THE GUBERNACULUM TESTIS HUNTERI: TESTICULAR DESCENT AND MALDESCENT

Arris and Gale Lecture delivered at the Royal College of Surgeons of England on 27th October 1959*

by

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MODERN SURGERY, AS this College well knows, owes much to the generosity of its benefactors. In 1646 Edward Arris, who five years later was to become Master of the Company of Barber Surgeons, founded his new Publique Anatomy. In 1655 John Gale of Bushey similarly left money in his will to found an annual lecture to be known as Gale's Anatomy. These two men are now remembered primarily as founders of the lectures given under their joint names in the Royal College of Surgeons. But it is not enough merely to remember them in this way, for these men saw not only lectures in anatomy as a result of generosity to their Company, but a new and expanding future for surgery, which could only arise out of scientific research and for which this present-day Royal College, a lineal descendant of their own Company, has grown. Arris, Gale, and other men of vision in the 17th century pointed out the anatomical needs of the modern surgery which was beginning to develop during their own and on into the 18th centuries. Foremost among the giants of surgical anatomy of this era was John Hunter. It is meet, therefore, that the subject of this Arris and Gale lecture should be one which was first introduced to surgical anatomy by John Hunter.

But before reporting my own work I have a duty to John Hunter to correct a theory which was developed in Germany during the last century and is now current in the U.S.A. (Charny and Wolgin, 1957), that Haller rather than Hunter first described the structure named by Hunter as the gubernaculum testis. The concept of an open processus vaginalis had been standard teaching for the disciples of Galen, but was discarded when studies in human anatomy had shown that this arrangement was not found in man. Albrecht von Haller, however, first showed during Stedding's disputation on cough at Göttingen in 1749, and later published in his *Opuscula Pathologica* (1755), that the foetal testis lies in the abdomen, and that in the foetus the processus vaginalis is open and ripe for the production of a hernia. His description, in Latin, could be more lucid, but it would be difficult to read a gubernaculum testis into it and certainly he gives no suggestion of a structure which would function in any way other than to allow a herniation of the testis into the scrotum. In fact Haller

* The publication of this lecture has been delayed so as to allow further experimental confirmation of one statement originally submitted on preliminary observations.

himself in his later writings attributes the first description of the gubernaculum testis and its part in testicular descent to John Hunter.

It was, however, the reading of Haller's work that stimulated William Hunter to have John Hunter carry out the study which was to lead to the original description of the gubernaculum testis. William Hunter had been in discussion with Sharp, who had found gut in contact with the testis in a hernia, and a similar observation had later been made by William Hunter himself: Haller's work was therefore of considerable interest to him when he read it in 1755. During the following winter John Hunter studied the problem and his observations were included in William Hunter's teaching in 1756. Percival Pott, John Hunter's old teacher at St. Bartholomew's Hospital, saw the work that had been done, and some of the details were published in his *On Ruptures* in 1756, much to the annoyance of William Hunter, who published a strong attack on Pott in his *Medical Commentaries* in 1762. In this work he accused Pott of using both Haller's work and that of his brother John without acknowledgement, and after this opening broadside John Hunter presented the first description of the gubernaculum testis. John Hunter's description is a remarkable example of both his ability as an anatomist, with a strong eye to function, and his caution. I would like to quote certain aspects of Hunter's description of the gubernaculum testis:

(1) " At this time of life the testis is connected in a very particular manner with the parietes of the abdomen, at that place where in adult bodies the spermatic vessels pass out, and likewise with the scrotum. This connection is by means of a substance which runs down from the lower end of the testis to the scrotum, and which at present I shall call the ligament, or gubernaculum testis, because it connects the testis with the scrotum, and directs its course in its descent. It is of a pyramidal form; its large bulbous head is upwards and fixed to the lower end of the testis and epididymis, and its lower and slender extremity is lost in the cellular membrane of the scrotum. The upper part of this ligament is within the abdomen, before the psoas, reaching from the testis to the groin, or to where the spermatic vessels begin to pass through the muscles. Here the ligament runs down into the scrotum precisely in the same manner as the spermatic vessels pass down in adult bodies, and is there lost. It is hard to say what the structure or composition of this ligament may be. It is certainly vascular and fibrous, and the fibres run in the direction of the ligament itself. It is covered by the fibres of the cremaster or musculus testis which is placed immediately behind the peritoneum; this is not easily ascertained in the human subject, but it is very evident in other animals, more especially in those whose testicles remain in the cavity of the abdomen after the animal is full-grown."

(2) " In the human foetus, while the testis is retained in the cavity of the abdomen the cremaster is so slender that I can not trace it to my own satisfaction, either turning up towards the testis or turning down towards the scrotum. Yet from analogy we may conclude that it passes up to the testicule, since in the adult we find it inserted or lost on the lower part of the tunica vaginalis, in the same manner as in the adult quadrupeds."

(3) " The use of this muscle, when the testicle is in the scrotum, appears to be evidently that of a suspensory: but what purpose it answers in the foetus, or in animals whose testicules remain in the abdomen, is not easily imagined, there being no apparent reason why such a muscle should exist."

(4) " Is the testis pulled down by the cremaster muscle? I can hardly suppose that it is; because, if that was the case, I see no reason why it should not take place in the hedge-hog, as well as in other quadrupeds; and if the musculus testis had this power, it could not bring it lower than the ring of the muscle."

Such is John Hunter's caution, but this did not stop his successors from attributing to Hunter the statement that the ascending cremaster muscle, which could be seen when the testis was pulled up into the abdomen in those animals with abdominal testes, was responsible, in both foetus and adult, for testicular descent.

Since Hunter's first description, the gubernaculum has been examined by many workers. In general the earlier authors (Paletta, 1777; Wrisberg, 1779; Vicq d'Azyr, 1780; Martin, 1780; and Brugnoni, 1785) described a peritoneal covered structure, extending from the testis to the scrotum, containing fibrous and/or muscular tissues, yet being essentially soft and jelly-like. In the course of time, however, this classical description was modified until the gubernaculum testis became generally described as a fibro-muscular cord or band (Gray, 1962).

