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Male sterility

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MALE STERILITY

by

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The inability to reproduce has been a major concern of mankind since the dawn of history but only within the last ten to twenty years has the male partner's ability to reproduce even been questioned. Today this field is making great strides and within a few years the male blame in sterile marriages may be properly established. Today it is generally accepted that ten per cent of our marriages are barren[1, 29, 31] and therefore sterility is and will continue to be an important problem. Today it is also an established fact that the male partner is responsible for approximately sixty per cent of these barren marriages.[2]

It was with this fact in mind and a feeling that it is a problem which will be encountered more frequently than before by the general practitioner as well as the urologist in our large medical centers that I chose this problem.

It has been my feeling, however, upon reading the literature dealing with sterility problems that too little stress has been put upon the anomalies, infections and obstructions. While the rather jumbled field of endocrinology[21] and the psychogenic factors have

been blamed only too frequently, I do not attempt to suggest that the endocrine and psychic factors may not play an important part but I decided to exclude them and stress the problem from formation of sperm to passage to the partner from the penis upon coitus. The psychic effect will be entirely excluded while the endocrine factor will be suggested only briefly in connection with its effect upon the formation of spermatozoa.

In order to properly appreciate the problem, I feel it is essential to prepare the reader for the subject matter. With this point in view, I have first presented a brief history of the subject and a definition of some of the terms, after which I have attempted to completely review the normal embryological development, histology, anatomy, and physiology and function in so far as necessary for a complete understanding of the normal male genital system.

I have divided the pathological study of the system into four divisions. In chosing my points of division, I have tried to chose natural dividing lines to include organs which suffered from the same pathology. It must, however, be understood that no real division can be made as a pathological process in one

organ of a region may exist without any pathology in the rest of the system or the whole system may be infected by a pathological process having gained a foothold in one minor organ.

My arbitrary grouping is as follows:

Group 1.

Penis, urethra, Cowper's Glands and the Glands of Littre.

Group 2.

Prostate, Seminal vesicles, ejaculatory ducts and associated organs.

Group 3.

Vas deferens and epididymis.

Group 4.

Testis.

According to Meaker[3] in most cases of marital infertility there is more than one causative factor. I am unable to quote any authority to contradict this statement but my interpretation of the majority of the literature was that the cause may be single or numerous with the greater percentage being singular.

To me, this factor is not important. I merely wish to point out the possible causes and suggest possibilities of correction.

I feel it is unnecessary to go into a complete discussion of history-taking, as, in order to be a good practitioner of medicine, complete detailed histories should be a general practice. The history should contain a few points which might not be included in a general history and physical so will be mentioned. These are:

Age at puberty, number of years married, any children by previous marriages, contraceptive measures if any, uses, types and duration. History of mumps, age and complications if any. History of venereal diseases, age, treatment. Injuries to pelvic region. Complete history of sexual life.

The physical should be general with special reference to the genito-urinary system, looking for the pathology discussed in this paper.

HISTORY

It was probably in an early stage of primitive life that man first observed a connection between coitus and propagation. The Kahun papyrus written about 2000 B.C. states, "To distinguish her who shall conceive from her who will not conceive pour thou fresh oil....examine her." Genesis VII and VIII speaks of Gods command to Noah and his sons to "keep seed alive on the face of the earth," and to, "be fruitful and multiply....Iestablish my covenant with you, and with your seed after you." From that time until now peoples of every land have ramsacked the temple and the apothecary shop in search of cures for sterility.

It was not until many thousands of years later that the true mechanism of impregnation and fertilization was discovered through the slow evolution of medical science.

In 1677 Antony van Leeuwenhock[4] first mentioned the configuration of spermatozoa. Dr. Ham was the first man to see spermatozoa under the microscope. The specimen was secured from a man who had a spontaneous discharge of semen after he had contacted gonorrhea. However, the spermatozoa were believed to be some sort

of putrefaction.[5] In March, 1678, Nicholas Harlsocker wrote about his findings and impressions of spermatozoa[6,7] and in 1694, published his "Essay de Dioptrique" which contained the first known illustrations of human spermatozoa.[8]

In 1878, two hundred years after Leeuwenhock, Robjou[9] published what was then the most "recent" work on spermatozoa. During this two hundred year period very little was accomplished.

Since 1878 there have been many great advances in the understanding and treatment of female sterility but only in the last ten to twenty years has the male problem come to the fore and we must look to the future for the satisfactory understanding of this problem.

DEFINITION OF TERMS

In order to facilitate the understanding of certain terms used in a discussion of sterility, certain terms will be defined.

Aspermia, aspermatism. A condition in which no semen at all is ejaculated by the male.

Azoospermia, azoospermatism. Complete absence of spermatozoa in the semen.

Necrospermia, necrospermatism. The condition in which all the spermatozoa in the semen are found to be non-motile.

Olegozoospermia, olegozoospermatism. A marked decrease in the number of spermatozoa in the semen.

Spermacrasia. This term indicates any abnormal condition of semen.

Spermaturia, semehuria. The presence of semen in the urine.

Spermatozo-uria. The presence of spermatozoa in the urine.

Semination, insemination. The introduction by any means of semen into the vagina or uterus.

Sperm. This term, beside meaning the mature spermatozoan, is also used to indicate the semen, or testicular secretion.

Spermatorrhea. Involuntary, to frequent, and excessive discharge of semen without copulation.

Spermatolysis. The destruction or solution of spermatozoa.

THE EMBRYOLOGY OF THE MALE GENITAL ORGANS

The embryological development of the male genital organs is complicated and some of the organs which will be discussed in this section have their origin in the urinary system but have a dual function in the urinary and genital tract.

The first stage of the development of the genital system is known as the indifferent stage. This stage has its onset during the fifth and sixth week of development and is named such because the sex of the embryo cannot be determined at this time either by gross or microscopic inspection of the internal and external genitalia. In addition to a pair of generalized sex glands, all vertebrate embryos are equipped at an early stage with a double set of sex ducts. Both are held in readiness until the time sexuality is declared, at which time only one set will advance while the complementary set will suffer regression.

The primitive sex gland makes its appearance within the urogenital ridge. This urogenital ridge is produced by the development of the mesonephric tubules which bulge ventrad into the coelom and thus produce on each side of the dorsal mesentary the long-

itudinal urogenital ridge. This soon divides into a lateral mesonephric ridge and a medial genital ridge. As the embryo further developes, longitudinal furrows separate the two primordia further. At six weeks the resulting sexless mass consists of a superficial germinal epithelium and an internal epithelial mass produced by an ingrowth from the germinal epithelium. By the end of the eighth week this has advanced to where the sex of the embryo is determined.

The male does not elaborate any ducts intended primarily for its own purpose. Instead it merely appropriates the mesonephric ducts and some of the mesonephric tubules and converts them into genital canals.

At the start of the sixth week the formation of the external genitalia begins. At this time a conical genital tubule is found in the midline of the ventral body. During the seventh week the genital tubule elongates into a somewhat cylindrical phallus whose tip is rounded into the glans. Lateral to the base of the phallus a rounded ridge makes its appearance on each side. These are the labio scrotal swellings. Rupture of the urethral membrane in the floor of the urethral groove provides an external opening for the

urogenital sinus during the eighth week. From this generalized set of primordia the external genital organs of the male will develope when sexuality is established.

As the male genital glands increase in size, they shorten relatively into more compact organs located farther caudally. At the same time the attachment of the mesonephros is converted into a gonadial mesentary, the mesorchium.

The testis cords in man seem to organize suddenly out of the diffuse epithelial mass already present at the stage of the indifferent gonad. The radially arranged testis cords converge toward the mesorchium where another portion of the epithelial mass is emerging as the dense primordium of the rete testis. Soon the cell clusters of the rete primordium become a network of strands which unite with the testis cords. Each of the latter split into three or four daughter cords, the forerunners of the seminiferous tubules. Their peripherial portions join in looping arches while the main extents of the tubule soon elongate into twisted tubuli contorti. Nearer the rete testis, however, they remain straight, as the tubuli recti. The rete testis unites the tubuli recti with the rest

of the duct system. By the end of the sixth month the lumina of the rete tubules and cranial mesonephric tubules become continuous and the mesonephric tubules are now called efferent ductules of the epididymis.

The efferent ductules are destined the convey spermatozoa from the rete testis into the mesonephric duct. The mesonephric duct undergoes certain regional specialization which transforms it into the chief genital duct. In completing these changes, the upper end of the mesonephric duct becomes highly convoluted and becomes the duct of the epididymis; the caudal portion remains straight and, as the ductus deferens and terminal ejaculatory duct extends from the epidiymis to urethra. Near its opening into the latter canal the male duct dilates to form the ampulla from the wall of which is evaginated the saccular seminal vesicles. Actually the testis cords do not begin to canalize into tubules until the seventh month. There central cavities extend toward those that are developing in the rete testis and thus the solid cords are converted into tubules, lined with epithelium but the process is still incomplete at birth.

The early testis cords are composed chiefly of so called indifferent cells. What becomes of the recog-

nizable primoridial germ cells is controversial but the latter generations of sex cells, at least, probably differentiate from certain of the small "indifferent" element. Other indifferent cells of the cord transform into the sustentacular cells. The full course of development of spermatogonia into spermatozoa will be described later.

The general bed of mesenchymal tissue in which the tubules of the testis lie, organizes into the connective tissue framework of the organ. Thus each lobule of the testis, containing three or four seminiferous tubules derived from a primitive testis,cord, becomes isolated by partitions. These septula converge at one end to the mediastinum testis while in the other direction they extend to the encapsulating tunica albuginia.

Certain cells of the mesenchymal stroma transform into large, pale elements which lie in the unspecialized connective tissue between the seminiferous tubules and hence are designated interstitual cells. They are believed to be responsible for the endocrine secretion of the testis. Following the early emergence of a tunica albugenia, the germinal epithelium reverts to an inert peritoneal mesothelium which does not accom-

pany the testis on its scrotal journey.

The primitive mesentery of the testis is the mesorchium. It is represented in the adult merely by the fold between the epididymis and testis.

The ligamentum testis developes in a caudad continuation of the genital ridge. It extends from the caudal pole of the testis to the transverse bend in the urogenital ridge. On the opposite side of the ridge a chorda gubernaculi soon bridges across to the adjacent body wall. This in turn is continued by way of the ligamentum scroti into the scrotal swellings. Thus at the beginning of the third month there exists a continuous mesenchymal cable from the caudal end of the testis through the inguinal canal to the scrotal swellings.

The descent of the testis is one subject about which there is much controversy. Some men state it is due to change in position, however, the more accepted descent is due to a farther elongation of the trunk cephalad in contrast to the slow growing gonad. This produces a relative shift of the latter in a caudal direction until the sex gland lies ten segments below its level of origin.[10] When the process of growth and shifting is complete the caudal end of the

gonad lies at the boundry between abdomen and pelvis. In addition to this early migration caudad, the testis later leaves the abdominal cavity and descends bodily into the scrotum. At the beginning of the third month while the testis are still fairly high in the abdomen, sac-like pockets appear in each side of the ventral abdominal wall. These are the beginnings of the vaginal sacs and from the fourth to the end of the sixth fetal month the lower poles of the testis lie near them without change of position. Each processus vaginalis evaginates through the ventral abdominal wall by way of the slanting inguinal canal, then over the pubis, and so into the scrotum which it invades from the seventh month on.

During the seventh to ninth month the testis also descends along the same path. The hypophysis controls this process in which the gubernaculum testis plays an important but disputed role. During the seventh month the gubernaculum extending through the inguinal canal into the scrotum not only stops growing but actually shortens one-half.[11] This shortening both relative and actual, is commonly said to draw the testis into the scrotum where they are usually found at least at birth. By further growth, usually within a few weeks

to a few months, the peritoneum usually grows together isolating the testis and scrotum from the peritoneal cavity.

The external genitalia of the male undergoes a definite process. The phallus becomes the penis. The edges of the urethral groove progressively fold together in a distal direction to form an open urogenital sinus into a cavernous urethra within the penis. The scrotal swellings shift caudad until each becomes a half of the scrotum with the scrotal septum separating it from its mate.

