

to be chosen on this account; (2) ligature in unskilful hands may injure the vas and the potency of the testicle, while the open operation in unskilful hands is commonly followed by prolonged suppuration. Suppuration is extremely rare with ligature, and either operation if skilfully and carefully done should avoid either complication; (3) atrophy of the testicle is as likely to occur after either operation. I have never seen it, nor have I seen relapse of the varicocele in any case upon which I have performed subcutaneous ligature; (4) subcutaneous ligature is a neater operation requiring shorter convalescence and involving less shock to the patient; therefore it is habitually to be preferred.

One other operation is frequently performed for the relief of varicocele—*viz.*, *ablation of the scrotum*. If a large varicocele have stretched the scrotal skin, it is the custom of many operators to excise a portion of this, partly to obtain an aesthetic result, partly to support the testicle. This second hope is vain. The distensible scrotal skin cannot be employed to support anything, and for the same reason, if the pressure of the varicocele is removed, the skin may be left to contract of itself, unless it has been enormously stretched.

XXXVII. TUMORS OF THE CORD.—The various hydroceles of the spermatic cord have already been dwelt upon. Of solid tumors the only one of any significance is the so-called fibrolipoma, a tumor which sometimes grows to enormous size simulating malignant disease of the testicle. In fact, so many of these tumors which have been pathologically passed upon as fibroma, fibrolipoma, or fibromyoma, prove by their prompt recurrence to be malignant that it is more correct to group the whole class as sarcoma, the pathologist to the contrary notwithstanding.

XXXVIII. DISEASES AND INJURIES OF THE SEMINAL VESICLES.—*Malformations.*—The malformations of the seminal vesicles are unimportant. There are never more than two vesicles, and if one is missing the testicle on that side is missing as well. The ejaculatory ducts may empty into the ureters or into the urethra at some point anterior to the triangular ligament, instead of on the edge of the prostatic utricle.

Wounds.—Guelliot recognizes only one case of undoubted accidental wound of the vesicle due to fracture of the ischium. Operative wounds of the ejaculatory ducts are doubtless frequent as the result of various perineal cystotomies, prostatotomies, and prostatectomies. Incision of one or both of the ducts is doubtless usually followed by obstruction which, if partial, causes dyspermia; if total and bilateral, sterility. Another result of such a wound is inflammation, showing itself as an acute vesiculitis and epididymitis. It is for these reasons that cystotomy performed upon a young adult should be suprapubic rather than perineal. Spermatic fistula has resulted from the old-fashioned lateral lithotomy operation. It heals kindly unless the parts are cancerous or tuberculous.

Acute Seminal Vesiculitis.—Acute inflammation of the seminal vesicle is a common complication of acute prostatitis. But the acutely inflamed vesicle gives no characteristic symptoms, and is not observed clinically except under three conditions: (1) acute epididymitis, with which there is always an inflammation of the vesicle; (2) chronic vesiculitis, the result of an acute attack; and (3) abscess of the vesicle.

Abscess of the Seminal Vesicle.—If the vesicular inflammation is so intense as to produce suppuration, the symptoms of prostatitis (for these patients always suffer first from an inflammation of the prostate) are intensified. The temperature is high, there may be chills, increased vesical irritability, and a sense of burning and discomfort deep in the perineum, oftentimes sufficiently irritating to cause sympathetic rectal tenesmus.

The pus accumulates either within or alongside of the vesicle and habitually points toward the rectum. Examination of such a case in its early stages reveals a hot, boggy, pulsating swelling above and to one side of the prostate, or perhaps extending down over that organ.

Later, as the pus focalizes, the tenderness and heat are less, while fluctuation becomes apparent.

If the inflammation is discovered before abscess has developed, an attempt may be made to abort it by placing the patient in bed and irrigating the rectum twice a day with water as hot as he can bear. But after fluctuation becomes apparent, the only appropriate treatment is incision and drainage, preferably through the rectum (see below).