Much of the confusion was caused by Seiler (1817), who, after studying the anatomy of a variety of adult mammals, uncritically applied his observations to the gubernaculum testis of the human foetus. Seiler stated that during sexual activity (" *in venerem* ") in adult male rodents, and in particular the *Sciuridae*, the testis is carried in the abdomen and the cremaster muscle later pulls it back into the scrotum; hence the same must occur in the human foetus. But in fact the cremaster muscle normally never becomes inverted in these animals even when the testes are retracted towards the abdomen as a result of cremasteric activity and, rather than being carried in the abdomen during the breeding season and in mating, the testes remain in the scrotum (Backhouse, 1959; Barrington, 1956). In spite of this completely inaccurate basic assumption, Seiler's views received support from Curling (1841), who described a layer of well developed striped muscle fibres surrounding the main bulk of the soft transparent and gelatinous gubernaculum. Following Seiler's contention, he believed that this muscle layer, with its various distal attachments, is gradually everted during testicular descent and persists as the cremaster muscle.

By that date, however, Cloquet (1817) and Carus (1827) had put forward an alternative view, that the cremaster muscle is formed mechanically, the passage of the testis through the abdominal wall pulling loops off the internal oblique and transverse abdominal muscles, and the remaining layers of the coverings of the testis and cord being similarly formed from other wall abdominal structures. In spite of the fact that the cremaster muscular system is made up of interdigitating fibres of medial and lateral components, of which the medial is often absent, rather than loops (though muscular loops can in fact be carried down from the free borders of the abdominal muscles in inguinal hernia) this theory is still current in both

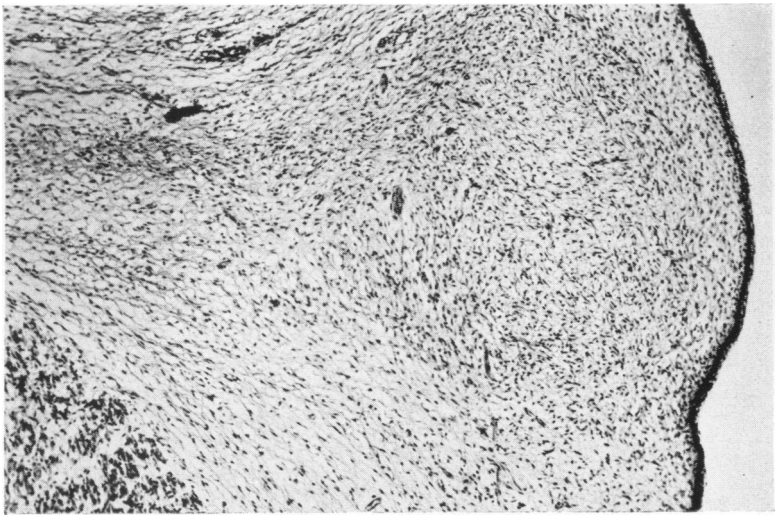
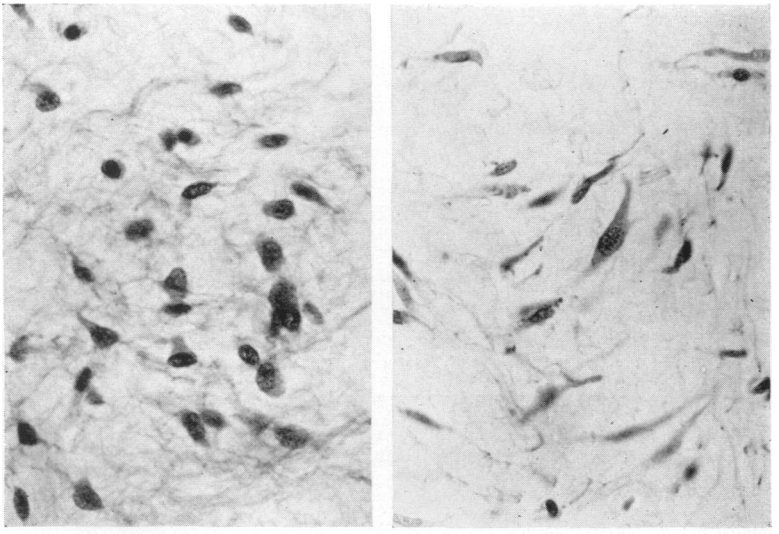


Fig. 1. The future scrotal area of a 45-mm. pig embryo to show its mesenchymatous core.



(*a*) (*b*)

Fig. 2. High-power views of the gubernaculum testis of (*a*) man, (*b*) bull, both shortly after the testis has passed through the inguinal canal.

anatomical and surgical textbooks (Keith, 1948; McGregor, 1957; Charny and Wolgin, 1957). Conforming in part with these views Curling stated that " the testicle, therefore does not pass directly and abruptly into a pouch prepared to receive it, but carries the peritoneum with it . . . "

Lockwood (1887–8), following Curling, attempted to show that distal muscular attachments of a fibro-muscular gubernaculum testis were responsible for the positions of ectopic testes. Although he was unable to find all the " tails " in the foetus that he postulated, he insisted that they must exist because a residual fibrous band always tethers an ectopic testis to its abnormal site.

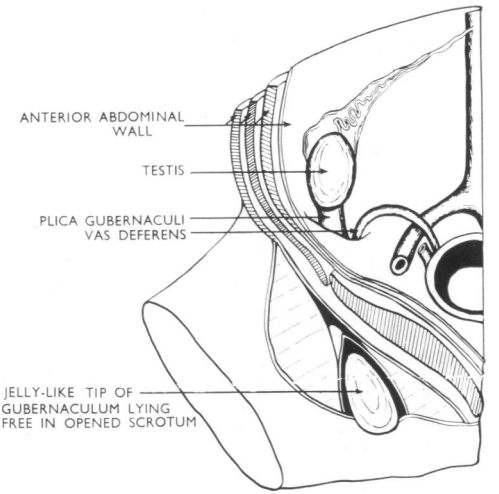


Fig. 3. Gubernacular apparatus of a 17-cm. pig foetus.