In the meantime the shaft of the penis elongates and then with a splitting of an epithelial plate the opening at the tip of the glans is formed. The proximal portion of the urethra is formed from the urogenital sinus. This consists of the rest of the prostate and all of the membranous urethra.

The prostate gland develops as multiple outgrowths of the urethral epithelium both above and below the entrance of the male ducts. The surrounding mesenchyme differentiates both connective tissue and smooth-muscle fibers into which the prostatic buds grow.

The bulbo-urethral glands arise in the male embryo at nine weeks as a pair of solid buds that grow

out from the ectodermal epithelium of the cavernous urethra.

The seminal vesicles develope as outpouches from the mesonepheric ducts in the fetus of thirteen weeks and gain a muscular wall from the adjacent mesenchyme.

The foregoing is a review of the embryology of the genital system of the male. An attempt has been made to condense, but to facilitate the understanding of male sterility, a fairly complete embryological picture is felt necessary.[12]

HISTOLOGY OF THE MALE GENITAL SYSTEM

The testis is a compound tubular gland, surrounded by a firm, thick white capsule, the albuginea testis--a typical fibrous membrane. At the posterior edge of the organ, the thickening of the capsule projects into the gland as the mediastinum testis. From the mediastinum, thin partitions, the septula testis, extend radially to the capsule and divide the organ into about 250 conical compartments, the lobuli testis, which converge with their apices toward the mediastinum. As the septula are interrupted in many places, the lobules intercommunicate, especially in their peripheral portions.

The cavity of each lobule contains the terminal portions of the seminiferous tubules. These tubules are thirty to seventy cm. long and 150 to 250 u in diameter. Their combined length in man is estimated at 250 meters. One to three of them occupy a lobule.

They have an extremely tortuous course, rarely branch, and are called the convoluted semineferous tubules. The tubules in adjacent lobules may be connected by loops. The sperm are formed in the convoluted tubules. The testis are suspended in the scrotum by

the spermatic cords. Each of these contains the excretory duct (ductus deferens), blood vessels and nerves supplying the testis on that side of the body. The epididymis, an elongated body attached to the posterior surface of the testis, contains the proximal parts of the excretory duct system of this organ.

In the adult the convoluted seminiferous tubule is lined by the complex seminiferous epithelium with its two kinds of cells. The first are nutrient and supporting elements, the sustentacular cells. The others forming the vast majority are the sex cells which through proliferation and complex transformations, furnish the mature sperm.

The sustentacular cells, in a tubule with active spermatogenesis, are slender, pillar-like elements perpendicular to the basement membrane to which they are attached. They are separated from one another at fairly regular intervals by the densely crowded spermatogenic cells.

There are two phases in the process of spermatogenesis. In the first phase, spermatocytogenesis, the germ cells undergo repeated mitoses and certain structural changes, and give rise to a new type of cell (spermatid) which contains only one half the

somatic chromatin mass in its haploid nucleus and is unable to divide. In the second phase, spermiogenesis, the spermatids undergo a series of complex transformations which result in the formation of the mature sperm or spermatozoa. They do no resemble other cells of the organism and have specific forms for different species.

As a rule the earliest generations of spermatogenic cells are near the basement membrane of the seminiferous tubule while the more mature forms line the lumen. The cells from which spermatogenesis starts are called spermatogonia. They divide mitotically, but the number of divi sions is not known. This first step in spermatocytogenesis is the period of proliferation. During this stage some of the spermatogonia remain unchanged and keep their position along the inner surface of the basement membrane. They are the source of the countless sperm produced in the course of the life of the individual.

With the completion of the last spermatogonial division the period of growth starts and each spermatogonium gradually increases in size and its nucleus undergoes marked transformations. This growth causes a further shifting of the cells toward the lumen of

the tubule. The growing cell is known as a primary spermatocyte. When it has reached its full development the period of maturation begins and the primary spermatocyte divides into two new cells--the secondary spermatocytes. Each secondary spermatocyte soon divides, giving rise to two spermatids. They are the last generation of spermatogenic cells. By individual transformations they become sperm.

The two mitoses occurring in rapid succession and leading from one primary spermatocyte to four spermatids are of a peculiar character and differ from the common somatic mitoses. They are called "mitoses of maturation," or "meiotic divisions," and through them the nucleus of each spermatid receives only one half of the somatic number of chromosomes typical for the respective animal species.

The nucleus in the earlier generations of spermatogenesis contains dustlike particles of chromatin and a round body that stains like chromatin. These early spermatogonia are called "primary spermatogenic cells," or "spermatogonia with dustlike nuclei." The cytoplasm contains granular mitochondria. Near the nucleus are a pair of centrioles and a thin crystalloid body smaller than that of the Sertoli cells.

The later generations of spermatogonia are smaller and are found either at the basement membrane or a short distance from it toward the lumen. The crystalloid seems to be absent. In the nucleus the chromatin is arranged as darkly staining flakes on the inner surface of the membrane--hence the name of "spermatogonia with crustlike nuclei." These differences between the earlier and the later generations of spermatogonia are not very distinct in man.

The mitoses of the spermatogonia show the somatic number of chromosomes characteristic of the species. This number is forty-eight in man. In the dividing spermatogonium the chromosomes consist of twenty-three pairs of varying sizes and shapes and of one pair of heterochromosomes (X-Y). During the spermatogonia mitoses, all of the chromosomes, including the heterochromosomes, split longitudinally in the usual way. The X and Y chromosomes in man were first accurately figured by Painter[13] (1923) although the claim of an X-Y condition in the male had previously been made by others.

The changes undergone by a spermatogonium developing into a primary spermatocyte (period of growth) represent a gradual preparation for the meiotic

divisions and the reduction of chromatin.

The primary spermatocytes move toward the lumen of the tubule and occupy the middle zone of the seminiferous epithelium. As their transformations extend over a considerable period of time, these cells are numerous in the seminiferous epithelium and show considerable variations in size and structure.

The fully developed primary spermatocytes are large, spherical or oval cells. The long axis of the oval cells, when they are closely packed together, is perpendicular to the basement membrane. The nucleus is also large; its structure undergoes a series of typical gradual transformations which begin at once after the completion of the last spermatogonial mitosis and finally lead to the first meiotic division.

In the first meiotic division of the human spermatocytes the X-Y chromosome separates, the X going to one daughter cell and the Y to the other. Thus, of the two secondary spermatocytes originating from a dividing primary spermatocyte, one will contain twenty-three ordinary chromosomes and and X chromosome, while the other will have twenty-three chromosomes and the Y. Thus, there are two kinds of secondary spermatocytes.

The daughter cells of the secondary spermatocytes, the spermatids, are relatively small, spherical cells. Each contains a spherical nucleus about 5 to 6 u in diameter, with several darkly staining chromatin granules. Half of the total number of young spermatids contain the X elements and half the Y.

The spermatids are the last generation of spermatogenic cells. They do not divide and each one has to undergo a long series of peculiar transformations, deeply affecting every constituent of the cell, before the mature sperm or spermatozoa is formed.

The mature human sperm consists of a head, a connecting or middle piece, and a tail. In ordinary sections the sperm do not show any particular inner structure. For seeing the details, special histologic methods such as iron hematoxylin and highest magnifications are necessary.

The head is a flattened, almond-shaped body measuring 4 to 5 u in length and 2.5 to 3.5 u in width. It is a condensed nucleus. The middle piece is of cylindrical or spindle shape and connects the posterior pole of the head with the tail. It has a length of 5 u and a thickness of 1 u. The tail has a length of 52 u. At its anterior end it has the same thickness

as the middle piece but gradually tapers down toward the free end. It can be subdivided into the principal part and a short terminal part of extreme thinness.

The successive phases of spermatogenesis are arranged in the seminiferous tubules according to certain definite rules. The least developed elements are always located nearer the basement membrane, the most developed nearer the lumen. The cause of this movement is purely mechanical and due to growth pressure. The spermatogonia remain adjacent to the basement membrane. The primary spermatocytes, in the early stages of the growth period, may keep this position for a while. The larger cells move toward the lumen and form a second, third, and even fourth layer of cells. The spermatids form the inner layer of the epithelium and are usually found in large groups, all the cells of which, originating from a single spermatogonium, show the samestage of development. The same typical arrangement in groups is characteristic of the first and second meiotic divisions. The transformations of all of one generation occur more of less synchronously.

During the process of spermiogenesis the spermatids seem to require specific external conditions, such as protection and special nutriment. For this purpose

they become temporarily closely connected with Sertoli cells. When the sperm have reached a certain degree of maturity, and their cytoplasm has been sloughed off, the whole group leaves the Sertoli cell. This seems to be the result of mechanical pressure exerted upon the Sertoli cell body. The new crop of spermatogenic cells, growing around a Sertoli cell, squeezes the sperm out of it in the direction of least resistance. After a short period of inactivity the same Sertoli cell receives another, fresh crop of spermatids.

In the human testis, spermatogenesis, having started at puberty, continues without interruption during the whole period of sexual activity.

Interstitial cells are scattered in the angular spaces between the tubules in compact groups without a definite relation to the blood vessels. Their body, measuring on the average 14 to 21 u in diameter, is irregularly polyhedral and is often provided with processes. Transitional forms to much smaller, round or elongated cells are common. The large, spherical or wrinkled nucleus contains coarse chromatin granules, and one or two large nuleoli. Cells with two nuclei are relatively common Adjacent to the nucleus is a large clear attraction sphere. It contains centrioles

which appear as a group of small round granules or as two rod-shaped bodies. The sphere is surrounded by a Golgi apparatus. The peripheral cytoplasm contains numerous mitochondria. The most characteristic features of the interstitial cells are the various inclusions in the cytoplasm outside the sphere.

In fresh condition the cytoplasm is filled with highly refractile granules, many of which react positively to tests for neutral fat and lipods (sometimes cholesterol esters). Some brownish granules are waste pigment (lipofuscin). The most interesting inclusions are rod-shaped crystalloids with rounded or pointed ends. These are characteristic of the human testis, although they are not of constant occurrence and show great variations in size. Sometimes they seem to dissolve in the peripheral layers of the cytoplasm and their substance leaves the cell body. They are monorefringent, swell in a 10 per cent solution of potassium hydroxide, and are dissolved by hydrochloric acid with pepsin. They are insoluble in 10 per cent hydrochloric, nitric, or acetic acid, and in fat solvents.

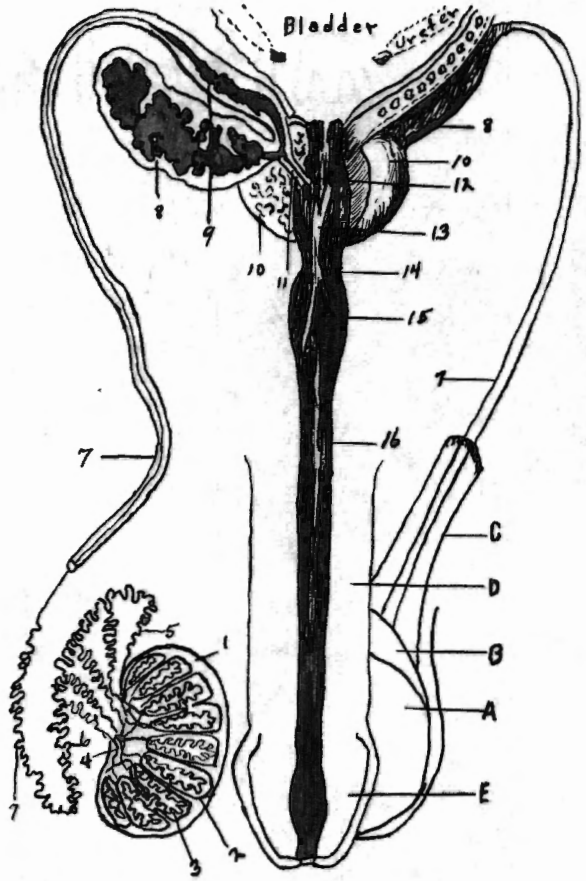
It seems that the interstitial cells are modified connective tissue cells. In inflammatory lesions of the testis and in tissue cultures they divide mitoti-

cally and become fibroblasts. They may increase in number through transformation of spindle-shaped connective tissue elements, probably of embryonic nature, scattered between the tubules and around the blood vessels.

