Summary

Four cases of acute benign pericarditis in childhood are recorded.

It is suggested that this disease may sometimes be a complication or manifestation of Bornholm disease.

We are grateful to Professors A. V. Neale and J. M. Smellie for permission to record details of cases under their care, to Dr. S. R. F. Whittaker for access to his cases, to Dr. F. O. McCallum for the serological investigations, to Dr. Clifford G. Parsons for his interest and advice, and to Mr. J. G. Williamson for the illustrations.

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AN INVESTIGATION INTO STERILITY AFTER LUMBAR GANGLIONECTOMY

BY

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"We are obtaining increasing evidence that males may not be sterile or have any alteration of sexual function after bilateral excision of the first lumbar ganglion or even the upper three ganglia." This observation of White and Smithwick (1942) crystallizes a belief contrary to the usual teaching and supports a view held in this clinic for some time. Professor A. M. Boyd instigated this work because of a clinical impression arising out of and sustained by a follow-up of several hundred cases of bilateral lumbar ganglionectomy in which there was every reason to believe that the first lumbar ganglion had been removed on both sides.

Before proceeding with a discussion on sterility following this operation it is important that a clear distinction should be made between sterility and impotence. Many patients arrive at this clinic under the impression that the two terms are synonymous, and alarm and despondency are created on these grounds. No one has ever suggested that an impairment of gross sexual function follows this operation, and this should be emphasized to the patient at the outset. Furthermore, the substitution of the term "seminal anorrhoea" for sterility conveys to the practitioner a full understanding of the symptom under consideration.

For many years there has existed a widespread belief that the bilateral removal of the first lumbar ganglion results in sterility. This belief has been based on experimental evidence which has implied a loss of ejaculatory function and clinical evidence which has perhaps been given undue prominence by the fact that only the patients in whom this symptom has occurred return to complain of sterility.

During the course of this investigation it has become increasingly clear that sterility, far from being a common post-operative complication, is only rarely encountered, and even then, as is shown later, is usually the

result of a much more extensive sympathetic denervation. The present communication is in the nature of a progress report, and the work is by no means complete. The conclusions drawn from the data at present available may be modified by further evidence.

Method of Investigation

The problem has been approached by posing the following questions: (1) Is there a failure of seminal emission after bilateral removal of the upper three lumbar ganglia? (2) If so, what is the mechanism of this failure? (a) Does the semen fail to reach the posterior urethra? Or (b) is it due to reflux of the semen into the bladder through a lax internal sphincter?

The subjects of this research have been divided into three groups: patients who have been subjected to bilateral lumbar sympathectomy; patients who have had a much wider sympathetic interruption for hypertension; and patients who have had an operation of similar or greater degree of severity to act as a control of sexual resilience.

In the sympathetomized patients the level of denervation has been ascertained by the use of the electrodermometer, an electronic apparatus devised by Hall Ratcliffe and Jepson (1950) for measuring the alteration in surface resistance consequent on drying of the skin. The constancy of the post-ganglionectomy skin-resistance patterns has been described by the same authors, and when a pattern showing an upper-thigh distribution is obtained (Fig. 1) it is safe to assume that the first lumbar ganglion has been included in the section of chain removed. It is certain that when the lumbar chain is followed under the internal arcuate ligament with division of the diaphragmatic crus if necessary, and the ganglion thus exposed is removed, this pattern is obtained. The high lumbar ganglionectomy is performed as a routine at this centre, for it is only by this means that an adequate sympathetic denervation of the lower limb can be achieved (Boyd *et al.*, 1949).

The purpose of the investigation has been carefully explained to the patients, and there has been no lack of co-operation. They were instructed to obtain a specimen of semen at a convenient time, a few hours before the proposed examination, and immediately afterwards two specimens of urine. The first specimen was to wash out the urethra, and the second specimen contained the rest of the bladder contents—making a two-glass test. The volume of semen was noted, a sperm count was carried out, and centrifuged specimens of the urinary samples were examined for the presence of spermatozoa. In addition the urinary specimens were tested for fructose by the Selivanoff test.