The gubernaculum testis in the pig

An initial study of the gubernacular apparatus in an ungulate such as the pig or sheep is of great assistance in understanding the rather more complicated picture found in man (Backhouse and Butler, 1960). The gubernaculum testis develops as a jelly-like mass, similar to Wharton's jelly, to form a simple mesenchymatous core for the inguinal canal and scrotum (Figs. 1 and 2). It is thus completely dissimilar in appearance from the usual descriptions given in current textbooks of human anatomy or surgery.

In a foetus of about 140–150 mm. crown-rump length, this jelly-like mass becomes separated from the surrounding scrotal wall to lie free distally in the scrotum, though remaining attached peripherally in the inguinal canal; thence it has no further distal attachment to the floor of the scrotum (Fig. 3). In the abdomen the gubernacular mesenchyme of the

inguinal canal extends proximally as a column with the testis at its apex. Both the testis and the gubernaculum within the abdomen are carried on a mesentery. This component of the gubernaculum, which has a mesentery within the peritoneal cavity, was called by Seiler the *plica gubernatrix*, and it is proposed that a name be revived for this structure. But it is considered that the correct gender is preferable to the female " gubernatrix " (helmswoman) and so the term *plica gubernaculi* is used.

During development the processus vaginalis grows distalwards as an extension of the peritoneal cavity into the gubernacular mesenchyme of the

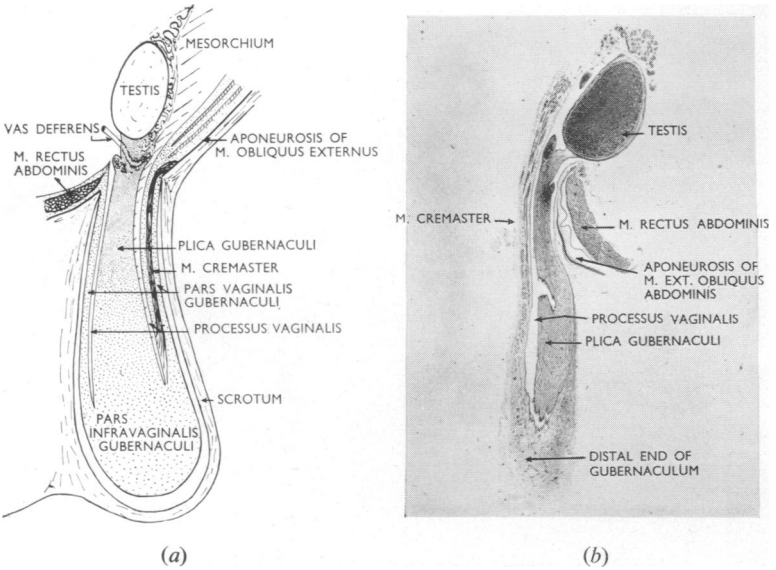


Fig. 4. (*a*) Schematic representation of the gubernaculum testis of an ungulate shortly before testicular descent, showing its structure and surroundings. (*b*) Section of testis and gubernaculum of a 16.5-cm. sheep foetus: the structures have been divided around the inguinal region; the distal end has merely been lifted from the scrotal sac.

inguinal canal and later of the scrotum, beginning around the inguinal end of the plica gubernaculi. In this way the plica gubernaculi gradually extends distalwards through the inguinal canal and into the scrotum, being separated off by the invaginating processus vaginalis from the surrounding mesenchyme. It lies on a mesentery within the processus vaginalis continuous with that of the abdomen. At the same time the cremaster muscle, which is only a single lateral bundle in these species, differentiates initially in the gubernacular mesenchyme of the inguinal canal and then grows distalwards in the peripheral part of the gubernaculum testis at the root of the mesentery of the plica gubernaculi. The distal growth of this muscle keeps pace with that of the processus vaginalis.

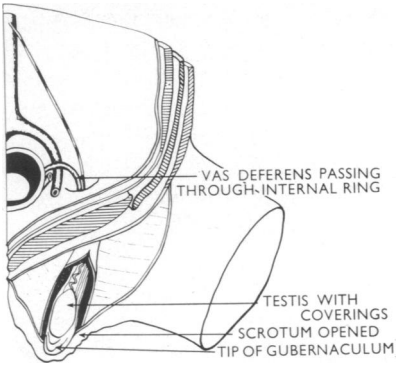


Fig. 5. Gubernacular apparatus of a 41-cm. pig foetus.

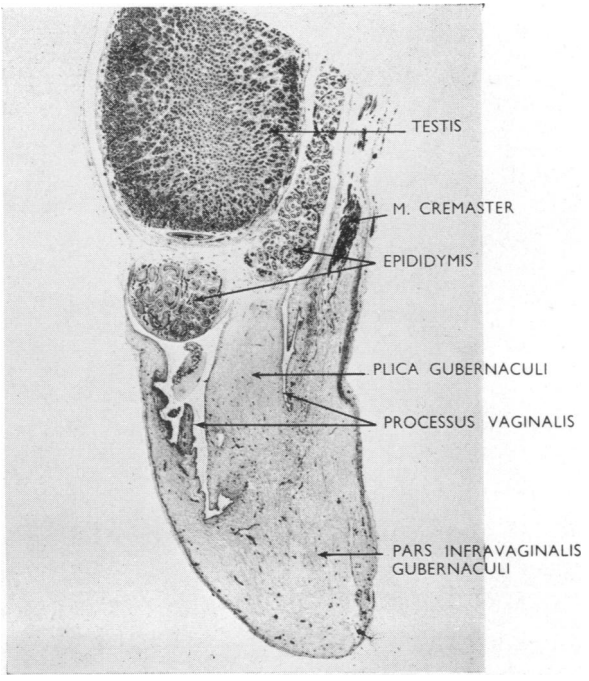


Fig. 6. Section of testis and gubernaculum of a 31-cm. pig foetus. The testis has descended and rapid growth is occurring in the cauda epididymis into the plica gubernaculi.

