-	N	4	5.7	0.5	M	0
17	14	A	A	21,000	+	N	1.7 4.5 3.2	0 0 0	— — —	S	0
18	12	E.C.	E.C.	8,000	-	N	1.7	0.2	0	S	0
19	10	E.C.	E.C.	10,000	-	N	3	126	—	S	0
20	11	C	C	6,000	+	N	3 2.5	27.6 30.3	— —	S	0
21	10	E.C.	E.C.	15,000	-	N	0.2 0.5 0.2	22 22.7 17.2	1 1.5	M	1
22	12	C	C	14,200	-	N	2.3	95	3	M	0
23	14	E.C.	E.C.	7,500	-	N	—	—	—	M	1
24	20	C	C	7,700	+	N	—	—	—	M	1

A = Abdominal. C = Canalicular. E.C. = Extracanalicular. S.I.P. = Superficial inguinal pouch. N = Normal.

that probably explains why spermatogenesis was preserved. Another patient treated at the age of 20 is married and has a child.

Discussion

The purpose of this paper is to indicate that there is a place for endocrine therapy in cases of undescended testes and that such treatment does not have a deleterious effect with regard to subsequent fertility whether the treatment is successful or not.

Though most authors agree that chorionic gonadotrophin should be given a fair trial, some consider it to be of only limited value. Gross and Jewett (1956) believe that its main benefit is to bring about the descent of retractile testes or those which would descend spontaneously in a few years' time. They do not subscribe to the view that it may facilitate the manipulation of the testis at the time of operation. Deming (1957) thinks that it is indicated in a selected group and brings about the descent in a very small percentage (14). He claims that its main value is as an adjunct to surgery. Charny and Wolgin (1956) and Hamm and Harlin (1953) recommend the use of chorionic gonadotrophin before resorting to surgery, though in their opinion descent occurs in very few cases. Hand (1955) gave a month's course of chorionic gonadotrophin and obtained a 20% descent in 20% of a selected group. This is the sort of percentage generally accepted, and illustrates the poor results usually reported in the literature.

Our own results show a much greater incidence of descent. 69% of a selected group of cryptorchid testes (canalicular, extracanalicular, and retractile) came down with chorionic gonadotrophin. It is true that 16 patients with retractile testes are included, and it may be argued that these testicles would probably have descended spontaneously. But we feel

that, if a retractile testis resides most of the time outside the scrotum at the age of 10, it is worth while giving a course of chorionic gonadotrophin. If the retractile testes are excluded the incidence of descent is 66%.

The evidence that chorionic gonadotrophin may cause permanent damage is rather tenuous. Maddock and Nelson (1952) made biopsy studies of the testicle in three adult men, before and after the administration of 5,000 units three times weekly for 46 to 65 days. The histological picture showed hyalinization of the basement membrane, peritubular fibrosis, and arrest of spermatogenesis. These effects, however, were only temporary and the dosage used was very large. Charny and Wolgin (1956) performed testicular biopsies on eight patients whose testes descended only after approximately 40,000 I.U. of gonadotrophin had been given. The histological picture in every case showed that spermatogenesis was severely impaired. However, 14 patients treated with 10,000 units revealed a normal histological picture on biopsy and normal spermatogenesis. This would indicate that it may be dangerous to use a high total dosage of chorionic gonadotrophin, but that moderate dosage does no harm.

Robinson and Engle (1954) performed testicular biopsies before and after administration of chorionic gonadotrophin, and they could detect no histological change due to the hormone. Andersen *et al.* (1955) studied biopsy material of testes brought down with chorionic gonadotrophin and could find no sign of degeneration. These studies strongly suggest that chorionic gonadotrophin does not cause permanent damage to the testis.

Assessment of Fertility

In patients with unilateral cryptorchidism the assessment of fertility offers a good opportunity to evaluate the effect of chorionic gonadotrophin on spermatogenesis. It is an accepted fact that the incidence of infertility in men with unilateral cryptorchidism is no greater than in the average population (Charny and Wolgin, 1956; Gross and Jewett, 1956). If chorionic gonadotrophin did produce permanent damage to the seminiferous tubules, one might expect that the number of patients with normal fertility after a course of chorionic gonadotrophin would be small.