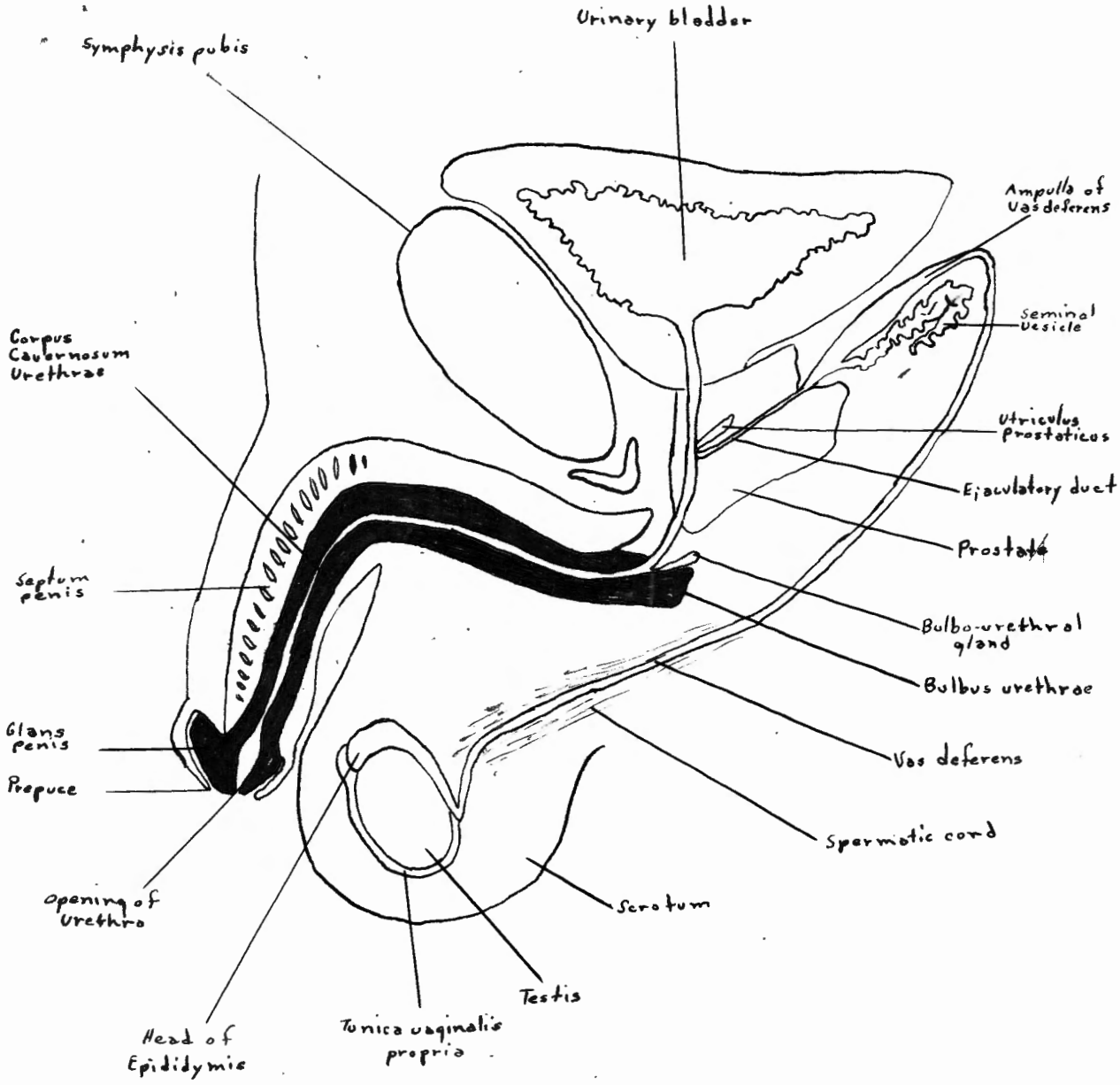
Some authors claim that the interstitial cells of the testis arise from the same source as the elements of the seminiferous epithelium in the tubules; others believe them to be remnants of the epithelium of the tubules of the mesonephros. Groups of interstitial cells may be found in the connective tissue of the epididymis.

The "epithelioid" character of the interstitial cells suggests the possibility of an endocrine-glandular function.[13]

The other histology of the male reproductive system is not discussed in this paper due to the feeling that it is not a contributing factor in fertility and sterility except in the matter of storage and transportation.



Sketch of male genital organs. A, Testis; B, head of epididymis; C, spermatic cord; D, penis; E, glans penis; 1, tunica albuginea; 2, septum of testis; 3, seminiferous tubule; 4, mediastinum with rete testis; 5, ductulus efferens; 6, ductus epididymis; 7, ductus deferens; 8, seminal vesicle; 9, ampulla of ductus deferens; 10, prostate gland; 11, ejaculatory duct; 12, colliculus seminalis with opening of utriculus prostaticus; 13, 14, 16, prostatic, membranous, and penile portions of urethra; 15, bulb of urethra. (After Dickinson.)(From Bailey's Textbook of Histology, Williams and Wilkins Co., Publishers)



Diagrammatic median section of male sexual apparatus. Redrawn from Eberth, slightly modified. (From Maximow and Bloom's Textbook of Histology, W. B. Saunders Co., Publishers.)

THE ANATOMY OF THE MALE GENITAL ORGANS

To facilitate understanding and brevity, the two illustrations of the anatomy of the male genital system are included. In addition, a brief review will be given. Only those organs of importance will be considered.

The testis are two glandular organs which secrete the semen. They are suspended in the scrotum by the spermatic cord. They are invested by coverings derived from the serous, muscular and fibrous layers of the abdominal parietes, as well as by the scrotum. The average dimensions of the testis are from 4 to 5 cm in length and 2.5 cm. in breadth.

The epididymis covers the upper pole and the posterior border of the testicle. It begins at the upper extremity where the vas efferentia leaves the testicle. These tubules dilate and form convoluted cones which make up the head of the epididymis. The cones unite into a single convoluted tube which forms the body of the epididymis. The terminal part of the epidiymis or globus minor merges into the vas deferns.

The spermatic cord begins superiorly at the internal abdominal ring and after passing through the

inguinal canal and external inguinal ring, descends into the scrotum and connects with the testis. In addition to the vas deferens it contains the blood vessels, nerves, and lymphatics of the cord, testicle and epididymis. It is covered by the internal columnar fascia, the cremaster muscle and the fascia propria. Two of these, the cremaster muscle and fascia propria, also cover the testicle. The arteries are the spermatic from the aorta, supplying the testicle and epididymis; the deferential from the superior vesicle supplying the vas deferens; and the cremasteric from the epigastric to the cremaster muscle. The nerves are the genital branch of the genitocrural and the scrotal branch of the ileoinguinal which supply the scrotum and spermatic plexus of nerves to the testicle. The veins of the cord consist of the pampiniform plexus, made up from the veins of the testicle and epididymis. They terminate in the upper part of the cord to form the spermatic vein entering the renal vein on the left and the inferior vena cava on the right. The lymphatics from the testicles, cord and epididymis drain into the lumbar glands.

The vas deferens is a thick walled fibro-muscular tube lined with ciliated columnar epithilium. It

ascends from the tail of the epididymis, lying behind the vessels of the spermatic cords. At the internal abdominal ring it passes downward behind the bladder, crosses the ureter and joins the duct of the seminal vesicle to form the ejaculatory duct. Its entire length is about 18 inches.

The seminal vesicles, two in number, lie above theprostate, adherent to the base of the bladder and are separated from the rectum by the fascia of Denonvillier. Each vesicle consists of a thin-walled fibromuscular tube 4 to 6 inches in length, closed at one end and coiled upon itself to form an irregular, crescent-shaped pouch about an inch and a half long, and flattened antero-posteriorly. The vas deferentia pass along the base of the bladder between the seminal vesicles and unite with the ducts of the vesicles at the base of the prostate to form the ejaculatory ducts.

The arteries are branches of the inferior vesicle and middle hemorrhoidal. The veins accompany the arteries and join the prostatic plexus. The lymphatics drain into the iliac gland and the nerves are from the hypogastric plexus.

The prostate is a musculoglandular organ situated between the neck of the bladder and the triangular ligament and surrounding the first portion of the

urethra. The ejaculatory ducts enter the base of the gland at its posterolateral angles and emerge on each side of the orifice of the utricle. The glands form about twenty ducts which enter the urethra on each side of the verumontanum.

The male urethra is the common channel for the transmission of urine and semen. It begins at the internal sphincter of the bladder, traverses the prostate near its anterior surfaces, passes through the two layers of the triangular ligament, and continues along the ventral surface of the penis to the tip of the glans. It is from eight to nine inches in length and is divided by the anterior layer of the triangular ligament into the posterior and anterior portions. The posterior urethra is divided into the membranous and prostatic portion and the anterior into the bulbous and penile urethra. The urethra passes downward and forward to the bulbous area. It then passes upward and forward to the penoscrotal junction from which point it turns downward when the penis is relaxed.

The prostatic urethra extends from the internal sphincter of the bladder to the apex of the prostate. It is 1¼ inches in length and is the widest portion

or the canal. Upon its floor is an oblong elevation, the verumontanum, composed of muscle and erectile tissue, and near the anterior end of the venumontanum is the orifice of the sinus pocularis or utriclem a cul-de-sac ¼ of an inch in depth. The openings of the ejaculatory ducts are situated on each side of the orifice of the utricle. There is a depression on each side of the verumontanum, the prostatic sinuses, into which open the prostatic ducts.

The membranous urethra is the most fixed and, except for the meatus, the narrowest portion of the canal. It is ¾ of an inch long, extending from the apecies of the prostate to the bulbous urethra. It pierces both layers of the trigeminal ligament and is enclosed between these layers by the external sphincter. Cowper's gland lies behind and on each side of the membranous urethra near its termination, their ducts pass forward to open into the bulbous urethra.

The anterior or spongy portion of the urethra extends from the anterior layer of the triangular ligament to the meatus. It is about six inches in length and surrounded except the roof of the proximal half inch, by the corpus spongiosum. The caliber of the anterior urethra is larger in the bulbous than the

penile portion. Anteriorly within the glans there is an expanded area, the fossa novicularis, immediately in front of which is the urinary meatus, the narrowest and most inelastic portion of the urethra.

The urethra consists of a muscular, submucous and mucous layer. The muscular layer consists of a thin layer of longitudinal unstriated muscle fibers and a layer of circular fibers. The submucosa is fibro-elastic tissue and the mucous membranes contain columnar epithelium.

The blood vessels supplying are the middle hemorrhoidal and inferior vesicle arteries to the prostatic urethra. The membranous portion by the middle hemorrhoidal and transverse perineal arteries while the bulbar artery goes to the anterior portion.

The penis is composed of three erectile bodies, two corpora cavernosa which are of equal size and lie on the same plane and the corpus spongiosium, a smaller body lying beneath the two corpora cavernosa. Each of these bodies is composed of a vascular, spongelike structure and covered by a fibrous sheath containing elastic tissue, the tunica albuginia. The penis is covered by a delicate, loosly attached integument, beneath which is a layer of closely woven fascia.

The corpora cavernosa arise from the tuberosities and ascending rami of the ischium. They join beneath the symphysis pubis and form the bulk of the penis. They terminate in a cone-shaped extremity.

The corpus spongiosum surrounds the urethra from the triangular ligament to the external meatus. It begins as an expanded portion, the bulb lying anterior to the triangular ligament and between the converging corpora cavernosa. Anteriorly it forms the glans penis which covers the conical ends of the corpora cavernosa.

The glans penis is a conelike body with an expanded posterior border, the corona glandis, and a grooved under surface which receives the attachment of the frenum. At the summit there is an anteroposterior slit, the meatus of the urethra. The glans is covered by a delicate, sensitive, semimucous membrane which contains numerous sebaceous glands.

The glans is covered by a loose, nonadherent fold, the prepuce, formed by a reduplication of the terminal skin of the penis. The external layer of the prepuce is of skin; the internal layer is sememucous in structure. These surfaces join at a narrowed area called the orifice of the prepuce. The tissue between the

layers is loose and like the remaining subcutaneous tissue of the penis is devoid of fat. The prepuce is attached to the groove on the undersurface of the glans by a triangular fold, the frenum. The fascia of the penis, Buck's fascia, invests the erectile bodies to the base of the glans and is continuous with that of the abdomen and scrotum. A dense band of fibers from the front of the symphysis pubis to the tunica albuginea of the corpora cavernosa is termed the suspensory ligament.