Chronic Seminal Vesiculitis.—Chronic inflammation of the vesicle may result from an acute inflammation, or may come on insidiously as a result of sexual intemperance or with no obvious cause. Many cases show no symptoms to distinguish them from chronic prostatitis. The surface prostatitis causes pyuria and chronic gleet, and there may well be no subjective elements of any deeper trouble; but the vesicular focus can be felt by rectal touch as a hard, irregular mass just above one horn of the prostate, and, unless this vesicular mass is dissipated by local treatment, it is impossible to cure the gleet. In other cases, however, there are subjective evidences of the inflammation of the vesicle, and all cases of chronic seminal vesiculitis may be classified as follows:

1. Cases (as noted above) in which there are no subjective symptoms of the vesicular inflammation, but only chronic gleet.

2. Cases of relapsing urethritis, the recurrence being occasioned by sexual excitement and due to a smouldering focus in the vesicle.

3. Cases of gleet complicated by painful or hemorrhagic emissions.

4. Cases of relapsing pyuria. These cases differ pathologically from all the others, in that the vesicle is a dilated pus sac, filling up and emptying at more or less regular intervals, so that the urine is at one time entirely free from pus and at another loaded down with it.

5. Neuralgic cases. These may be subdivided into cases of neuralgia about the perineum and along the urethra, and cases of neuralgia of the back and of the testicles. In the former class the indurated vesicle is usually very tender and local treatment immediately efficacious; while in the latter class there may be only a little enlargement of the vesicle with scarcely any tenderness, although the reflex neuralgia in the testicle, the rectum, or the loin be intense. Such cases are slower to improve under treatment.

Diagnosis.—The diagnosis of chronic seminal vesiculitis is made by rectal touch. The prostate may or may not be inflamed; it may be large and congested, or it may contain foci of induration; but above and at the outer angle of the prostate is always felt a lumpy mass; this is the inflamed vesicle. In some cases it is soft and massage upon it for a few minutes will greatly decrease its size, while drops of pus exude from the meatus, and the urine next passed will be extremely purulent. In other cases the mass is harder and less affected by massage.

Treatment.—The treatment of chronic seminal vesiculitis may be local or hygienic. Hygienic treatment consists in abstention from excessive sexual intercourse, and, in severe cases, from all sexual matters whatever. An improvement in the surroundings of the patient, a vacation in the country, will often entirely relieve the mild neuralgic and gleet cases. But in the majority of instances hygiene should be employed only as an accessory to local treatment in order to keep the patient in a condition in which local measures can effect a cure.

The local methods of treatment are: (1) Mechanical, (2) thermic, (3) chemical, (4) electric.

1. The mechanical treatment consists in massage, a manipulation which is performed by the finger introduced into the rectum. The vesicular induration is palpated and then gently rubbed in all directions with a to-and-fro and spiral motion, and the pressure is gradually increased until it is quite firm; but severe manipulation is to be avoided for fear of lighting up an epididymitis.

Various metal implements have been devised for massage but it is so difficult to employ them with sufficient

gentleness that the surgeon's finger is the instrument to be preferred.

2. Thermic treatment is applied by means of the double-current rectal tube. The tube I prefer is that devised by Dr. Chetwood (Fig. 4264). This is inserted into the patient's rectum, as shown in Fig. 4265, and two quarts of water at the temperature of 105° F. are run

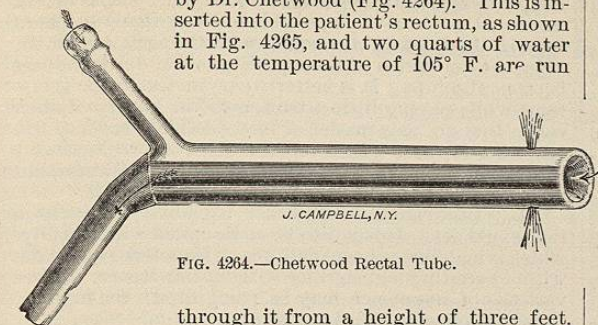


FIG. 4264.—Chetwood Rectal Tube.

through it from a height of three feet. The only difficulty experienced in the use of such a tube is in getting the water out. It runs in easily enough, but some experience is required before it can be made to flow out through the tube without running up the bowel and causing colic and an evacuation.

3 and 4. Chemical and electrical applications to the prostate have been generally employed without any great success. Ichthyol suppositories are well spoken of.