These changes thus separate the original simple mesenchymatous gubernacular mass into a tubular peripheral portion, containing the cremaster muscle, outside the processus vaginalis, and the plica gubernaculi lying within the processus. This outer tube, which is attached to, and continuous with, the surrounding structures around the inguinal canal, but free distalwards within the scrotum, is called the *pars vaginalis gubernaculi.* Distally until development is completed there will be a

Fig. 7. Sectional diagram of the gubernacular apparatus of an ungulate shortly after the testis has traversed the inguinal canal. It has been cut across below the external ring and removed from the scrotum.

portion of the original solid gubernacular tip not yet invaginated by the processus vaginalis, nor involved by the cremaster muscle, the *pars infravaginalis gubernaculi* (Fig. 4*a* and *b*).

With descent the testis moves distalwards into the tube of the pars vaginalis, which retains its connections with the inguinal region, now proximal to the testis. The distal mass of gubernacular mesenchyme still lies free in the scrotum, but relative to the size of the animal is shorter though for a time bulkier (Figs. 5 and 6).

In the ungulates all these components are comparatively simple and developed well in advance of testicular descent. They are therefore much easier to recognize and interpret than in man and in those rodents and marsupials which have been most frequently studied. The important features thus shown in the pig are that: (1) there is no muscular tissue extending in the gubernaculum testis, i.e. the plica gubernaculi, from the testis to the floor of the scrotum or to those other sites described by Lockwood at any stage in the descent process; (2) the gubernaculum testis lies free within the scrotum at the time of testicular descent; and (3) the processus vaginalis grows distalwards into the mesenchyme, and, at the same time and rate, the cremaster muscle grows along the root of the mesentery of the plica gubernaculi, but outside the processus vaginalis (Fig. 7). The cremaster muscle is never inverted to any significant extent nor does it ascend towards the testis as a *conus inguinalis* in the manner previously described in man and rat by such workers as Seiler (1817), Curling (1841) and Felix (1912), nor does it ever encroach upon the plica gubernaculi, the true link between testis and scrotum.

The gubernaculum testis in man

In man the gubernaculum testis exhibits the same basic morphological characters as in the pig, but differs in the relative times at which processes occur and in the complexity of the cremaster muscle. This cremasteric complexity is probably the major cause of past difficulties in description and interpretation.

During the early stages of human development no gubernaculum testis can be seen until the embryo is about 16 mm. crown-rump length, when a ridge develops extending from the differentiating gonad over the mesonephros and around the body wall to the future inguinal region. It consists of simple mesenchymatous material covered by coelomic epithelium, which, upon further growth, becomes an intra-abdominal column carried on a mesentery, the plica gubernaculi. The inguinal and genital regions are still essentially mesenchymatous at this stage, but the body-wall muscles are beginning to differentiate. No muscular differentiation occurs at the future inguinal region, there being a large mesenchyme-filled gap at this point transmitting the genito-femoral nerve. The inguinal canal is thus formed at this stage as a muscular deficiency, filled with undifferentiated mesenchyme (Backhouse and Butler, 1955), and there is no question of the muscle layers being pushed out by an outgrowing gubernaculum as is often described. The mesenchymatous column extending distalwards from the gonad can be seen to be continuous with the undifferentiated mesenchyme filling the future inguinal canal and scrotum (Fig. 8). Meanwhile a small indentation forms around the plica gubernaculi at its attachment to the internal inguinal region of the abdominal wall, the processus vaginalis. Small bundles of medial and lateral cremaster

muscle fibres now differentiate, running in the mesenchyme of the inguinal canal, from their separate attachments on the pubis and the inguinal ligament.

These give a passing impression of being " inverted " and running towards the testis, but in fact this direction of growth is only transient and serves to take the muscle fibres into the inguinal canal mesenchyme from their origin. They are directed towards the rudimentary processus vaginalis but do not continue into the plica gubernaculi, which maintains its essentially mesenchymatous nature throughout development. If, as described by John Hunter, the testis is pulled up into the abdomen in order

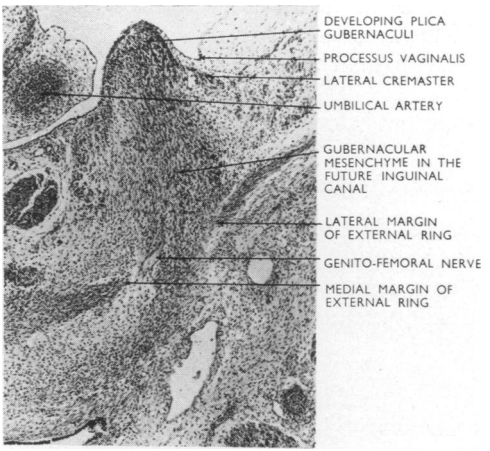


Fig. 8. Section through the inguinal region of a 23-mm. human embryo, showing the well-marked opening of the external ring and the developing gubernaculum testis.

to examine the gubernaculum then muscle fibres can be seen, but these are fibres drawn up from the abdominal wall and are not normal constituents of the gubernaculum. As the cremaster fibres are laid down they begin to orientate themselves into the beginnings of the adult fibre pattern for these muscles, interlacing ventrally relative to the processus vaginalis. In this way when growth is eventually completed the medial and lateral units of the muscle interlace across the cord anteriorly and then run round to gain an insertion into the root of the mesorchium. But growth of both cremaster muscle and processus vaginalis is very slow in man once the rudimentary formation is past, and little more happens until near to the time for testicular descent, when rapid growth takes place in both. Neither processus nor cremaster muscle extend distalwards beyond the inguinal canal until shortly before descent.