A questionnaire was also submitted with regard to the pre-operative and post-operative sexual function, with particular reference to any alterations noticed.

This simple routine has given the answer to Question 1 without difficulty—that is, does sterility occur in these cases? There is no doubt that in the majority of them the bilateral removal of the upper three lumbar ganglia does not cause sterility. If, however, a more extensive

FIG. 1.—Pattern shows area of sympathetic denervation achieved by bilateral removal of L1, 2, and 3.

sympathectomy is carried out sterility will almost certainly occur. The cases in the three groups were as follows.

Group I.—Thirty cases of bilateral lumbar ganglionectomy.

Group II.—Ten cases of various surgical procedures 21 days after operation. These consisted of three partial gastrectomies, two perforations, one ureterolithotomy, one pyelolithotomy, one bilateral inguinal hernia, one intestinal obstruction with gut resection.

Group III.—Eight cases of hypertension in which some extensive form of sympathectomy had been carried out. In this series the segment of sympathetic chain removed extended from T9 to L3 at least, and in all cases the splanchnic nerves were removed in addition.

The groups of cases are further analysed in the Table.

Group Analysis of Cases

	Normal	Sterile with Reflux	Sterile No Reflux	Total
Group I	27*	1	2	30
Group II	10	—	—	10
Group III	Nil	3†	5	8

* One case had no emission for three months and then gradually recovered.

† One case of this group has now a small seminal emission.

Results

Group I

Of these 30 cases 27 had normal ejaculation. One of this number, however, stated that he had no ejaculation for a month after operation, while noticing no abnormality in other respects; but at the time of examination four months later he was found to be quite normal. He had also noticed that there was some post-coital cloudiness of his urine during the first post-operative month. Another patient in this series had passed the acid test and become a father since the operation.

Of the three patients who showed no ejaculation one was a young man of 28 with a history of congenital syphilis and recent gonococcal infection. Unfortunately, no pre-operative test was carried out, but there was reason to believe that his functions were already considerably impaired. The second patient was a healthy man of 50 who had lost all seminal emission up to the time of examination 15 months post-operatively. There was no evidence of bladder reflux in his case. The third patient was a young man of 26 referred from another clinic on account of a post-operative loss of seminal emission. There was definite evidence of reflux of semen into the bladder when he was examined after a year.

It is seen, therefore, that there was no ensuing abnormality of seminal emission in 27 out of 30 cases of high bilateral lumbar ganglionectomy in which there was every reason to suppose that the first ganglion was removed. Furthermore, one of the cases regarded as sterile had an intercurrent disease which may have been responsible.

It should be added that many other cases of bilateral lumbar ganglionectomy in which there was a detectable failure to remove the first lumbar ganglion on one or both sides were subjected to post-operative examination, and all of these were perfectly normal in every respect.

Group II

Tests were carried out on these widely differing cases of general surgical procedures on about the twenty-first post-operative day; it was apparent that, normally, the function of ejaculation was not impaired and no case of lack of emission was found at this early period.

Group III

These are the most interesting patients of all, and it is here that some light is thrown on the ejaculatory mechanism.

In striking contrast to the simple bilateral ganglionectomy, seven out of eight of these extensive sympathectomies

resulted in complete absence of ejaculation, while there were no other sexual abnormalities. The eighth case was remarkable in that, after several months of failed ejaculation, there was a gradual return of this function, albeit to a diminished degree. It is seen, therefore, that the more radical procedures nearly always result in lack of seminal emission. How, then, is this form of sterility brought about? The answer lies obviously in the study of the anatomy and physiology of the sympathetic chain, the splanchnic nerves, and the musculature of the bladder-neck, vas, vesicles, and ejaculatory ducts.

The occasional occurrence of seminal anorrhoea after a high lumbar ganglionectomy would seem to indicate that the critical level is close to the first lumbar ganglion, and a working hypothesis to explain these cases must postulate an abnormally high removal of the chain, an abnormally low exit of the ejaculatory pathway, or a coincident removal of important medial branches.