In choosing the treatment appropriate to a given case it is best to place one's chief reliance upon the hot-water irrigations. These may be used once or twice a day, and it is my custom to employ them for two weeks out of three. Except in hyperacute cases the patient experiences little or no immediate relief from this treatment, but under it the indurations slowly disappear. In some neuralgic cases cold water is more efficacious than hot. At the same time it is well to massage the vesicle once or, in severe cases, twice a week. Rectal irrigation must be kept up for from eight to twelve weeks, as a rule, though it is not necessary to employ massage during the latter part of this time.

Tuberculosis.—Genital tuberculosis often begins in the seminal vesicles (see above). It seems always to begin as a unilateral disease; indeed, it often involves the vesicle, the epididymis, and even the kidney of one side, with one-half of the prostate, before making any incursion upon the other side. But it is apparently through tuberculosis of the vesicle and of the prostate that the disease passes from one testicle to the other.

There are commonly no symptoms directly referable to the vesicle. Hemosperm, abscess, fistula, and irritation or apathy of the sexual appetite are very exceptional manifestations. In most cases the disease is discovered only by rectal examination and manifested only by symptoms of the associated inflammation in the prostate and in the epididymis.

Diagnosis.—The diagnosis depends upon the discovery in a patient with prostatic or epididymal tuberculosis of hard nodules, boggy, inflamed areas, or large fluctuating masses in the region of one or both vesicles. Primary vesicular tuberculosis without prostatic or epididymal disease is not diagnosed.

Treatment.—The treatment appropriate to most cases is systemic. Local applications or massage can only do harm by increasing the epididymal inflammation. The tuberculous vesicle should rarely be examined, never massaged.

Operations.—A suppurating vesicle, whether tuberculous or simply inflamed, may require incision. This for simple inflammation may be carried through the anterior rectal wall where the abscess points. Such incision, though theoretically subjecting the patient to grave danger from sepsis, is practically followed by the happiest results. It may be performed without anaesthesia by means of a thin-bladed knife introduced on the finger, and it results in evacuation of the abscess without untoward complications.

Incision of the tuberculous vesicle is always followed by fistula, and must therefore be carried from the perineum. It is convenient to make a circular incision beginning at one ischial tuberosity and encircling the front of the anus about one inch from it, carried past the opposite tuberosity and back to the median line, thus surrounding the anus by three-fourths of a circle. This incision is carried upward through the deep fascia and the levator ani muscle; blunt dissection and retraction of the rectum then expose the prostate and the vesicle. Through this incision the vesicle may be incised, scraped, or excised. Excision of the organ is a difficult and tedious operation on account of the depth at which one must work. Although the apex of the vesicle rests against the peritoneum, it is usually easy to shell it away, and rupture of the peritoneum is a complication of this operation which has not been recorded. The real dangers of the operation are puncture of the urethra or of the rectum. These are avoided by introducing a sound into the former, a finger into the latter.

The vesicle may also be excised by a Kraske or Rydger excision of the sacrum and lateral displacement of the bowel; while Young, of Baltimore, has reintroduced Villeneuve's operation of excising the vesicle as a complement to castration, employing the oblique inguinal incision.

Vesicular Cysts.—Prolonged inflammation of the vesicle may leave it greatly dilated. Such cysts are not uncommon in the aged. Occlusion of the ejaculatory duct

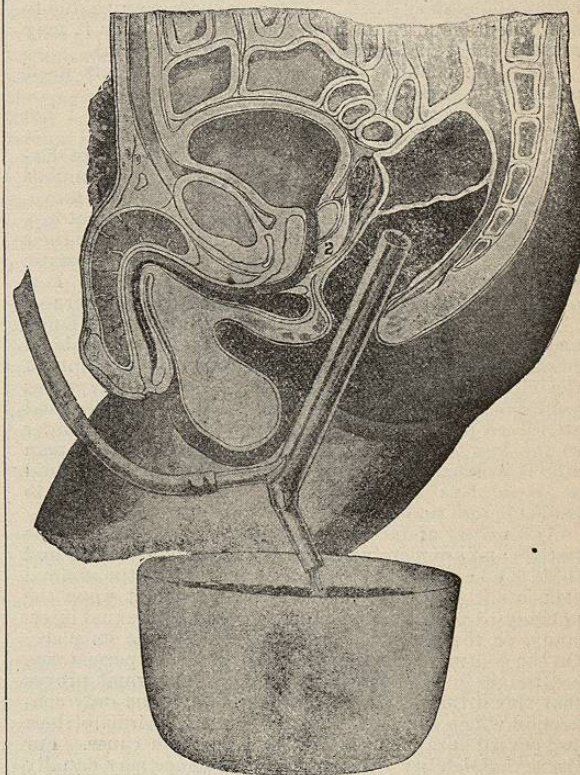


FIG. 4265.—Rectal Irrigation.

does not cause dilatation of the vesicle. Several instances of retrovesical echinococcus cysts have been attributed without convincing proof to the vesicle.