The arteries come from the internal pubics and end in the erectile tissue. The veins begin in the erectile tissue and for the most part join the dorsal vein. The lymphatics drain into the inguinal lymph nodes.

The prostate is a musculoglandular organ situated between the neck of the bladder and the triangular ligament and surrounding the first portion of the urethra. Its apex is situated forward and its base toward the rectum from which it is separated by an extension from the pelvic fascia, the fascia of Denonvillier. It weighs from 16 to 24 grams and about 1½ inches in its longitudinal and transverse dimensions and three-fourths of an inch thick. The ejaculatory

ducts enter the base of the gland at its posterolateral angles and emerge on each side of the orifice of the utricle. That portion behind the ducts is known as the posterior lobe; the portion in front of them is divided into two lateral lobes, and an anterior and a median lobe. The prostate contains both longitudinal and circular fibers which are intimately connected with the musculature of the bladder. The circular fibers surround the urethra. The glandular structure is composed of compound tubular glands supported by a fibromuscular network. The glands form about twenty ducts which enter the urethra on each side of the verumontanum. The prostate is encased in a dense fibrous capsule and is supported by the puboprostatic ligaments and the anterior fibers of the levator ani muscle. Its arteries are branches of the internal pubic, middle hemorrhoidal and inferior vesical. The veins after forming a plexus on the sides and base enter the internal iliac vein. The nerve supply is from the hypogastric plexus.

The prostate excretes a thin opalescent fluid which serves as a diluent to the semen and a nutrient medium to the spermatozoa.[14]

PHYSIOLOGY OF THE MALE REPRODUCTIVE SYSTEM

The physiology of the male reproductive system will be reviewed here. The relationship of the possible effect of each organ upon sterility will not be considered not but will be considered after the reader has had the normal male presented.

The functions of the testis are two in number. One is the production of spermatozoa. The other, the elaboration of internal secretions. Both are essential to the propagation of the species. One function is the formation of the cell by which the race bridges the gap from one individual to another; the other is the elaboration of internal secretions producing the drive by which transfer of union is make possible.

The process by which spermatozoa are produced has been reviewed, pages 11 to 17, and will not be repeated.

The problem of internal secretions by the testis in the normal male is one which is rather poorly understood at best. The basic function of the male sex hormone is to produce normal development of the male reproductive tract and to maintain the secondary male sex characteristics and behavior patterns, in short,

"a specialized provision to insure contact between the egg and spermatozoa."

Development of the penis, seminal vesicles and prostate depends upon androgenic stimulation. In addition, descent of the testis occures under its influence. Accessory characteristics such as depth of the voice, distribution of facial and body hair in the male pattern, and the male type of skeletal muscular development are dependent upon this factor. The male hormone produced in the testis and credited with the physiology mentioned is named testosterone and is produced by the interstitual cells.

The exact function of the epididymis, other than that of a conveyance for the spermatozoa, is not known. Present opinion veers toward the belief that the epididymis acts by absorption as a maturing chamber, and a grave yard for the spermatozoa. Young[15, 16] believes it is necessary for spermatozoa to spend some time in the epididymis enroute from the testis to the ampulla of the ductus deferens if full maturity is to be permitted.

The ductus deferens probably plays a role somewhat similar to that of the epididymis, acting as a storage organ even to a larger degree than is generally appreciated.

The physiology of ejaculation is still unknown, but it is well accepted that sperm do not exhibit sufficient activity to leave the epididymis under their own motive power. It should be added that the epididymis although it secretes no hormone is believed to secret into its lumen a secretion which may act as a preservative. This theory, however, is not generally accepted.

The secretions of the seminal vesicles are yellow, viscid and of tapioca-like consistency. Huggins and Johnson[17] made chemical analysis of the semen and concluded that the seminal vesicle fluid contains phosphates, reducing substances, nonprotein nitrogen and chlorides. MacKenzie, Miller and Bangners[18] have contributed information confirming this. Thus, the main source of glucose is thought to be the seminal vesicles, and in this regard their function is indispensable to the welfare of the sperm. This is in controversy to past and present popular opinion which assigns them the role of "storehouse" or "graveyard" for the sperm. Beams and King[19] reviewed this literature and feel that it is the frequency with which sperm are found in the seminal vesicles at post mortum that accounts for this popular belief.

The prostate seems to play somewhat the same role as the seminal vesicles. Although no figures are present from a study of its function it is believed to furnish about 50 to 70 per cent of the total ejaculate and other than this function the role of the prostate remains unknown. It is important to realize that with the remarkable knowledge we have of the function of the rest of the male genital system that we know so little about the part the seminal vesicles and prostate play.

The rest of the organs necessary for fertilization of the female are spoken of as the delivery organs. The penis and urethra, with the accessory glands, form the only part of the genital organs sharing a function with the urinary tract. Coupled with this channel, which is about 18 inches in length, are two glands known as Cowper's glands, small compact groups of lobules, each about the size of a pea. Their secretions consist of a clear mucous material rich in albumin. Discharge is effected by an interlacement with the external sphincter of the bladder and contracture of perineal muscles. Their exact purpose is not known, although the presumption is that the alkaline excretions from the glands neutralize the

acidity of the urethra and prepare the channel for ejaculation. In addition to Cowper's glands, the glands of Littre contribute to the semen. The epithelial, subepithelial and submucosal glands secrete a clear mucus which probably does little more than to keep the lumen of the urethra moist.

The urethra is surrounded by the vascular sinuses, the corpora cavernosa and the corpus spongiosum, which are in turn encased in the voluntary muscles of the perineum. The erection of the penis is afforded by the distention of these blood spaces. The propulsive mechanism to the ejaculate depends upon the perineal muscles and the muscles surrounding the corpora.[20]

PENIS, URETHRA, GLANDS OF COWPER AND LITTRE

This group as explained earlier is entirely mechanical as the products of the glands have an unappreciable action upon the spermatozoa and the volume of the ejaculate is not materially affected by their contribution.[22] Any affect had on this group of organs by the other groups will be taken up in connection with the latter group.

Dysfunction of the erectile power, or important obstruction or malformations of this group of organs can impose conditions of sterility even though the other components of the genital tract are without fault.[24]

We will consider first the congenital abnormalities. These are caused by upset in the normal embryological picture given earlier. Malformations of the penis will be considered first. These are usually associated with other anomalies very often of the urethra. Associations with such defects as hypospadias and epispadias are most common. Penile malformations are rare and may be classified in the following eight groups;

a. Agenesis. This condition is rare and

may be found with external genitalia present or absent. It is difficult to differentiate from other types. There is no effective treatment for this condition.

b. Rudimentary penis or hypoplasia of a mild degree is not uncommon. Any marked degree of arrested growth is usually on a hormonal basis and will not be discussed.

c. Adherent penis, usually along the raphe of the scrotum, gives a fore-shortened appearance and may interfere with coitus. It may be correctible by surgery and is often found with hypospadia.

d. Concealed penis is usually a further grade of a rudimentary one being hidden beneath the pubic fat, but the penis may be concealed under a single envelope of skin. It may be ammendable to surgery and surgery should be considered.

e. Tortion of the penis may be slight or show a full twist from unequal growth of the corpora cavernosa. Tortion is most common in association with some degree of epispadia or hypospadia. Incurvation may be associated. These may require and be ammendable to surgery.

f. Facial ossification, although rare, occasions dispute, regarding an atavistic reversion or aquired calcification. An inflammatory origin is not established. This may make coitus difficult or impossible.

g. Cleft penis of varying degree has been reported.

h. Double penis occurs in several forms. It may be total or only the glans may be duplicated.

Malformations of the glans without an associated defect of the penis or urethra are almost unknown and should be treated with the associated conditions. Malformations of the frenulum take the form of foreshortening or, in association with hypospadias or epispadias, of absence. A short frenulum may hamper erection or produce incurvation. It may tear easily and repeatedly and cause painful or impossible coitus.

Malformations of the urethra are many and varied. Congenital imperforations are found and if compatible with life still make proper transportation of sperm impossible. Congenital narrowing of the meatus is common and all baby boys having this obstructive condition should have early meatotomy. Abnormal

openings of the urethra are of two types, (1) epispadias and (2) hypospadias. Epispadias is a congenital malformation in which the urethra opens upon the upper aspect of the penis at some point posterior to its normal termination. Its etiology is not clear. Three degrees of epispadias are encountered; (1) Balanitic or glandular, (2) penile, and (3) complete or penopubic. In the balanitic form, the penis may appear almost normal but the urethra opens upon the dorsal surface of the glans at the level of the coronary sulcus. In the penile form the opening of the urethra is on the dorsum of the shaft at some point between the glans and the pubis, usually near the symphysis. The roof of the urethra is lacking, only the floor remains. The meatus is a wide open slit. Complete epispadias is the most common of the three degrees and is characterized by complete absence of the roof of the urethra. The penis is rudememtary, flattened and curved upward against the pubis and held there by a band of connective tissue which replaces the urethra. I was unable to find any literature as to treatment of this condition in relationship to sterility, therefore I feel that although it would depend upon the degree, the outlook for correction and

improvement of male fertility is very poor in severe cases. Plastic surgery should be tried in the milder forms. Hypospadias is about 15 times as common as epispadias and carries a considerably better prognosis as in hypospadias the balanitic type is most common. In this condition the types are about the same (1) of the glans or balanitic (2) of the penis, and (3) of the penoscrotal or perineoscrotal region. There are a great many types of the balanitic variety. The urethra most frequently opens just behind the frenum at a point where the frenulum, which is absent, normally attaches. The glans, in these cases, may or may not exhibit an indentation marking the normal urinary meatus. The glans is slightly flattened and incurved and the defective prepuce forms a redundanthood on the dorsal aspect of the glans. This type of hypospadias rarely causes any interference with the normal generative functions except improper ejaculation i f the opening is small. In penile hypospadias, the urethra may be situated at any point along the penile urethra, but usually lies about half way between the glans and the scrotum. In this type the penile deformity is greater. The urethra anterior to the opening is usually absent but may form a cul-de-sac, which may

have one or more fistulous openings. The penoscrotal or perineoscrotal varieties are rare but serious. In the extreme forms the scrotum is cleft, each half containing a testicle which is atrophied. The penis is dwarfed and may be more or less completely concealed by the scrotal folds. The urethra opens at the base of the penis, in the cleft of the scrotum, or on the perineum. These people are usually sterile and secondary sexual characteristics often fail to develope due to testicular atrophy. There is no hope for this type but fortunately it is rare. The foregoing is condensed from Hinman.[27]

The treatment of all congenital malformations is plastic operations to correct the penile deformity with restoration of the urethra and normal micturation and ejaculation as far as possible. The first step should be straightening of the penis. This should be done at an early age long before puberty so as to aid in normal developement later.followed by a restoration of the urethra to normal position.[31] A discussion of each operation is impossible as it depends upon the degree of malformation within each type and the age of the patient at time of discovery.

Males who report for a sterility problem usually will present either a balanitic hypospadias or epispadias and if by surgical means this can be overcome, it is recommended but if impossible to correct so that proper ejaculation into the vaginal vault can take place, a condom with an opening in the end may be used or the ejaculate may lend itself to artificial insemination[28] and this possibility should be kept in mind.

There are many other congenital abnormalities of the genito-urinary system but it is felt they have no relationship to sterility in men so they will not be mentioned.

The most important pathology we find in this system is infection with its ultimate results. Urethritis is important because of two factors; first of all, primary pathological changes with stricture of the urethra[21, 29] and secondary as an etiological agent in infection of the organs composing group two in my paper.[21, 29] The second factor will be considered when the latter group, that is, the prostate, seminal vesicles and ejaculatory ducts are studied.