Once the gubernaculum has become formed few major changes take place until the foetus measures about 120 mm. crown-rump length (i.e. 4½ months). So far both male and female have possessed a well formed and similar gubernaculum, but the gubernaculum in the female begins to change from the essentially male character it has maintained so far. Further distal growth of the cremaster muscle and the processus vaginalis ceases and the gubernacular mesenchyme gradually differentiates into the fibrous round ligament and into the inguinal and labial connective tissue. These changes take place at approximately the same time as the general fibrous connective tissue of the body wall is being laid down and it is possibly merely one aspect of this generalized process. In the male on

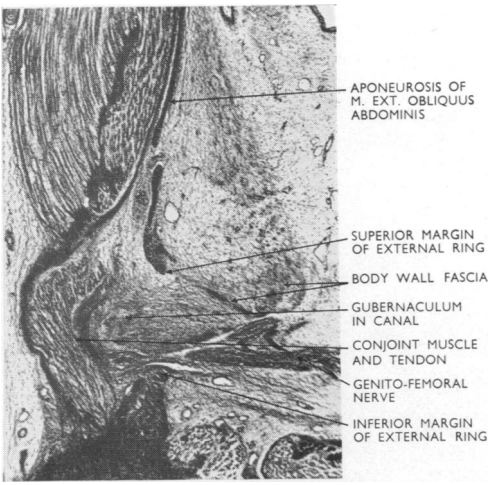


Fig. 9. Sagittal section through the external inguinal ring of a 127-mm. human foetus. Note the clear-cut external ring and the superficial fascia being laid down in the abdominal wall and round the extra-inguinal part of the gubernaculum.

the other hand the mesenchymatous gubernaculum continues to develop. The gubernaculum testis within the abdominal wall and scrotum becomes more obvious due to the abdominal wall and scrotal fascia being laid down. As in the case of the abdominal wall muscles this fibrous differentiation occurs around the gubernaculum and normally does not encroach upon it. Thus the surrounding body-wall mesenchyme becomes formed into the adult fascial pattern. The gubernaculum testis is now clearly delineated as a mesenchymatous mass lying within the formed abdominal and scrotal walls (Fig. 9). The gubernaculum continues to grow in size, but, concurrent with the development of fibrous tissue in the scrotal wall, the contained gubernacular mesenchymatous mass begins to swell. The swelling is due to increase in bulk of the ground substance, the original relatively compact mesenchyme coming to resemble Wharton's jelly, its

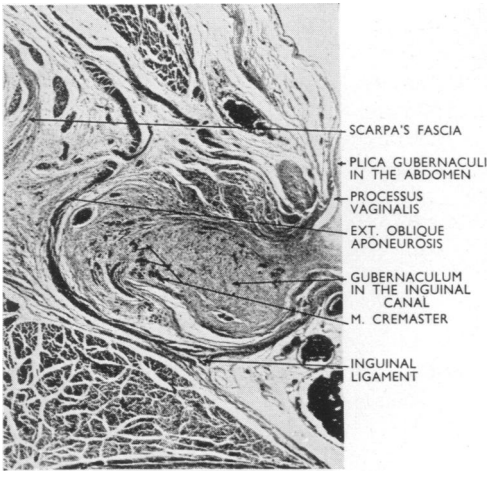


Fig. 10. Sagittal section of a 165-mm. human foetus through the internal ring.

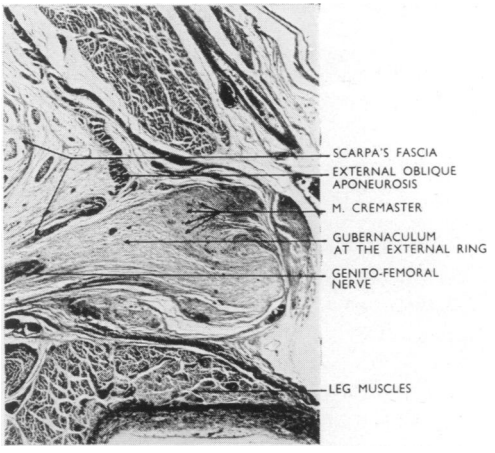


Fig. 11. Sagittal section of a 165-mm. human foetus through the external ring.

ground substance having a high acid mucopolysaccharide content composed largely of hyaluronic acid. Thus first the scrotum and later the inguinal canal are gradually dilated by the gubernacular core. At the same time a cleavage place is formed between the gubernaculum and the scrotal wall so that the distal end of the gubernaculum comes to lie free and unattached within the surrounding scrotum. This process is, however, much less well marked than in the ungulates.

Testicular descent, which usually takes place at about the end of the seventh month of intra-uterine life or soon after, is preceded by a very rapid growth distalwards of the processus vaginalis and cremaster muscle

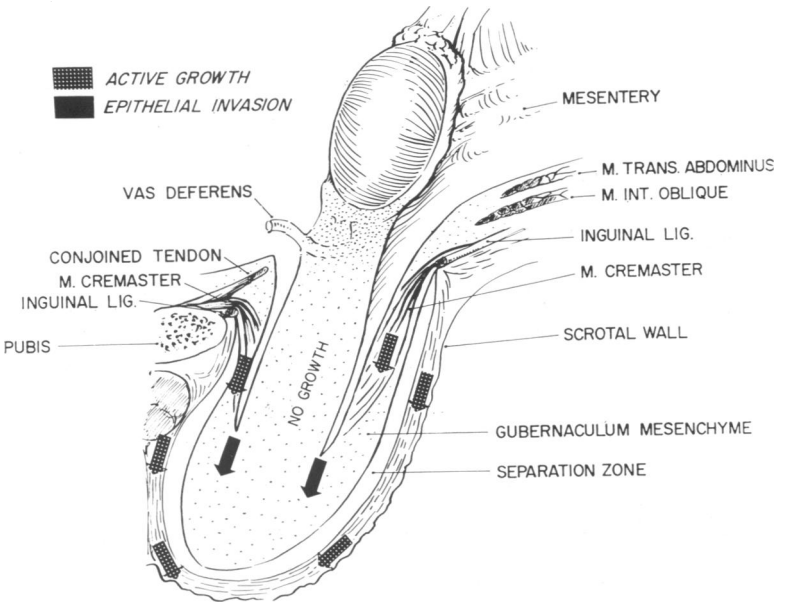


Fig. 12. Diagram of the human gubernacular appartus shortly before testicular descent. Arrows indicate the growth features which permit descent.