This, in fact, is not the case in our series. Only one of 22 patients treated with chorionic gonadotrophin was subsequently found to be infertile. The average dosage of chorionic gonadotrophin was 10,000 I.U., varying from 4,000 to 34,700 I.U. Only two patients received a total dosage of 30,000 I.U., and one appears to be fertile while the other is sterile. The number, however, is too small to evaluate the danger of giving large doses of chorionic gonadotrophin. Nevertheless it seems clear to us that moderate doses of chorionic gonadotrophin can be administered without fear of causing permanent damage to the seminiferous tubules.

The importance of bringing bilateral undescended testes down to the scrotum in order to achieve normal spermatogenesis is well recognized. Experiments on many species of animals have demonstrated that testes rendered cryptorchid show atrophy of the seminiferous tubules (Foncin, 1930; Korenchevsky and Dennison, 1932) and absence of mature spermatogenesis (Wangenstein, 1935). Histological studies of human testicles have stressed the importance of bringing the cryptorchid testis down before puberty (Felizet and Branca, 1902; Wangenstein, 1932; Rea, 1942; Nelson, 1953). The greater the interval between puberty and operation the more advanced is the degree of atrophy and fibrosis of the seminiferous tubules (Vines, 1935).

Histology

The ideal time to bring the undescended testis down is still a matter of controversy. Cooper (1929) made detailed studies of the histology of testicles removed at different ages and different stages of maldevelopment. She makes the important observation that over the age of 3 years histological defects have already begun to appear. More recently the introduction

of testicular biopsy in man has provided an opportunity to study in more detail the development of the normal and the cryptorchid testis.

Testicular biopsies done at different ages have shown that the development of the normal testis proceeds in three stages (Robinson and Engle, 1954; Charny and Wolgin, 1956). The first is the resting phase and lasts from birth up to 4 years. The second is the growth phase and extends from 4 to 10 years. The third is the maturation phase, which stretches from 10 years throughout adolescence. Similar studies on patients with undescended testes demonstrate that during the first stage the cryptorchid testis is identical with the normal testis, but from then on the development is retarded. Histological changes appear during the period of growth, and the testis shows retardation in development as compared with one in its normal position. The difference between the two is much more pronounced during the maturation phase, and permanent damage is almost the rule if the testis remains undescended beyond puberty (Sohval, 1954; Hinman, 1955).

In view of these findings, several authors recommend treatment before any histological change appears—namely, at five or six years of age (Hamm and Harlin, 1953; Nelson, 1953; Robinson and Engle, 1954; Hinman, 1955; Deming, 1957). It is difficult to evaluate if treatment during these earlier years gives any better result, since none of these authors have published follow-up studies. But the histological studies are a strong argument in favour of early treatment.

This is, however, no evidence that the histological picture seen during the second stage indicates permanent damage to the seminiferous tubules. There is retardation in development, but if the testis is brought down before the age of 10 it is able to develop normally. Charny and Wolgin (1956) performed testicular biopsies before and after descent on 17 patients treated with chorionic gonadotrophin before the age of 10 and found a normal histological picture after descent in all. Andersen *et al.* (1955) performed testicular biopsies on 30 testes from cryptorchid boys. In those treated before puberty there were no signs of degeneration or atrophy of the seminiferous tubules, while the ones treated after puberty showed severe degeneration.

Age for Treatment

We believe that no severe damage to the seminiferous tubules results from postponing treatment until the age of 9 or 10, and that there are many advantages in doing so. Precocious puberty is occasionally brought about by chorionic gonadotrophin, and this may be embarrassing at the age of 5. It is of much less significance, however, at the age of 9 or 10. There is also the suggestion that the tissues are more responsive to chorionic gonadotrophin at the time of puberty, but this is difficult to demonstrate.

Finally, some surgeons claim that operation is much easier and less hazardous at that age. Gross and Jewett (1956) maintain that it is extremely important to consider the technical problem of performing a suitable orchidopexy in children of different ages. There can be no doubt that the larger the individual the easier will be the surgeon's task and the less will be the risk of damaging the testicular blood supply.