The etiology of infection of the urethra has changed since 1919 at which time it was found in the

first Australian Dermatological Hospital, Bulford, England, that 95 per cent of patients admitted to the hospital suffered from gonorrhea and 4.4 per cent from catarrhal urethritis while in 1943 in the Ninth Australian Admission Camp Hospital it was found that only 35.6 per cent suffered from gonorrhea while 64.4 per cent suffered from urethritis.[22] Denny[23] reports similar results. This, as we can see, shows a remarkable change in etiological agents and is unexplainable at this time. In a carefully controlled study it was found that in 31 per cent of the cases they were unable to culture any microorganism while in the other 69 per cent they found Gram-positive Bacilli, diplococci (intra cellular), and cocci and Gram-negative diplobacilli, bacilli and large Gram-negative cocci in pure and in different combinations on culture. Denney[23] reports in order of frequency, streptococci, diptheroids, staphloccoi, pneumocci, colon bacilli, and mixed and indeterminate types. Kreutzmann[21] reports 50 per cent of his cases as giving a positive history of gonorrhea and suggests the the percentage is probably greater.

Predisposing factors seem to be a history of sexual excess and abuse which result in prostate irritation.[23, 30]

and will be discussed at the proper time.

The pathology found here consists of hyperemia, ulceration, and granulation followed by fibrous tissue or scar tissue formation and contracture with an ultimate stricture.[25, 26, 21] The stricture is more frequently found in the bulbo-membranous portions than in the pendulous portion. Inflammatory stricture rarely involves the prostatic urethra.[27] The 436 strictures in Young and Garaghty's [25] (1906) series of 400 patients were located as follows:

Bulbous	140
Membranous	116
Bulbomembranous	52
Pendulous	104
Glandar	24

In Keys[26] series of 564 cases, 345 of them were bulbo-membranous. From this we see that not only are the majority of the strictures bulbomembranous but may even be multiple.[25] Kreutzmann[21] states a severe urethral stricture may prevent conception by preventing sufficient sperm being deposited in the vagina.

Ballenger et al[34] feel that most obstructions which cause sexual disturbances are found behind the verumontanum and consist of papillomas cysts, bulbous

edema, diverticula, false passages, varicose veins, angiomas, bands, bars, valves, fibrous contractures, utriculites, and other abnormalities of the verumontanum. The verumontanum is a very sensitive part of the prostatic urethra and is pressed on by muscular contractures of this region. Disturbances of this organ result in a variety of urinary and sexual symptoms. Unless suspected as the cause of these symptoms, the sensitive verumontanum may not be regared as their cause. The symptoms are: postpubic or deep perineal itching, discomfort or pains, urinary frequency, nervousness or premature emissions or impotence.

The most common condition caused by abnormalities of the verumontanum is sexual "neurosis" or sexual neurasthenia. This is often associated with mental disturbance or "nervousness" out of all proportion of the pathological process causing it.

The etiological factors in the production of pathology here seems to be masturbation, prolonged "necking" without sexual gratification, withdrawal before emission and other such abnormal habits.[24]

The treatment for disease of the urethra seems to confine itself to correction of the etiological

factors. As for hyperemia and hyperesthesia of the verumontanum and urethritis, the treatment is correction of the sexual life, and repair of the abnormalities. The cutting current is used for correction of gross lesions of the deep urethra, congenital or acquired, such as valve, bars, bands and fibrous contractures. The coagulation current is used for the small papillomas, cysts and varicosities. Dilitation with sounds for urethral strictures and meatotomy for an excessively small urethral diameter.[21, 24, 29]

Pathology of Cowper's glands and Littre's glands is rare and results usually in abscess formation so would have no actual value in discussion for sterility.

SUMMARY

From the foregoing we can see that:

1. Abnormalities are an important factor in sterility of the male and should be corrected by plastic operation at an early age.

2. Mild degrees of abnormalities of the male penis seen for the first time in adult life may not require surgical treatment. By the use of a condom with a hole in the end, the sperm may be deposited in the region of the cervix. If this method fails, artificial insemination of the female using the husbands semen may be a satisfactory treatment.

3. Infections of this group of organs are very important because

   a. They may produce stricture of the urethra which will prevent pregnancy.

   b. They may infect other genital organs.

4. The majority of the infections are caused primarily by the gonococcus.

5. The majority of the strictures are found in the bulbomembranous portion of the urethra.

6. The symptoms and signs pointing to this region may be nonexistant even in the presence of extensive pathology.

PROSTATE, SEMINAL VESICLES AND EJACULATORY DUCTS

The prostate gland, seminal vesicles and ejaculatory ducts will be considered together as many authorities[36, 43, 34, 50, 47, 33] feel that if one organ shows pathology the other two organs will share this pathology and thus contribute to the final picture.

The first thing of importance to consider is congenital abnormalities and their possible effect upon male fertility. It is believed that the many anatomical variations of the seminal vesicles have no significance.[34] They may be congenitally absent in combination with abnormal development or ending of the vas. Unilateral absence is more common, and is found more often on the left than on the right. Duplications and diverticula or formation of cysts sometimes occur. The effects of these later seem to be somewhat important in the etiology of infection. Malformations of the ejaculatory ducts are mainly abnormalities of termination. They may open into a ureter or run well forward beneath the urethra to open near the meatus urinarius. Malformations of the prostate usually occur in company of aplasia of the organs mentioned and have little significance.[43] Congenital cyst of

the prostate are rather important in that they may obstruct the passage ways and must be differentiated from cystic dilitations of the sinus pocularis, the ejaculatory ducts and seminal vesicles.[43] From this we see that the main effect of congenital malformations are (1) predisposition to infection, (2) obstructions, and (3) diversion of the seminal stream from the normal tract.

Injuries to this set of organs are rare and usually, although no always, are secondary to treatment for some condition. They seem mainly to be a part of the predisposition to the main pathological condition of this region, that of infection. Other contributing causes are masturbation over a protracted period of time, excessive sexual excitement without gratification, excessive sexual intercourse, and coitus interruptus.

Infections may be (1) haematogenous, (2) ascending from the anterior part of the urethra, bladder and kidney, or (3) exacerbations of a latent chronic infection that has originated from either 1 or 2.[50]

The organisms are various and authorities differ as to percentage. However, in a series of 216 cases of chronic infection, Staphlococcus Albus accounted

for 50.0 per cent, Diphtheroid group 37.0 per cent, Staphlococcus Aureus 13.4 per cent, Streptococcus Fecalis 12.5 per cent and Streptococcus Viridans 9.7 per cent. In this series thirty different microorganisms were isolated.[39] Shea[38] reports similar findings. Delzell and Lowsley[37] report 90 per cent of their cases showed positive for gonorrhea. White and Gradwohl[40] found gonococci in 80 per cent of their cases. These were in pure culture in 60 per cent of the cases. Similar results were gotten by Herbert,[45] Hyman and Saunders,[46] and Zigler.[42] Delzell and Lowsley obtained a history of gonorrhea in 90 per cent of their cases.

However, Kretschmer et al,[49] in a study of 1,000 cases of chronic prostatitis, identified the gonococcus as the offending organism in only 24 cases. Their belief is that gram-negative cocci are frequently mistaken for gonococci and that a careful study should be made before the diagnosis is made. However, it is understood that the gonococci is very frequently, as mentioned before, the initial cause being replaced later by another organism.[34, 48] Kreutzmann[21] reports a positive history of gonorrhea in 50 per cent of his cases and feels the percentage is even higher. It is also an accepted fact by urologists that distant foci

of infections can cause infection in the prostate, seminal vesicles and ejaculatory ducts when the proper predisposing causes are present.[29, 43, 34, 35]

The symptoms and diagnosis of an acute infection of this region presents little difficulty, but the insidious onset and absence of symptoms pointing to the urinary tract in many chronic infections may fail to attract either the patient or the physician's attention to the region as the source of infections.[34, 35, 38]

The pathology is classified briefly and simply on the basis of intrinsic and extrinsic changes. Microscopically, the mildest cases showed thickening of mucous folds, due to round cell infiltration and granulation tissue, with some denuding of the mucosa. Later the folds may become more fibrous in character, and form recesses between them containing inflammatory exudates, secretion, necrotic cells, and microorganisms. In places, the lumen becomes narrowed. In more advanced cases, the granulation is increased, and more lobules are obliterated, and are replaced with fibrous tissue. The fibrous sheath is thickened and leukocytic and round cell infiltration is more obvious in the perivesical tissue. Later there is a destruction of glandular tissue, with fibrous tissue more advanced.[35, 37, 44]

If the condition is allowed to progress, ultimate obstruction results.[21, 29, 34, 48] It is important in considering the pathology as well as the infection to remember that the grades of inflammation and therefore pathology may be of the same degree in the prostate, ejaculatory ducts, and seminal vesicles or one may show very little involvement while the others show maximum involvement.[48, 50, 34]

The symptomes and signs divide themselves into neurotic, bladder and urinary, perineal and testicular, abdominal, sexual and rheumatic.[40] The symptoms are important to us with the exception of the sexual symptoms only in so far as they help make a diagnosis and suggest treatment. The sexual are doubly important as they help explain why such a disease may cause relative or absolute sterility.

The neurtoic symptoms may be present in degrees varying from a mild state of apprehension to one of suicidal intention. Perineal, testicular and anal symptoms are present in practically all cases and although frequently referred it is common to find them. Pain is present in varying degrees ranging from only slight discomfort to sensations of dragging, drawing, and a feeling of dullness and pressure. Fifty per

cent of cases complain of itching and burning about the anal orifice. Bladder and urethral symptoms consist of frequency and urgency, suprapubic pressure and pain and tenesmus, chronic or acute discharge and other symptoms of dysurea. Rheumatic symptoms are not too common and are not helpful to us.[34, 37, 40]

The sexual symptoms are important and in about 35 per cent of the cases sexuality was markedly affected.[40] The male may show every phase from mild inaptitude to complete impotency. Atonic vesicles were noted in cases of ejaculatory praecox with mild degrees of imperfect erection,[50] whereas, cases of complete impotency invariably presented hard, fibrous sclerotic organs. Seminal vesiculitis in 75 per cent of those cases was productive of marked loss of strength, nightly pollution and desire. Blood and pus are found in the ejaculate material. Painful orgasm, painful and incomplete erection are other symptoms of importance which were found.[40]

Differential diagnosis need not be considered as had the patient had severe enough symptoms to cause confusion he would have presented himself to the physician as a sick individual and not as a sterility problem.

It is understood that in order for the male to present himself as a sterility problem the symptoms must be slight or nonexistant.

We can see from the foregoing data that reasons for sterility or relative sterility from this group of organs is due to: (1) Obstruction of the ejaculatory ducts or other organs due to infection with ultimate fibrosis and scarring.[21] (2) Chronic discharge preventing proper storage of sperm and discharge at intercourse. (3) Inability to complete a satisfactory intercourse due either to (a)sexual neuroasthenia or (b) pain and destruction of the sperm by the inflammatory reactions.

Treatment here is very important not only from a sexual standpoint but also from a general health viewpoint and although the sex angle in the majority of cases would become secondary we will discuss it from this standpoint. Any congenital defect or abnormality should be corrected if possible and will not be discussed as they are rare and only warrant mention and correction.

The teatment of an acute infection of these organs is heat and protection from trauma. Here massage should never be used[34, 40, 36] due to the

danger of secondary injury and spread retrograde of the infection to the vas deferens and epididymis. However, acute infection is not a sterility problem, but a medical or urological one.

The treatment of chronic infections of this region is well established. Degree seems to be the big point of disagreement. The major concern of White and Gradwhol[40] seems to be to prevent over-treatment. The basic principles of treatment are (1) removal of all foci or infection no matter how minor they seem, and (2) drainage of the entire system with all procedures carried out as gentle and free from trauma as possible. The entire urethra should be gradually and thoroughly dilated by the use of urethral dilators. The dilitations should be alternated with emptying of the prostate, seminal vesicles and ejaculatory ducts.[32] Whether the emptying is carried out by gentle but firm rectal massage, masturbation, or sexual intercourse is not important as long as the desired results are obtained.[32, 33, 37] The number of drainages is arbitrary but the best results seem to be obtained with two treatments a week and as the disease subsides, reduction in number.[34] Some urologists prefer to have the treatment with the bladder at least partially full

and use the urine to flush out the bacteria and pus[37] while others instill an antiseptic solution into the posterior urethra and bladder either before or after the treatment.[32] All seem to be adequate and it is merely one of individual choice. After the urethra is adequately dilated, if further treatment is indicated, as it frequently is, catherization of the ejaculatory ducts is indicated. Prior to catheterization an endoscopic examination should be performed at which time the verumontanum is cleared of granulations by the use of phenol-glycerine.[32]

For dilation of the ducts, F4 to 6 olivary-tip uretheral catheters are most practicle, while the whistle-tip is preferable for injection. A five per cent solution of mild silver albuminate may be used but it is the mechanical dilitation and not the antiseptic solution that is of value.[32, 35]

I have included the technique of Gonzales-Iman:[35] The Peterson catheter which consists of a gold tip attached to an ordinary woven silk catheter is used.