(Figs. 10 and 11). Part of the growth of these structures is, in the case of the processus vaginalis, by direct invasion of the gubernacular mesenchyme by the coelomic epithelium, and in the case of the cremaster muscle by differentiation in this mesenchyme. But there is also considerable growth of the pars vaginalis gubernaculi, which produce increase in both the size of the formed cremaster muscle and of the parietal layer of the processus vaginalis. Meanwhile the plica gubernaculi and the pars infravaginalis gubernaculi increase in girth, the increase being greatest distally within the scrotum. Growth of these structures in length slows down and eventually stops, so that with continued growth of the surrounding structures the

gubernaculum becomes relatively, and to some extent absolutely, shorter, probably due to dilation. The increase in girth of the gubernaculum dilates first the scrotum and later the inguinal canal. Due to the relative shortening, the tip of the gubernaculum may even become withdrawn from the floor of the scrotum, but this is less marked in man than in the ungulates previously described.

Growth of the testis does not match in thickness that of the gubernaculum, and so it appears as a relatively small object at the apex of a mesenchymatous column which, due to swelling being greatest distally,

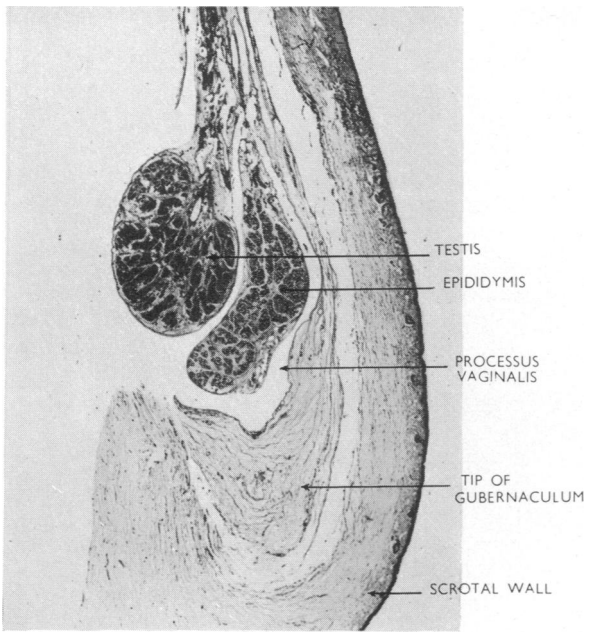


Fig. 13. Section through part of the scrotum, testis and gubernacular tip of a full-term still-born child.

resembles an elongated cone. As this column does not grow in length commensurate with the rate of the foetal body and the surrounding pars vaginalis gubernaculi, then the tendency will be for the testis to descend. The shape of the conical plica gubernaculi which is dilating the inguinal canal will facilitate the movement, the mesentery of the plica gubernaculi and the mesorchium accommodating the change (Fig. 12).

The vas deferens and the testicular vessels meanwhile show quite rapid growth in length, thus allowing the descent. Following descent, the testis grows at a somewhat greater rate than before. The gubernaculum on the

other hand ceases to increase even in girth commensurate with the testis and becomes relatively less bulky (Fig. 13). The growth of the vas deferens at the time of descent is associated with an extension in the tubular system of the epididymis. So far the epididymis has been a relatively small structure with virtually no cauda, the vas running through the plica gubernaculi for a distance before leaving on its course. Now epididymal growth becomes much more marked and an increase in length of this tubular system occurs quite rapidly, extending into the mesenchyme of the plica gubernaculi, until a well formed cauda epididymis virtually fills this structure (Fig. 14).

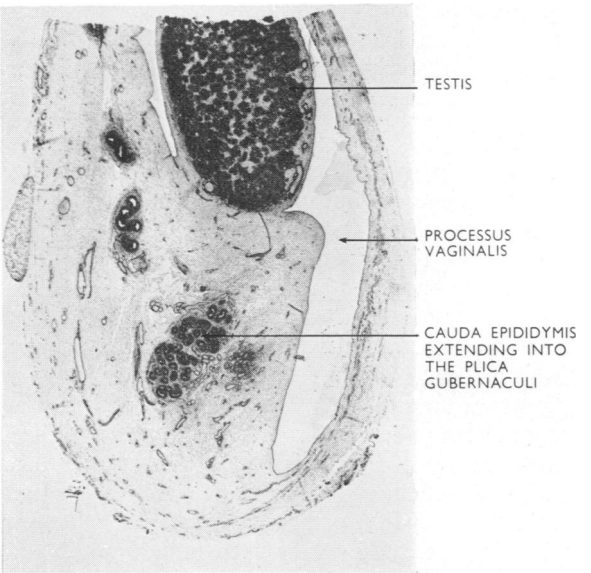


Fig. 14. Section through the testis and gubernaculum (removed from the scrotum) of a full-term child. Note the epididymis invading the remains of the gubernaculum testis.

Thus the gubernaculum testis ceases to exist as a separate structure. The processus vaginalis has extended down to the tip of the gubernaculum; the cremaster muscle has differentiated in the extra-vaginal part and is now completely developed and has gained its insertion into the root of the mesorchium. The remaining mesenchyme of the extra-vaginal part, i.e. inside and outside the cremaster muscle, is converted into connective tissue to form the internal and external spermatic fasciae, being continuous with the fasciae of the abdominal wall with which they have traditionally been associated. The central plica gubernaculi, which has been invaded by the growing cauda epididymis, becomes converted into the connective tissue of this structure and its mesentery.