Modern knowledge of the function of the ganglionated chain and its branches is based largely on the classical work of Professor Learmonth carried out at the Mayo Clinic in 1930-1, and this has supplanted and supplemented the somewhat fragmentary information gained earlier in this field by other workers (Budge, 1858; Langley and Anderson, 1895).

Learmonth took a unique opportunity of studying these nerves at operation, and systematically stimulated the individual roots of the presacral nerve while recording the effects on the prostate, posterior urethra, and bladder-neck.

He proved without doubt the sympathetic origin of the innervation of the accessory genital apparatus, and put forward the denervation theory of post-sympathectomy sterility. He also produced an unrivalled description of the roots of the presacral nerve, which is diagrammatically represented in Fig. 2. For the sake of clarity multiple branches arising from the same nerve have their course demonstrated by a single line. An abnormally high removal of the chain may be brought about by extensive upward dissection or by the removal of a fused first lumbar and twelfth thoracic ganglion, thus interrupting the ejaculatory pathway before it leaves the sympathetic chain. The important medial branches carrying this pathway probably leave, in the majority of cases, just above the L1 level, as removal of the lumbar chain and therefore its splanchnic branches does not usually interfere with ejaculatory function. Reference to Fig. 2 reveals a possible route for the fibres under discussion — namely, from the region of the twelfth thoracic ganglion through the renal and possibly the aortico-

Fig. 2.—Formation of presacral nerve (after Learmonth). (1) Greater splanchnic nerve; (2) lesser splanchnic nerve; (3) least splanchnic nerve; (4) coeliac plexus; (5) aorticorenal plexus; (6) renal plexus; (7) preaortic plexus; (8) inner part of lateral root of presacral nerve; (9) outer part of lateral root of presacral nerve; (10) lateral root of presacral nerve; (11) presacral nerve. It is postulated that (8) may carry the ejaculatory pathway.

renal and coeliac ganglia to the nerve or bundle of nerves which run down the aorta lateral to the preaortic plexus. This bundle forms an inner part of the lateral root of the pre-sacral nerve and should normally escape damage during lumbar ganglionectomy. The preaortic plexus is not regarded as an alternative pathway, for, as Learmonth pointed out, it is largely vasomotor in function. Possible avenues of escape through aberrant ganglia have been suggested, and these merit further consideration, but the part played by sympathetic filaments accompanying the testicular vessels is thought to be of little importance.

It is seen, therefore, that a high or extensive sympathectomy such as is undertaken for hypertension will produce sterility, while removal of L 1, 2, and 3 with the intervening chain should leave intact the ejaculatory function.

Sterility after Extensive Sympathectomy

The patients in whom extensive sympathectomy has been carried out show interesting variations in the manner in which sterility has been produced. (1) Five patients have no evidence of sperm entering the urethra at all; (2) three have evidence of reflux of semen into the bladder; and (3) one patient, although sterile for six months after operation, now has a small seminal emission.

De Takats and Helfrich (1941) report a similar case of recovery of seminal emission after extensive sympathectomy, and Lake (1944) describes two more.

In the first group (1), without seminal emission, if there are no urethral sperm, no bladder sperm, and no urethral fructose, ejaculation into the urethra has not taken place, and it must be assumed that denervation of the vas, vesicles, and ejaculatory ducts has occurred.

This is the first mechanism by which post-operative seminal anorrhoea is brought about, and there is a considerable amount of clinical and experimental evidence to support this view. Experimental evidence brought forward by Simeone (1933) confirmed the innervation of the vas, vesicles, etc., by the sympathetic in the guinea-pig; and those findings which are of especial interest from the point of view of this investigation are summarized below. It was found that (1) the normal vas deferens and epididymis undergoes peristalsis; (2) sympathectomy abolishes this movement and substitutes a segmentation movement; (3) spermatozoa float inertly along the vas while reaching maturity; (4) sympathectomy slows the passage of spermatozoa by four-fifths and many degenerate by the time they reach their destination; (5) motility of spermatozoa occurs only at ejaculation; (6) sympathectomy abolishes prostatic contraction and secretion, and therefore limits the production of the activating hyaluronidase; (7) the vesicles become enlarged after sympathectomy.