They consider these factors to be so important as to make it desirable to defer surgery till the prepubertal years, and the results they report in regard to subsequent fertility are excellent. Other surgeons (Hinman, 1955) believe that the dangers and difficulties of operation differ little in children of 6 as compared with those experienced in children of 12 years of age.

Some authors, such as Johnson (1939) have been impressed with the high proportion of cases in which spontaneous descent occurs and recommend treatment after the age of 16. We feel that "watchful waiting" until after puberty or later is not justifiable. Histological studies of testicular biopsies have shown without doubt that the majority of testes that remain undescended until after puberty will be permanently

damaged (Hinman, 1955; Andersen *et al.*, 1955; Charny and Wolgin, 1956). We agree with Charny and Wolgin, who conclude that boys with bilateral cryptorchidism will become sterile men and that it is of great importance to institute therapeutic measures aimed at correcting such bilateral non-descent before the age of 10.

Late Results

There are a few long-term studies regarding the late results of treatment so far as fertility is concerned. Hansen (1949) studied the fertility in operatively treated and untreated cryptorchidism and concluded that no increased production of spermatozoa occurred from testes brought into the scrotum. He studied the seminal specimens of 25 patients with bilateral cryptorchidism treated 10 years previously by orchidopexy and found that only two had a normal count. He does not mention the age of treatment in these cases. Rea (1951) followed up eight patients operated upon 10 years previously for bilateral cryptorchidism. All had been married between one and six years, but none had children. They all had small testes, and testicular biopsies performed on four of them showed complete absence of sperms.

Hand (1955) followed up 27 patients treated for bilateral cryptorchidism just before puberty with a course of chorionic gonadotrophin and orchidopexy. All had been married for more than a year and 15 of them had children. If we accept this as presumptive evidence of fertility, 62% of the patients in this series were fertile.

Gross and Jewett (1956) report on their experience in the treatment of 1,200 cases of undescended testis. The majority were treated by orchidopexy before the age of 10. Combining their results with those of MacCollum (1935), they report that, of 38 men studied, 30 were fertile, an overall fertility of 79%. This is based on sperm-count evaluation or parenthood only. They conclude that orchidopexy is valuable for ensuring fertility if the operation is performed according to their technique. They rejected the Torek type of operation, since they believe it is apt to damage the blood supply of the testis.

Charny and Wolgin (1956) studied testicular biopsy specimens of patients treated previously by orchidopexy. They found that all of these patients had good cosmetic results, but the histological follow-up disclosed significant tubular alteration. From the point of view of spermatogenesis they considered that operation for cryptorchidism is only occasionally successful.

In our own series 70% of the patients show evidence of normal fertility. This is the result of a combination of endocrine and surgical treatment, and compares favourably with other studies. It has to be remembered, in assessing the result of treatment of bilateral cryptorchid testes, that a certain number of those testes are congenitally abnormal. Sohval (1954), Hinman (1955), and Charny and Wolgin (1956), after an extensive study by testicular biopsy of normal and cryptorchid testes, conclude that testicular dysgenesis may play an important part in the aetiology of certain cases of cryptorchidism and may have an important bearing upon therapy. It may account for the failure of hormonal treatment to induce descent and the failure of orchidopexy to improve the fertility potential.

Keeping these facts in mind, we feel that our results are reasonably satisfactory and doubt if treatment at an earlier age would improve them. Our series is too small to have much statistical significance, but it suggests that two patients out of three with bilateral cryptorchidism will attain a normal degree of fertility if properly treated.

Summary and Conclusions

A follow-up study of 209 patients with undescended testes is presented. The importance of assessing the initial position of the testis in regard to the choice of treatment is stressed.

Hormonal treatment with chorionic gonadotrophin is successful in bringing down more than 60% of a selected group of undescended testes.

There is no evidence that chorionic gonadotrophin in moderate dosage can cause permanent damage to the seminiferous tubules.

Orchidopexy is the treatment of choice when there is a mechanical defect or when chorionic gonadotrophin fails.

Hormonal and surgical treatment should take place about the age of 9 or 10.

Assessment of fertility in 24 patients with bilateral cryptorchidism reveals that 70% of them have a normal degree of fertility 10 years after treatment.