The curved tip of the catheter in a few sedonds can be introduced several millimeters into the ejaculatory duct by twisting the catheter and simultaneously rotating the telescope. The holder is then loosened

and the urethroscope is elevated to a 40 to 60 degree angle as required. Under direct vision, the tip of the catheter is directed downward and inward into the ejaculatory duct, then, by slow twisting and gentle pushing, the tip is directed downward and outward.[35]

If x-ray films are desired to observe patency, a 20 per cent solution of Sodium Iodide can be injected into the ejaculatory ducts until the patient notices a sensation of fulness in the region of the rectum.[37] Herbst and Merrick[33] and Fraser and Goldschmidt[41] strongly favor this treatment.

In 1923 Kidd[42] reviewed the treatment of chronic infection in this region and recommended vasostomy. However, later literature condemns this proceedure.[35, 36, 37, 40] Therefore I mention it here only to point out that later literature condemns the proceedure.

Chemotherapy may be helpful, either the sulfonamides given 1 gram 6 times a day for 10 days or penicillin 10,000 u I.M. q 3 hours for 10 days may be helpful but should not in any way modify the local treatment. In addition all foci of infection in the genital-urinary tract and any place else in the body should be eradicated.[37, 38]

The outlook for patients with pathology in the region with sexual symptoms is hard to evaluate as

pointed out in a study by Hinline.[34] In a series of 100 cases of chronic prostatitis and seminal vesiculitis following treatment, 60 of the cases showed complete relief with return to normal of the prostatic secretion. In 24 of the others, the symptoms were relieved but the prostatic strippings still contained some pus. In the remaining 16, clinical improvement was not noticed and these patients all complained of some sexual dysfunction.[34] These dysfunctions were not further analyzed but it suggests the gravity of the prognosis in just this one region from a sterility standpoint. Brunet et al,[51] report an identical result. Keshin[121] reports low sperm counts with a high percentage of abnormal forms and usually with a decrease in motility in patients with a chronic prostatovesciculitis. The sperm will be discussed in section four and this is presented at this time to facilitate study and understanding of the abnormal sperm later in the paper.

SUMMARY

From this we see:

1. Congenital anomalies are unimportant except in their possible connection with predisposition to infection.

2. Authorities vary as to the causitive bacteria. It is believed that the gonococci is the primary etiolical agent in from 70 to 80 per cent of the cases but is frequently replaced by a secondary invader before the patient is seen by the physician.

3. The symptoms, signs, and physical findings may be non-existant or extreme and in a sterility problem are of little help.

4. The pathology may be mild or extreme depending upon virulence of the organism and the length of the illness.

5. Treatment is very important but should be conservative, gentle, and free from trauma.

6. The essential ponts in treatment are (1) eradication of all foci of infection in the body, (2) drainage of the entire system. This is best accomplished by dilitation of the urethra, massage of the region either manually or physiologically.

7. Catheterization of the ejaculatory duct is a procedure which has gained wide recognization within the last twenty years.

8. Vasostomy is a procedure which should not be used in the treatment of prostatitis and vesiculitis.

9. Chemotherapy may change the entire treatment but at present should in no way modify the treatment described.

10. Evidence is presented which shows that persons with pathology in this region complaining of sexual symptoms have a rather poor prognosis for complete relief of symptoms.

VAS DEFERENS AND EPIDIDYMIS

Congenital abnormalities of the vas deferens rarely occur except in combination. Lespinasse[74] reported a case of absence of both vas with normal testis but a small prostate and probable absence of both vesicles. Guizzith[75] found at autopsy of a young man of twenty -five an entire absence of the right vas deferens and vesicle, but all other urogenital organs were normal. Diverticulation or formation of cysts of the ampulla or vas occurs. Baird[60] reported a case of cyst of the epididymis and reviewed the literature. From his article I interpret that although the condition gives rise to symptoms and pathology it in no way causes pathology in the epididymis, vas deferens, or testicle so is not important from a sterility standpoint. Abel[61], Abeshause,[62] Campbell,[63] and Colt[64] report similar findings. Various other abnormalities of position in the scrotum in relation to the testis are found, There may be varying defects of urogenital union so that the epididymis will be not only malformed but abnormally related to its testis. An epididymis may not be formed, the ductule efferentes uniting to form a vas, or the union between tubuli

collective of epigentalis and rete tubules of the testis may fail. Other possibilities of malformations are innumerable but very seldom encountered.[59] However, from this we can see that connection between the testis and ejaculatory ducts is essential and it must be patent. If these conditions are met there is no reason why any congenital anomaly reported in the literature should in itself cause sterility.

Infections in this group may be caused by any organism, the most frequent are staphlococcus, streptococcus, colon bacillus, gonococcus and tubercle bacillus. Although it has been shown that these bacteria cause the malady, their exact mode of entry to the epididymis and vas deferens is not completely understood. While it is most common to find pathology in both organs if one is infected it is not always found. However, the general opinion seems to be that the infection may be (a) blood born, (b) lymphatic born or (c) direct spread within the lumen from the prostate, urine, or seminal vesicles. Henline[68] believes that the majority are by direct migration from other organs. He also believes that many are caused by trauma, either external, as a blow, lifting, or dilitation of strictures, or internal, as sexual excitement or abuses. Thomas[126]

believes tubercle bacillus can be present in the epididymis and vas deferens without producing clinical epididymitis. Kennedy[69] points out that it has long been an accepted practice to prohibit strenuous physical activities in patients suffering from gonorrheal prostatovesiculitis in an effort to prevent infection from extending down the vas deferens to the epididymis. Jacobson[65] reports a series of cases in which Blastomycosis causes epididymitis and vasitis, however, these resulted usually in early death and are not a sterility problem. Mason and Reifenstein[66] report a case of epididymo-orchitis following minor trauma which resulted in death. Although neither of these reports are directly concerned with sterility, it definitely shows us that minor injuries and infectious process could cause sufficient pathology to cause obstruction of the vas or epididymis and result in sterility.[21] Huhner[67, 76, 77, 78] Kreutzmann,[21] and Meaker[29] report that an old epididymitis is a frequent cause of occlusion of one or both vas or epididymis with resultant sterility without the presence of a palpable nodule. A very important statistical study by Huhner[67] reports that by a study of the reports of the various authorities it is impossible to get an

adequate indication of the per cent who do suffer from this disease because the authorities vary too greatly as to percentage. However, he feels that 10 per cent of all marriages are sterile and that 60 per cent of the trouble is due to the male partner. Sangree[2] reports 50 per cent due to the male while Meaker[29] and McLane[31] report 30 per cent is the fault of the male partner.

Lowsley and Reaboff[70] report a case of calcification of the vas deferens and review the literature. They report the condition as rare, that is, only 31 cases in the literature, but as well worth recording. The ages reported vary from 14 to 81 years of age, with 66 per cent of the cases in men under 60. Only eleven, including their case, were diagnosed before autopsey, which indicated that this may be an etiological factor which goes undiagnosed. It is important because it will upset the normal sexual act and cause improper transport of the sperm. The condition seems to divide itself into an inflammatory and noninflammatory grouping. The noninflammatory seems to be due to senile changes while the inflammatory to an infection of the vas, epididymis, seminal vesicles, or prostate. The symptoms are non-specific and diagnosis is mainly

by x-ray examination at operation or at autopsy.

Benjamin Robertson and Cheitham[71] report a new clinical entity, vasitis nodosa. In their case it had nothing to do with sterility as the man had three healthy children, however, they were born prior to the onset of symptoms so it does not mean that he could not have had obstructions. The etiology of this condition is not known. It may be due to (1) infection (2) diverticula (3) faulty development, or (4) cyst formation. This condition is mentioned only at this time to suggest the possibilities of surgical treatment on cases of the type with obstruction of the lumen of the vas or epididymis and the so-called cases of tuberculous epididymitis and vasitis, in which no organisms can be found as well as selected cases of tuberculous occlusion. Our final interpretation of these men's findings must await the reporting of similar cases in the literature. Eisendrath[72] states obstruction in the epididymis, vas deferens and ejaculatory ducts following inflammatory processes in these structures is common. They may also be of congenital origin.

Another reason for sterility by lesions in this region is accidental severing or ligation of the vas in hernia repairs.[54]

Treatment of disease or afflictions of this region is mainly surgical correction of the pathology following an acute condition. Sulfonamids 4 gm. initially and 1 gm. every 4 hours until the condition is controlled or penicellin 10,000-20,000 units every 3 hours are new drugs which may change the resultant sterility greatly but our treatment will be mainly with the chronic condition. This is best performed by chemo-therapy and surgery. The best results seem to be by reconstruction of the vas and epididymis.

The reconstruction of a patent vas deferens has been reported only a few times in the literature, however, it definitely establishes that this is a possible treatment in selected cases. To facilitate the understanding of the subject one of the typical case histories will be presented.

Episode #1. Bilateral vasectomy performed in 1924 because of serious illness of wife of patient. Thereafter patient was potent but not fertile. No spermatozoa in microscopic specimen.

Episode #2. Loss of first wife by demise.

Episode #3. Remarriage of patient to young wife in good health, desiring children.

Episode #4. Development of depression and

melancholy by patient. Psychiatrist advised revision of vasectomy if possible.

Episode #5. Bilateral operative repair of vas deferens. (1928)

Episode #6. Microscopic examination of specimen now showed live spermatozoa. Mental condition improved immediately and within 18 months wife bore a child. Recheck, microscopic, March 8, 1938, showed active spermatozoa.

Technique of operation: Under general anesthetic an incision was made over the right vas, and the two cut ends were brought to the surface and freshened to the point where patency could be observed. Catgut with a needle threaded on each end, was used to make end to end anastomosis. Each needle was passed up the lumen of the freshened end of the vas to a distance of three-quarters of an inch and thrust through the wall and tied to the other catgut end. This made a loose hammock loop, and forced the two ends of the vas together, all layers properly approximated.

The opposite vas was repaired in like manner and wounds closed.

A recheck was made following the operation and live spermatozoa were found in the semen. The mental

condition improved following the operation and the patient has had normal off-spring. Recheck March, 8, 1938, was also positive.[52]

Baker[53] reported in 1940 a case almost identical with identical results. A child being born within 14 months after restoration of the continuity of the vas. Freeberg and Lepsky[54] reported one similar case with return of the male factor to normal but the female has failed to conceive even though she is given a clean bill of health by the Obstetritions and Gynocologists. Nilsen[55] reports a case in which two surgical procedures very similar to that given earlier were necessary before the male became fertile but shows us that if the first surgical proceeaure should fail that the sterility may still be correctible. Cameron[57] reported a similar case with similar technique and results except that no subsequent pregnancies are reported. Strode[73] has reported two cases of anastomosis of the vas after seven years. Although no pregnancies resulted it seemed that the operations were successful as morphologically normal sperm were found proximal to the anastomosis which may have caused sterility in the first place.

The most important addition to this literature

and case history is a case of gonorrhea epididymitis which was corrected by surgery.

Gonorrhea with bilateral epididymitis accounted for only one case of sterility in a series of fifty-five.[56]

The patient is a white male 34 years of age who was first seen in December, 1940. He had been married five years and presented himself for a sperm examination. His history was negative except for a severe bilateral gonorrheal epididymitis in 1931. Physical examination was also negative except for a nodule of induration in the lower pole of either epididymis.