Testicular descent and maldescent

It will be apparent that testicular descent in man is not associated with any contractile forces supplied by a classical fibro-muscular gubernaculum testis. Instead there is the maintenance of a primitive mesenchymatous core in the inguinal and scrotal regions, which is not encroached upon by the developing body and scrotal wall structures. This simple mesenchymatous core must remain in order to allow free growth distalwards of the processus vaginalis and the cremaster muscles later in foetal development and prior to testicular descent. Once the processus vaginalis is formed those other changes attendant upon testicular descent can be effective, namely gubernacular swelling which dilates the scrotum and descent pathway including the inguinal canal, reduction in length of the plica gubernaculi relative to the actively growing surrounding structures and rapid growth of the testicular vessels and in particular of the vas deferens.

The changes leading to and associated with testicular descent have an established relationship with gonadotrophins which are primarily from maternal or placental sources but perhaps also to a small extent from the foetus, and these in turn stimulate foetal testicular androsteroid production. The early formation of the gubernaculum and of the processus vaginalis and cremaster muscle appears to be independent of this hormonal stimulation, since the changes occur in both male and female embryos. In fact these structures grow most effectively in the female until about the fourth month of intra-uterine life. By this time, however, the foetal testis is producing significant amounts of androsteroids. From now on growth and development of the gubernacular apparatus ceases in the female but is maintained in the male by direct androsteroid stimulation. Concurrent with the changes of testicular descent there is marked secretory activity in the interstitial cells of the foetal testis which continues until shortly after birth, when it practically ceases until puberty. Although it would be unwise to say that all the changes associated with testicular descent are under hormonal control, sufficient evidence is now available to show that the most significant ones are under the control of gonadotrophins which stimulate foetal androsteroid production. Certainly the rapid growth of the vas deferens and the tubular system is stimulated directly by androsteroids and possibly the same is true of the vessels. The changes in the gubernacular ground substance leading to descent occur under a like influence. It is not possible to be certain of the stimulus which leads to growth of the processus vaginalis, but that of the cremaster muscle and of the scrotal wall is influenced by a combination of direct androsteroid stimulation and the dilating influence of, at first, the swelling gubernaculum and later the swelling testis and in particular the epididymis (Backhouse, 1960).

A hormonal deficiency due to failure of adequate androsteroid production by the foetal testis or a low tissue response to the hormone on the

part of the gubernaculum, vas deferens or vessels can upset the normal process of descent. Such a natural upset occurs after birth, when the child ceases to be under the influence of the maternal and placental gonadotrophins, the testicular interstitial cells becoming much less active and testicular descent (if it is not yet complete) ceasing until it is reactivated at puberty or by hormone treatment. It should be pointed out, however, as Scorer (1957) has shown, that during the first months after birth testicular descent may still be completed normally before the androgen level becomes too low.

Experimentally the administration of oestrogens via the maternal circulation or directly to the foetus has been shown to derange the gubernacular apparatus, with a considerable reduction in its size (particularly in the amount of the ground substance), and the testicular descent processes, in the rat and in pouch young of the Virginian oppossum. Comparable studies have also been carried out by Raynaud (1958) in the mouse. The primary cause of the disorganization appears to be due to the effect on the foetal testis leading to a reduction in the androsteroid production (physiological castration), but direct effects of the oestrogens on the gubernacular or tubular structures are possible. However, an experimental cryptorchid condition can be produced in which at least one important aspect is the depression of foetal androsteroids. There is also evidence that oestrogenic effects of certain synthetic steroid hormones administered in pregnancy to experimental animals and probably to man can simulate the effects of true oestrogen treatment and produce disorganization of testicular descent processes in the male foetus. Conversely, certain synthetic progesterone-like hormones have been shown to maintain a male-like development of the gubernaculum as well as other reproductive structures in the female foetus.

The processes associated with testicular descent are, however, dependent upon a pathway being prepared for them, without which they are not likely to be successful. Thus the processus vaginalis must be adequately developed, as a prerequisite of testicular descent. It is possible also that the cremaster muscle is important, but normally both muscle and processus form more or less synchronously and it seems rare that one develops without the other. As previously described, the processus vaginalis develops initially in both the male and female but continues to make progress only in the male, having, in the human, a burst of activity just prior to the time of descent. The available evidence suggests that growth of the processus vaginalis in man may be influenced by hormones in the foetus, but it is not possible to be certain. In view of the fact that the processus vaginalis and cremaster muscles develop at somewhat different times relative to the times of testicular descent in the various species of mammal available for experimental study it would be unwise to postulate too enthusiastically for man on evidence derived from other species. It does appear uncommon to find a deficiency in the growth of the processus

vaginalis and cremaster muscle as the only feature of a cryptorchid state unless there is a mechanical barrier to their development.

The growth of the processus vaginalis and cremaster muscle have been shown to be dependent upon an intact mass of gubernacular mesenchyme into which they can grow at the required time, that is, in the human, shortly before the time for testicular descent. But the intact nature of this gubernacular mesenchyme in the inguinal canal and scrotum is in turn dependent upon the fibrous tissue of the scrotal and abdominal walls not