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STRONTIUM IN DIET

BY

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The results of analysis of soil, grass, milk, sheep bone, and human bone for radio-strontium in 1956 have been given by Bryant *et al.* (1957). During 1957 the sampling and analysis was extended to an investigation of the stable and radio-strontium contents of the principal items of diet. Most of the samples were taken in Wales and the west and north of England, since these are the regions of highest rainfall and therefore the highest fallout (Stewart *et al.*, 1957). This also had the advantage that the proportion of milk and vegetables imported from a distance in the sampling areas was less than would be the case in the Midlands and south-east of England.

Samples

Flour and Vegetables.—National flour, new potatoes, carrots, cabbage, lettuce, and peas or runner beans were purchased in July and August, 1957, from small shops selling local produce. One such shop was visited in four towns in each of the four regions, as shown in Table I. The sub-samples from each region were bulked before analysis. The vegetables were prepared as for cooking. The potatoes and carrots were washed but not peeled, and the outer leaves

TABLE I.—Food-sampling Regions

Region	Flour and Vegetables	Milk-collecting Centre
Somerset/Wilts . . .	Frome, Radstock, Bath, and Westbury	Frome
West Wales . . .	Carmarthen, Lampeter, Newcastle Emlyn, Cardigan	Carmarthen
Cumberland/Dumfries	Wigton, Longtown, Bramp-ton, Gretna	Carlisle
Yorkshire (E.R.) . .	Malton, Driffield, Market Weighton, Beverley	Driffield

of cabbage and lettuce were discarded. The peas from the Somerset/Wilts and West Wales regions were removed from the pods and the peas and pods analysed separately, but those from the Cumberland/Dumfries area were inadvertently ashed while still in their pods. Two additional samples of old potatoes were obtained in October, 1957, and the peel and flesh of the tuber analysed separately (Appendix 1).

Dried Milk.—Dried milk was obtained at intervals during the year from factories in each of the four regions shown in Table I, and also from other factories (Appendix 2). Each factory receives bulk supplies of milk from an area of 10 or 20 miles around, so the process of collection introduces a diversity in the samples. Some of the samples were full-cream dried milk and some skimmed. It is known from Canadian work that the strontium-90/calcium ratio is the same in the cream as in the skimmed milk, and the same also in dried as in fluid milk (Atomic Energy of Canada, 1957).

Liquid Milk.—It was desirable to supplement the bulk samples of dried milk by liquid milk from individual farms. Hill farms with cattle grazing marginal land were chosen (Appendix 3). They were not at all typical of dairy farms, but were intended to show the maximum radio-strontium activity in milk likely to be found in Britain.

Animal Tissue.—No estimations have been made on meat, but on certain assumptions the ratio of strontium to calcium in the flesh of an animal will be similar to that in its bones. The assumptions are that there is little or no discrimination between strontium and calcium in movement between blood and bone (Comar, Russell, and Wasserman, 1957), and also that the animal has been sufficiently long on a diet of constant strontium/calcium ratio for equilibrium to have been set up. The same considerations apply to the ratio of strontium-90 to calcium.

A list of results on animal bones and other animal products is given in Appendix 4.

Methods of Analysis

The vegetable and flour samples, except those from the Carlisle area, were dried overnight at 80° C., and the dry weights recorded before ashing. All samples of vegetables, flour, and dried milk were ashed in muffle furnaces at 800° C. Liquid milk was ashed without previous drying by allowing it to drip into silica beakers maintained at red heat over bunsen flames.

The ashed samples were analysed for strontium-90 by determination of yttrium-90, using methods previously reported (Bryant *et al.*, 1956, 1957). They were also analysed for stable strontium. Emission spectroscopy was used for bone ash and flame photometry for milk and plant ash. The full methods will be reported separately. The results were expressed as micrograms of strontium per gramme of calcium in the ash.

An interchange of samples of bone and milk ash was made with workers in the Medical Research Council Radio-

TABLE II.—Comparison of Activation and Spectrographic Analysis of Bone Ash

Bone Ash (Sowden and Stitch, 1956)	B31	C16	B30	B41
Activation analysis ($\mu\text{g. Sr/g. Ca}$) . . .	220	250	290	300
Emission spectroscopy ($\mu\text{g. Sr/g. Ca}$) . . .	220	260	280	310