The ejaculate studied on three different occasions revealed no sperm. In December, 1940, a needling of either epididymis was done and live sperm were found on the left side. The patient was then advised of the possibility of epididymo-vasostomy, but because of the disparaging remarks by a physician did not submit to this suggestion. He returned for reexamination in October, 1942, when his condition was found unchanged. In November, 1942, a bilateral epididymo-vasostomy was done according to the technique of Hagner. Three months later a masturbated specimen revealed a normal ejaculate with a count of 85,000,000. Within four

months after the operation, the patient's wife became pregnant.[56]

It seems reasonable to assume that this patient had been sterile at least eight years and very likely thirteen years. No other case of sterility with a definite epididymitis as its etiology has been cured by epididymo-vasostomy is reported. However, it is one case in conjunction with the results obtained in correcting a surgical sterility and suggests the possibilities of the use of this technique.

Cotore, Leiter, Knaus and Spath[79, 80, 81, 82] are in agreement that, following vasectomy, permanent damage to the testis does not occur. Knaus[80] states that if the testis remains in the scrotum no testicular degeneration occurs. Leiter[81] reports the same findings.

The technique also may be of great benefit in the reconstruction of patent vas that have been damaged in hernial repairs. Campbell[58] reported in the fall of 1945 at the Mid-West Clinic that he had found damage and obstruction to the vas in his last five cases due to faulty hernia repair.

SUMMARY

We can conclude from the work of these men that:

1. Congenital abnormalities can cause sterility but are rare and probably of little clinical significance.

2. Gonorrhea is probably the most frequent etiological agent in an infection of this region.

3. Gonorrhea can produce bilateral obstruction in either the epididymis or vas deferens without producing a nodule or other symptoms.

4. Anastomosis of the epididymis or vas to secure a patent lumen has been accomplished in cases of gonorrheal obstructions and surgically induced obstructions.

5. Most obstructions in this region, no matter what the cause, under proper technique and study are probably ammendable to surgery.

6. Case histories are presented as proof of the effectiveness of the anastomosis.

7. A new clinical entity is presented which may be found to be an important fact in causing obstruction and sterility.

8. The technique may be valuable in correcting sterility produced by improper hernial repair.

TESTIS

When we consider the testis we first of all think of the sperm. This one branch is coming to the fore and is being blamed more and more for sterile marriages. It is of rather marked importance and so will be considered more in detail but we will still exclude the endocrinological factor. The full normal function of the testis seems to be related to heredity, age, nutrition, temperature, infections, neoplasms, castration, obstructions, circulatory upset, irritation, pressure, constitutional states, and endocrines.

The hereditary factor in relation to male sterility has not been proven satisfactorily. Various men have reported conclusive results on lower animals but no human results have been reported.[83]

There has been considerable work done to date in an attempt to corrulate the age of the parents and the mentality and the number of still births. Yerushalmy[84] has shown a marked relationship between the still birth rate and the age of the father. Th e rates were high for old fathers and very young fathers independent of the age of the mother. Engle[85] reported abundant spermatozoa in the testis and ducts of more

than one half of a group of men past 70. He observed that with senility there is apt to be a thickening of the tubule, with resulting failure of spermatogenesis. However, this peritubular fibrosis is found in young men as well and so he does not regard it as characteristic of the aged. Seymour[86] reported a case of authenticated fertility in a man of 94. Stieve[87] believes that similar changes occur in testis of younger men who have suffered general illnesses, and, in a study of autopsy material from general deaths, can find little difference in the testis of young and senile men either in the interstitial cells or in the structure of the testis tubule. It is also understood that the male decline in reproductive capacity is not as sudden or as rapid as in the female and probably age plays a very minor if any part in sterility in men from our viewpoint.

Nutrition is important in the function of the testis as well as any other part of the body. No definite proof that any of the added vitamins, minerals, or proteins have a direct effect on male sterility has been reported but it is common knowledge that the best nutritional balance possible is desirous and may play some part.[21, 29, 31] Many animal experiments along this

line have been reported but will not be considered due to the lack of adequate proof of their effect on human tissue. Reynolds and Macomber[88] feel they have had clinical observations comparable to those of the experimental work, each supporting and reinforcing the other. However, from their literature and other of a later date, I feel that no definite proof has been established.[21, 29, 31]

Changes in termperature have a great effect upon spermatogenesis. This effect is best illustrated by a cryptorchid where the testis is at least partially atrophic and damage to spermatogenesis has resulted. Moore,[89, 90] Fuken,[91] and Hiller[92] as well as Phillips and MacKenzie[93] have brought forth specific information on the character and extent of injury caused by heat. Rea[94] estimates that 10 per cent of untreated human cryptorchids remain fertile. He estimates that 82 per cent of men treated by orchidopexy have active spermatozoa in the semen but believe even such testis have poor function. MacLeod and Hotchkiss[95, 96] gave fever treatment to six young healthy normal men. The temperature used was between 40.5 and 41°C. The men were examined thereafter at from three to six day intervals. They found that following such single

treatments that abnormally low sperm counts were found for 32 days following the treatment with the middle of the low point reached 42 days following fever. Brown[114] reports a very interesting case where a patient under observation for two years got ulcerative membraneous stomatitis with a resultant temporary azospermia. Sperm counts were made at approximately weekly intervals throughout the illness. Within one month the total sperm count per ejaculate had fallen from 118 million to 10 thousand sperm. Many abnormal forms were found, and a reduction in normal motility and resistivity was found. Under continued observation the sperm returned to normal in nine weeks. Hotchkiss[115] reports similar results. Thus we see that abnormal increase in temperature can effect male fertility whether due to increased temperature produced by maldevelopment, as in a cryptorchid testical, infections or by artificial fever.

Infections of the testis proper are important but rather rare. When they occur they show the same symptoms, signs and pathology as the epididymis, vas deferens, prostate, seminal vesicles, and ejaculatory ducts so will not be considered in detail. They usually exist in conjuction with an epididymitis. In addition, syphilitic lesions, namely gumma of the

testis, will destroy a portion of the testis and lower its effectiveness. However, these are not common. Tuberculous of the testis also falls into this category and I was unable to find any literature which suggested either tuberculous or syphilitic lesions of being a frequent cause of sterility.

Orchitis following mumps is probably the most important infection of the testicle proper and , although not common, causes marked atrophy of the organ with damage to spermatogenesis. Orchitis is never found before puberty but is a rather common complication of mumps occuring after puberty.[31]

Infections have a direct affect upon the number of sperm in the ejaculate but yet do not affect the normal pattern of spermatogenesis.[124, 29] These infections as described by Charny are the specific and non-specific infection exclusive of orchitis.

Complete castration of the male concludes all possibilities of fertility. If only one testis is removed, the resulting effect on the fertility of the individual is proportional to the value of the remaining gonad. It is unlikely that the total sperm content of the ejaculate will be reduced to a level at which

at which the chances of conception are materially altered if only one testical is removed.[116]

Obstructions are rare in the testicle proper and have been considered with the proper group.

Circulatory upsets can be mild or severe. The part played by varicoceles is controversial. Small or even moderate sized ones probably have no clinical significance.[96] Large varicoceles in the middle aged are often associated with soft flabby testis.[96] Hernia repair with ligation of the vas deferens has been discussed but it must be remembered that the blood supply may be upset to such an extent that atrophy of the testicle may occur. Torsion of the testicle may cause stasis or even gangrene of the testicle when the blood supply is cut off. If the patient survives the attack without surgical correction or removal there is apt to be a diminution in the size of the testis.

Irradiation reaching the body by direct penetration of the surface as well as by inspiration into the lungs, affects both spermatogenesis and mature spermatozoa. Numerous experiments have shown that external irradiation can produce an ejaculate devoid of spermatozoa. Irradiation apparently affects only those humans who have had extensive or continued exposure.[121]

Physicians, dentists, physicists who have been exposed, technicians who have given extensive treatment and patients who have received extensive treatment are likely subjects.[116] Huhner[97] suggests that certain testis are radio-sensitive and are damaged by dosages harmless to others. Holstein[98] claims that electrical welding is harmful to genital structures and causes damage to testicular tissue.

Pressure from hydroceles and of the muscles of the abdominal wall on undescended testicles can cause atrophy but under ordinary conditions has no effect.[116] Meaker and Vose[29] report varococeles as a possible etiological factor in atrophy of the testis.

In consideration of this section the most important factor to us is the spermatozoa so we will consider the entire procedure from collection of the specimen to treatment for abnormalities of the sperm.

In a study of the semen of a male patient, many things must be taken into consideration. First of all a semen specimen must be collected and although there are many methods, I will give but on in detail and merely mention the others. Masturbation into a wide-mouthed container is a very satisfactory method of securing semen. This should be done at the physicians

office. The patient should be shown into a small room which is comfortable and dark. The door should be locked from the inside and no one allowed to go near the room. By this method the patient will probably procure a normal specimen. The jar used should have a large enough mouth to allow easy access. It should be clean and well dried. By this method Weisman[99, 100] feels it is possible to secure a normal specimen.

Withdrawel at intercourse with ejaculation into a wide mouthed jar is the next best method but is not as satisfactory as the proceeding. The use of a condom should never be recommended as the powder and other ingredients used in making the condom have a harmful effect upon the sperm and at best poor results are obtained.[101] The collection of semen from the vagina is poor due to the acid pH of the vaginal canal which tends to destroy the sperm and abscure the correct interpretation of the specimen. The Huhner[102] test consists of examining sperm taken from the cervix of the female and is given much confidence by Huhner himself, but this to me, although valuable, seems to be a rather late proceedure. The other proceedures used are even less valuable and apply only in selected cases as by obtaining a specimen from the uterus, by

rectal massage and testicular asperation. These latter have not been discussed as they are of value in such few cases and their technique limits their practical use in sterility diagnosis.

After the semen specimen is obtained no matter which procedure has been used it should be kept at room temperature and taken at once to the laboratory for study. A complete analysis can be a very complicated procedure but for a routine analysis only the more practical tests are utilized. These are as follows:

1. Physicochemical tests.

   The volume of the ejaculate should be accurately determined to within one tenth of a cubic centimeter. The volume varies normally from 2.5 to 5 cm. The turbidity of the colloidal suspension should be noted. The suspension usually ranges from milky to yellowish, and is opaque but in some cases it may be fairly clear. The viscosity and general appearance of the specimen should be noted as fresh ejaculate is entirely different in appearance and viscosity from that which is one half hour old. within 30

minutes after ejaculation the semen should be a uniform, easy-flowing liquid with few or no gross particles visible. The semen is always alkaline and normally shows a pH of 7.5 to 8 by the Nitrazine method.[29]

Abnormalities in volume of the ejaculate other than those discussed in proceeding sections are usually due to an excessive number of ejaculations.[127] Dickenson[117] showed that indulgence in coitus resulted in early sterility and impaired seminal specimens. Although it is understood that larger volumes of semen do not necessarily contain higher total numbers of sperm, it does tend to neutralize the vaginal acidity and allow the sperm to live longer.[118] The turbidity and viscosity of the semen are usually within normal limits and along with the pH are considered by Hotchkiss[111] to be important only if no motility of the sperm is found and it seems to be of general agreement that where normal motility is found the latter determinations have no value.

The most important study of spermatozoa is the microscopic one. The important total number of spermatozoa per cubic centimeter of semen is controversial. Hotchkiss[29] feels that it depends upon the total number of sperm in the ejaculate rather than on the number per cubic centimeter. However, Meaker[112] and McLane[31] state that in their experiences pregnancy has never occured in cases where the sperm count was below 60,000,000 per cubic centimeter. Pollak and Joil[110] consider the normal variation of spermatozoa to be from 60,000,000 to 120,000,000 per cubic centimeter. These indicate that the total normal counts per ejaculate should probably range from 300,000,000 to 500,000,000. And from a review of the literature Wiesman[113] feels that sterility is most likely to be found in males whose average count is less than 50,000,000 spermatozoa per cubic centimeter and whose total count is approximately 150,000,000 or less.

The technique for total spermatozoa count can be carried out in many ways. The simplest

and most satisfactory method, however, is probably that of Macomber and Saunders.[103] An ordinary white blood cell pipette with a 1:20 dilution and ruled counting chamber such as is used in making blood counts are the equipment needed. The semen is allowed to stand until liquified. Then it is shaken well and drawn into the pipette up to the marker labeled 0.5; next, the diluting fluid is drawn up to the 11 mark.