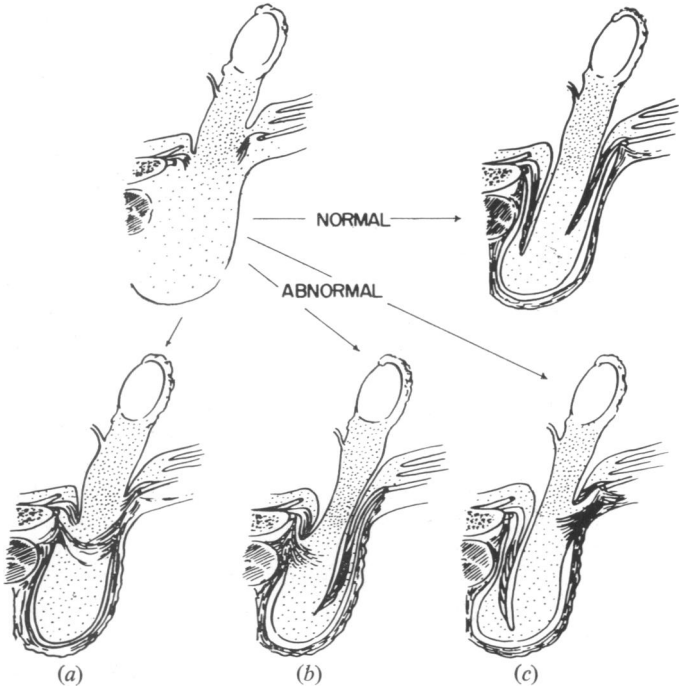


Fig. 15. Schematic representation of the aetiology of the " tails of Lockwood " which predispose to ectopia testis: (*a*) Complete septation leading to immobile mechanical cryptorchism. (*b*) Pubic. (*c*) Lateral inguinal.

encroaching upon it for any reason when forming, this fibrous tissue being laid down before the processus vaginalis or cremaster muscles extend distal to the external ring (Figs. 9, 10, 11). If for any reason fibrous tissue encroaches upon the gubernacular mesenchyme in any region which is later to be invaded by the processus vaginalis or differentiated into cremaster muscle, then the distal growth of these structures is prevented at that point. Such mechanical barriers do occur, though whether they are due to a local breakdown in tissue organization or to a local tissue reaction with fibrous tissue formation is not known. A complete septum can form across the neck of the scrotum more or less in continuity with the superficial abdominal wall fasciae, thus preventing further growth of the processus

vaginalis and cremaster muscles beyond the external inguinal ring. Such a condition is found from time to time in cases of cryptorchism although the testis and tubular systems appear at first to be normal (though obviously secondary changes occur in the testis as a result of the mechanically enforced cryptorchid state). Local fibrous involvement is much more common and only prevents distal growth of the processus vaginalis and cremaster muscle at one point, growth elsewhere being normal (Fig. 15). Thus a fibrous band is formed (a " tail of Lockwood ") which anchors the gubernaculum and later the testicular apparatus to the surrounding tissues, and, by virtue of the processus vaginalis having been formed normally elsewhere, the descending testis is diverted from its course in the direction of the band. This then is the aetiology of an ectopic testis and also the formation of the tails of Lockwood, which are a pathological feature rather than a normal component of the gubernaculum.

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REFERENCES

BACKHOUSE, K. M. (1959) *Proc. Int. Cong. Zool. XV*, 413–415.
——————— (1960) *J. Physiol. (Lond.)* **151**, 41.
——————— and BUTLER, H. (1955) *Cong. int. Anat. VI.*
——————————————— (1960) *J. Anat. (Lond.)* **94**, 107.
BARRINGTON, F. J. F. (1956) Personal communication.
BRUGNONI, J. (1785) *De Testium in foetu positu; eorum in scrotum descensu; tunicorum, quibus continentur, numero et origine*, Taurino, in E. Sandifort (1788) *Opuscula anatomica*, p. 215. Lugduni Batavorum.
CARUS, C. G. (1827) *An Introduction to the Comparative Anatomy of Animals*, **2**, 346. London.
CHARNY, C. W., and WOLGIN, W. (1957) *Cryptorchism.* London, Cassell.
CLOQUET, J. (1817) *Recherches anatomiques sur les Hernies de l'Abdomen.* Paris.
CURLING, J. B. (1841) *Lancet*, **2**, 70.
FELIX, W. (1912) *Manual of Human Embryology*, edited by F. Keibel and F. P. Mall. **2**, 752. Philadelphia.
GRAY, H. (1962) *Anatomy*, 33rd edition by D. V. and F. Davies. London, Longmans.
HALLER, A. von (1755) *Opuscula Pathologicc*. Lausanne.
HUNTER, J. (1762) Observations on the state of the testis in the foetus, and on the hernia congenita, in William Hunter *Medical Commentaries*, part 1.
HUNTER, W. (1762) *Medical Commentaries*, part 1. London.
KEITH, A. (1948) *Human Embryology and Morphology*, 6th edition. London, Arnold.
LOCKWOOD, C. B. (1887–88) *J. Anat. (Lond.)* **21**, 635; **22**, 38, 461, 505.
MARTIN, R. (1780) *Nova Acta Reg. Soc. Sci., Upsala*, **3**, 225.
MCGREGOR, A. L. (1957) *Synopsis of Surgical Anatomy.* Bristol, Wright.
PALLETTA, J. B. (1777) *Nova gubernaculi testis Hunteriani et tunicae vaginalis anatomica descriptio*, Mediolani, in E. Sandifort (1788) *Opuscula anatomica*, p. 89–158. Lugduni Batavorum.
POTT, P. (1756) *On Ruptures.* London.
RAYNAUD, A. (1958) *Bull. Soc. Zool. France*, **83**, 249.
SCORER, C. G. (1957) *Arch. Dis. Child.* **32**, 520.
SEILER, B. W. (1817) *Observationes nonnulles de testiculorum ex abdomine in scrotum descensu et partium genitalium anomaliis.* Leipzig.
SHARP, S. (1750) *A critical enquiry into the present state of surgery.* London.
VICQ D'AZYR, F. (1780) *Hist. Acad. roy. Sci., Paris* (1784), p. 494.
WRISBERG, H. A. (1779) *Observationes anatomicae de testiculorum ex abdomine in scrotum descensu ad illustrandam in Chirurgia de herniis congenitis utriusque sexus doctrinam.* Gottingae.

ADDENDUM TO HONOURS LIST

CLIFFORD HENRY COOMBER SEARBY, F.R.C.S., was awarded a C.B.E. in the recent Birthday Honours List.