These effects were not usually permanent in the guinea-pig, and recovery tended to occur after several weeks. It is true, however, that considerable caution must be used in the application of these findings to man, but investigation of those cases which showed no evidence of ejaculation into the posterior urethra suggests that in man, under these circumstances, there is also no prostatic secretion or contraction. Further work is in progress on the size of the seminal vesicle after sympathetic block, and there is reason to believe that there is an increase.

Seminal emission following bilateral vasoligation does not become completely absent for almost three months post-operatively (Wells, 1948), while it disappears immediately after an extensive sympathectomy, as would be expected following a sudden denervation of the ejaculatory organs.

Seminal Reflux into Bladder

The second mechanism to be discussed is that of seminal reflux into the bladder, and, of the patients under review, five are considered under this heading. In Group I—that is, after high bilateral lumbar ganglionectomy—one patient had definite ejaculation into the posterior urethra, but no external emission; while the other, although functioning normally at the time of examination, had a history which

suggested that regurgitation had occurred during a period in which ejaculation had failed. In Group III—that is, after extensive sympathectomy for hypertension—two patients showed definite evidence of seminal reflux, and one who had complete seminal anorrhoea for six months post-operatively now had a small seminal emission, coupled with some degree of bladder reflux.

In cases in which all the emission regurgitates into the bladder, it would seem that, although the vas, vesicles, and prostate are still able to act normally, there is a free communication between the posterior urethra and the bladder at the moment of ejaculation. A consideration of the neuromuscular arrangement at the bladder-neck throws some light on this mechanism.

The internal sphincter is an arrangement of muscular loops curving round the anterior aspect of the bladder-neck and continuous below with the inner circular muscle of the prostate. It is supplied by both sympathetic and parasympathetic fibres, the former carrying motor impulses and the latter inhibitory impulses.

The mode of opening of this sphincter has been the subject of much controversy, and the part played by the trigonal muscle alternately magnified and minimized. This broad triangular band of fibres runs immediately beneath the mucosa from the inter-ureteric bar and converges on the internal meatus to plunge through the internal sphincter and to be inserted

FIG. 3.—Mode of opening of internal sphincter. (a) closed; (b) open. (After Young.)

at the base of verumontanum. Contraction of this muscle, or, as some authorities believe, its inherent elasticity combined with inhibition of the internal sphincter, causes opening up of the bladder-neck and posterior urethra in the manner shown (Fig. 3). The relative importance of the component parts of this action has been variously stressed by different authors, but it is felt that the conception of a balance between the two is more in keeping with physiological principles.

The Internal Sphincter after Denervation

It is now necessary to consider the effect of sympathectomy on micturition, and in particular on the behaviour of the internal sphincter after denervation.

Although it has been reported that a funnel bladder-neck may occur after sympathectomy, it is certain that if any permanent loss of tone did occur one would expect rather more than just a few days' post-operative frequency of micturition; and if it is argued that the external sphincter takes complete control—undoubtedly true after prostatectomy—it can be stated with equal confidence that no case of frequency or incontinence has developed after radical sympathectomy in parous women—that is, those patients whose external sphincters are notoriously unreliable. Furthermore, the results of investigation of the pre-operative and post-operative pressures of the sphincters, although, it is admitted, carried out with a crude home-made instrument, lead us to the opinion that normal resting tone is quickly recovered. A new instrument is at present being devised, and the experiment will be repeated.

It is probable, then, that the competence of the internal sphincter is dependent on a certain basic tone which is inherent in the muscle itself. Its competence during ejaculation, however, depends on superadded spasm, which is achieved through its sympathetic nerve supply. The simplest possible explanation of post-operative reflux, therefore, is the failure of this superadded spasm to occur. This will

explain all our cases of seminal reflux except the case in which a return of ejaculatory power occurred after a six-months interval. This patient had noticed a post-coital cloudiness of the urine at first—a sign common to the other cases which showed reflux—although there was no actual emission. Later, with the return of emission, the cloudiness had become less obvious. A further point of extreme interest was the fact that he believed the return of seminal emission coincided with a much more virile erection. He was one of the few patients who thought he had not been quite normal in this respect after operation.