The diluting fluid is a bicarbonate-formalin solution, consisting of 5 per cent sodium bicarbonate and 1 per cent formalin dissolved in water. The pipette is shaken will, the first three or four drops are blown out and discarded and the next drop is placed in the counting chamber. One square millimeter, usually at the center or at a corner of the counting chamber, should be counted. The value obtained is multiplied by ten to obtain the number found in 1 cm. which is in turn multiplied by 1000 to find the number in 1cc. To arrive at the number contained in undiluted semen, it is now

necessary to multiply once more by the dilution used, in this instance 20, for the final count.

Other counting methods are available as Hotchkiss[104] method, and Belding's[105] method. These methods are of value but require greater skill and so are not as valuable to the general practitioner.

2. Morphology of Spermatozoa.

Within the last ten to twenty years the most outstanding development in the study of male fertility and sterility has been the study of the morphology of the spermatozoa. In the opinion of Williams[106] this study is the deciding factor as to whether the patient is normal or abnormal.

There are various techniques of study; hanging drop with living sperms with or without stains. However, the most effective method according to Weisman[107] is by the use of fixed slides and special techniques and stains.

Although there are many effective stains I will present one which seems to be effect-

ive as well as simple. It is to be understood that the other stains are probably as effective and would give the same ultimate results.

Method of Cary and Hotchkiss:[198]

A. Prepare thin cover-slip smears as used in the preparation of blood for staining.

B. Fixation in Schawdinn's solution.

1. While still wet immerse for one minute in a 7 per cent solution of corrosive mercuric chloride, two parts, and absolute alcohol, one part.
2. Immerse for half a minute in 50 per cent alcohol.
3. Immerse for half a minute in distilled water, 3 ounces, and tincture of iodine, 2 drops.
4. Wash in tap water.

C. Staining process.

1. Immerse for half a minute in aqueous solution of eosin, 5 per cent.

2. Immerse for one minute in 50 per cent alcohol, 3 ounces, and concentrated hydrochloric acid, 2 drops.
3. Wash in distilled water.
4. Immerse for one minute in distilled water, 3 ounces, and glacial acetic acid, 2 drops.
5. Wash in distilled water.
6. Dry and mount.

With this technique excellent contrast between the nuclear material, which stains blue, and the cytoplasm, which stains red, is obtained.

There have been many classifications of the abnormalities found in spermatozoa. Williams[106] has presented a simple but effective classification. He feels there are but six classifications which are as follows:

1. Normal
2. Pyriform head
3. Nucrosperms
4. Megalosperms
5. Abnormalities of the acrosome
6. Miscellaneous types

Normal semen, according to Williams[106, 125] contains approximately the following proportion of atypical elements:

Abnormal Cells in Normal Semen

Type of cell	Per cent
Pyriform heads	not over 9
Nucrosperms	" " 12
Macrosperms	less than 5
Defective acrosome	" " 5
Miscellaneous*	" " 4

*(Defective head, tail, body)

Hotchkiss, Brunner, and Grenley[104] studied 200 normally fertile men and arrived at the following percentages for normal semen. Their report seems to agree with and summarize the comparitive findings for normal semen.

Differential Cell Count for Normal Semen

Type of Cell	Per cent
Normal	89.81
Megalosperms	.40
Pyriform	3.68
Microsperms	.20
Round forms	1.65

Type of cell (cont)	Per cent
Duplicate cells	1.84
Amorphous	2.10

Other more complicated procedures and classifications by Moench,[120, 109] Pollak and Joil,[119] and Keshin and Pinak[121] have been presented but according to Weisman[113] they yield very little information that has not already been obtained from the stained smears. Testicular biopsy has, however, been recognized recently as a very valuable office proceedure and an aid to diagnosis.

The technique of testicular biopsy of Charney[127] is simple and can be performed in the office if strict aseptic technique is available.

The testis with the scrotal skin taut, is held in the operator's left hand. After application of an antiseptic, a portion of the skin overlying the anterior surface of the testis is infiltrated with 1 per cent procaine hydrochloride. An incision about 1.5 cm. long is make through the skin and carefully carried through all the fascial

layers until the parietal layer of the tunica vaginalis is opened. This is signalized by the escape of serous fluid and the appearance of the glistening visceral layer of the tunica vaginalis. The later and the tunica albuginica are nicked with a small scalpel. Gentle pressure on the testis now serves to extrude a small bead of tissue, which is cut off with a curved iridectomy scissors. The testicular incision need not be sutured. The skin is closed with two interrupted catgut sutures and a collodion dressing applied. The patient may return to his former duties the following day, a suspensory being worn a day or two. The specimen of tissue is preserved in Bouin's solution, mounted in parraffin for section and stained by hematoxylin eosin.[127]

After the specimen is examined, it is possible to tell whether the azoospermia is due to obstruction of the genital system or whether it is due to atrophy of the testicle with ultimate faulty spermatogenesis.

Huhner's[78] testicular asperation described much earlier tends to secure the same results but is not as informative so will not be described.

The advantages claimed for testicular biopsy are:

1. In azoospermia, to differentiate between obstructive and non-obstructive types.
2. In oligozoospermia, to determine the severity of the pathologic process and to differentiate betwee n faults in spermatogenesis and postinflammatory obstructive lesions of the ejaculatory ducts.
3. As a prognostic gage, to observe the severity of the pathologic process and thus determine the capacity of the tubules to regenerate.
4. As a therapeutic gage, to evaluate by repeated biopsies the effecacy of the various extracts recommended for stimulation of spermatogenesis.

3. Motility and resistivity.

The motility of the sperm on examination is important as in the normally fertile specimen about 10 to 15 per cent of the spermatozoa are found to be dead or non-motile. Death in a normal healthy specimen is due to one or both of two factors, old age or immaturity. Old age death is probably due to too long a time in transport through the vas deferens.

The following types of motion should be included in the differential count. There are more complete descriptions of motility but they are not practical for general use.

Motility of Normal Specimen		Per cent
Motionless (dead)	less than	15
Sluggish, struggling motility	"	15
Moderate degree of motility	at least	75
Normal swift movements	" "	75

The technique consists of allowing the specimen to stand at least half an hour before being tested. One drop of liquified semen is then placed on a slide, covered with a coverglass, and examined first under the low power-lens to gain a relative idea

of the activity of the sperms. A part of the field toward the end of the coverglass, where the cells are less dense, is brought under the field of vision. The high power lens is then brought into position, and 100 cells are studied for absolute non-motility, sluggishly struggling motion, moderate motion, and normally rapid movements.

The appraisal of motility and viability of the spermatozoa is second in importance only to the morphological study in the assay of male fertility according to Portney.[122] Beginning soon after ejaculation a drop of seminal fluid is placed under a cover glass and examined under the high-power objective. This is repeated at intervals of three to four hours, using a fresh drop of semen each time, until there is no further motility. The specimen is kept at room temperature in a loosely covered glass jar throughout this time. A normal specimen should show 80 to 90 per cent very active motility for the first 6 to 8 hours. Sixty to 75 per cent should maintain a good motility for at least 16 hours.

> At 24 hours about 50 per cent should still show fair motility.[122] One's suspicion should be aroused as to the fertility of any specimen in which all the spermatozoa die off within 24 hours.[122] Hotchkiss[111] reports similar results with a slightly different technique.

The treatment of this section divides itself rather clearly into two divisions, (1) medical and surgical, and (2) endocrinologica. The treatment in connection with obstructions, infections, general diet and health, and normal control of sex life have been considered in previous sections so will not be repeated. The use of x-ray has been suggested at different times and although it is general knowledge that large dosages cause damage to spermatogenesis, Keshin and Pinak[121] report some favorable results with an increase in motility and young forms with the use of controlled dosages of x-ray.

The majority of the other treatment is in the field of endocrinology where conflicting results seem to be an every day occurance so I have excluded this field except to mention that a low metabolic rate is frequently found in cases of abnormal morphology and

reduced sperm count and are found to respond to thyroid extract.[121, 122]

The only other treatment I will consider is the surgical correction of cryptorchidism. Some cases will respond to hormones but here we will consider those cases which do not. We will not consider their possible etiology but will present a technique for treatment which seems to be adequate and emphasize that the best time for surgical correction is at an early age.[123]

Technique of Moore and Tapper.[123]

The usual hernial incision is made down to the fascia of the external oblique muscle. The external ring is located, and the testicle located. For better exposure, the external oblique fascia is divided up to the internal inguinal opening. The testicle is freed from surrounding structures and the gubernaculum is loosened if attached. The coverings of the testicle, including the processus vaginalis, are then opened. The processus vaginalis may or may not contain abdominal contents, but in our series the majority have an opening continuous with the peritoneal cavity. The hernial sac is removed by blunt dissection and ligated at the internal ring. The vas is isolated and pulled

to one side. The vascular cord is then elongated by severing the fascial bands which run vertically with the vascular funiculus and are more pronounced on the posterior surface. This is all gradually freed by blunt and sharp dissection so that only the blood vessels, including the pampiniform plexus of veins, are left. Freeing of these bands of adhesions allows the testicle to be placed into the scrotal pouch which has been prepared manually, a needle treaded with linen or silk suture is brought through the gubernaculum and then out through the skin at the most dependent part of the scrotum. The needle is then passed through the skin of the thigh. The other end of the suture is similarly placed and the two tied with moderate traction. The testicle is also anchored to the bottom of the scrotum with catgut sutures. A purse-string chromic suture placed at the superior part of the scrotum, that is, in the subcutaneous structures, the cord being included in this suture, and is then loosely tied. The purpose of this suture is to produce a band of adhesions and thereby prevent the testicle from slipping upward into the inguinal canal, after the linen or silk sutures attached to the thigh are cut, generally in about two weeks. Closure is by the usual method of repairing a hernia.

SUMMARY

1. There has been no definite proof of a hereditary factor in male sterility.

2. The age factor is of minor importance in sterility in the male.

3. Adequate nutrition is essential to normal sexual activity but excessive protein, minerals and vitamins have not been proven to be of advantage in humans.

4. Temperature increase due to infectious processes and artificial fever causes temporary reductions in fertility.

5. Non-descent of testicles causes sterility in 90 per cent of the cases if not corrected at an early age.

6. Infections of the testicle proper are rare and are discussed under the proper sections.

7. Tuberculosis and syphilitic gumma are rare causes of sterility in the male.

8. Orchitis with testicular atrophy is the most important primary testicular infection and results in damage to normal spermatogenesis.

9. Infections of the testicle and other organs

as well as distant foci cause reduction in the number of sperm per ejaculate but do not upset normal spermatogenesis in the testicle.

10. Circulatory upsets can cause pathology of the testicle but rarely do.

11. Irradiation causes upset in normal spermatogenesis but in selected cases may be used to stimulate spermatogenesis when used in controlled dosages.

12. The proper methods for securing and examining a semen specimen are presented.

13. Normal semen findings are presented and explained.

14. Abnormalities of semen which are encountered are presented and explained.

15. Treatment in so far as possible, is evaluated and explained.

CONCLUSION

In this paper I have tried to confine my study to facts which would be of value to a general practitioner of medicine. I have not attempted to be complete in every detail as it would be impossible in a subject which as so many divergent possible etiological factors. I have left out factors which can cause sterility but in which a study would be a waste of time when the primary factor holds such a dangerous prognosis. An example of this, it seems to me, would be a discussion of malignant growths in a paper on sterility. It is generally accepted that a malignancy of any genital or urological organ might well cause sterility so they might well have been discussed. However, what man is going to be interested in his prognosis from a sterility standpoint when informed that he has a malignant growth. From this I felt the percentage interested was too small to warrant mention. Other minor etiological factors have been excluded for the same reason.

My discussion of the embryology, histology, anatomy, and physiology and function could be considered rather over emphasized. I felt that in order to avoid excessive explanation in the body of the thesis,

a fairly complete review of the normal picture should be given. I also felt that in a brief review of the normal I would be unable to present more than the barest facts which would be of little, if any, help to anyone who had forgotten any embryology, histology, anatomy or physiology.

I have tried to point out the possible causes of male sterility and present a fairly adequate working foundation for the study of male fertility and sterility. At the same time keeping the procedures simple enough to be of possible value to the majority of the medical profession and the cost entailed in such a study within the range of the pocketbook of the majority of the public.

I have summarized each section as I completed it in order to review what I had attempted to show and to facilitate reference to it.

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