This case raises the point of production of urethral obstruction by erection. Apart from the narrowing produced by the erect corpus spongiosum, it is obvious that if the erectile verumontanum enlarges proportionately it would help to block the posterior urethra. This would account for the well-known difficulty of micturition in full erection, and is beautifully illustrated, for example, by a case reported by Swift Joly (1929).

This unfortunate patient suffered from continuous priapism due to vesical calculus, and although constantly driven to attempted micturition was prevented from obtaining relief until the erection had sufficiently subsided.

The attachment of the trigonal muscle to the base of the verumontanum has suggested—and this theory is put forward purely as a possibility—that during normal ejaculation the trigonal muscle, now acting synergistically through the

FIG. 4.—(a) Tight internal sphincter. The dotted line represents shortened trigonal muscle, and the verumontanum is pulled up to plug the internal meatus. (b) Lax internal sphincter. The dotted line represents straightened-out trigonal muscle with open bladder-neck. The verumontanum is not pulled up.

unyielding ring of a spastic internal sphincter, expends its energy in shortening its fibres as it is prevented from straightening itself out. It therefore pulls up the erect colliculus, thereby shortening the posterior urethra and plugging the bladder-neck (Fig. 4, a). This renders doubly secure the closure of the internal meatus, and possibly even opens the ejaculatory ducts. If this theory is correct it is easy to visualize how the denervated internal sphincter now yields to the contracting trigonal muscle, so that shortening of its fibres fails to occur. The verumontanum is not elevated, therefore, and seminal reflux occurs into the bladder (Fig. 4, b).

This hypothesis postulates that in normal ejaculation the internal sphincter is of predominant importance, thoroughly able to resist the antagonistic attempt of the trigonal muscle to open it, and indeed assisting in the action of this muscle to elevate the verumontanum. The combined tight spasm of the internal sphincter aided by the obstructive effect of the erect colliculus seminalis serves to prevent seminal reflux. If, however, the sympathetic denervation of these muscles occurs, the internal sphincter, although it may recover sufficient tone to remain closed under normal conditions, cannot undergo the accentuated spasm which normally occurs at ejaculation and therefore fails to resist even the weakened attempts of the trigonal muscle to open it. The resulting incompetence is aggravated by failure of the plugging action of the verumontanum secondary to the shift in the balance of muscular power.

Summary

Thirty cases of bilateral lumbar ganglionectomy in which the first, second, and third lumbar ganglia had been removed have been followed up with regard to post-operative sterility (seminal anorrhoea). Only three of this series were found to be sterile.

Eight cases of extensive sympathectomy for hypertension were followed up, and seven were found to be sterile.

The sterility in 11 of the above 38 cases was due in seven cases to complete failure of ejaculation to occur, while four cases showed that there was reflux into the bladder. There was no obvious reason for the difference in these two groups.

The mechanism of sterility in these cases is discussed and a theory of normal ejaculation is advanced.

This paper is regarded as a report on work that is as yet incomplete, and further investigation is in progress. I am grateful to Professor A. M. Boyd for his constant stimulation and advice and for his original idea which initiated this investigation.

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COMBINED USE OF HEXAMETHONIUM BROMIDE AND PROCAINE AMIDE IN CONTROLLED HYPOTENSION

A PRELIMINARY REPORT

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Despite increased experience in the use of hexamethonium bromide it was felt that this drug was not of itself wholly satisfactory, and there still remained the small percentage of patients in whom it seemed impossible to produce a blood pressure low enough to achieve the required ischaemia for relatively "bloodless field" surgery. Successes had risen from 50% (Enderby, 1950) to 85% (Enderby and Pelmore, 1951). Failures were almost always in the younger age group of patients, and it was observed that such patients often responded to the administration of hexamethonium bromide by an increased pulse rate (up to 120–140 a minute) and a small and often inadequate fall in blood pressure.

A constant search has been maintained for a drug which would either replace or enhance the action of hexamethonium bromide. Procaine amide appeared likely to achieve the latter for two reasons: (1) its vaso-