Concretions and Calculi.—Vesicular concretions formed of starchy matter, epithelia, and phosphatic salts are common in the aged; exceptionally they give rise to *spermatic colic*. This pain occurs spontaneously or at the

moment of ejaculation, and is sharp, colicky, and nauseating. It is most intense at a point about an inch up the anterior rectal wall or at the neck of the bladder; thence radiating to the testicle and the loin. The pain is caused by the impaction of a concretion in the ejaculatory duct. It may cause painful or deficient emission or hæmospem. It may be long-continued or of brief duration.

The treatment of a mild case consists in introducing a finger into the rectum and gently massaging the painful spot. This usually dislodges the concretion and relieves the patient. Recurrent colic seems to be relieved by the hot rectal douche. If the attack is severe, prostate and vesicle may be massaged against a full-sized sound introduced into the urethra; this failing, incision may be considered.

Malignant Growths.—Guelliot records one case of primary carcinoma of the vesicle; secondary involvement occurs from the prostate, the bladder, or the rectum.

XXXIX. SEMINAL INCONTINENCE OR SPERMATORRHOEA.—Seminal incontinence or spermatorrhea may be defined as the involuntary and unconscious loss of seminal fluid. It may show itself in one of two ways: either the semen leaks away quite continuously, in which case a few spermatozoa may be found in the centrifuged urine, or else the semen is squeezed out by muscular exertion or by defecation, in which case it appears as a pearly drop at the meatus. Both conditions are fairly common, and neither involves any symptoms or threatens impotence. The lesion to which the seminal leakage is attributable is a weakness of the prostatic muscle encircling the orifices of the ejaculatory ducts. This weakness may be due to antecedent gonorrhœa or to perineal section, or it may result from sexual causes (habitual masturbation).

Thus the condition of spermatorrhea presents itself clinically in three types:

1. Spermatorrhea without Symptoms. This I am confident is a large if not the largest class of cases.

2. Spermatorrhea without any Symptom except Exudation from the Meatus. The pearly drop of mucus which is so commonly extruded by a constipated movement of the bowels habitually contains no spermatozoa and has no connection with the seminal vesicles or their contents. In most cases it consists entirely of prostatic secretion and is evidence of a prostatic congestion. It is quite exceptional to find spermatozoa in this discharge.

3. Spermatorrhea with Neurotic Symptoms. Lallemand's huge tome upon spermatorrhea is the text-book from which modern charlatanism draws the elements of the lurid pictures with which it deludes and depraves young men suffering from sexual weakness. Lallemand attributed practically every urinary and genital disorder to the loss of seminal fluid, and inasmuch as any man who is worried about his sexual capacity rates that fluid as his most valuable possession, it is an easy matter to persuade him that its loss entails many and dire evils.

As a matter of fact, spermatozoa are elaborated in the testicle and are merely stored in the seminal vesicle, and there is no evidence to show that leakage of the seminal elements from the vesicle has any more effect upon the potency or nervous tone of a man than has sexual intercourse or the nocturnal emissions which take its place. On the contrary, the frequency with which spermatozoa are found in the urine of men sexually normal proves that this dribbling is entirely harmless. The only connection which can be established between spermatorrhea and sexual incapacity is that of a common cause. For the sexual debility which causes impotence may equally well cause spermatorrhea, and the lymphatic, neurotic individuals who are most subject to sexual weakness are equally subject to the muscular weakness and the gonorrhœal inflammations which cause spermatorrhea.

The treatment of spermatorrhea is a matter of hygiene, local, general, and mental. The tone of the urethra and of the prostatic muscles should be strengthened by counter-irritation with sounds, with the cold-water rectal douche, or with mild electrical currents. The general health may be built up by muscular outdoor exercise to

replace the lounging, smoking, and drinking with which these men are prone to occupy their leisure hours. While above all and most difficult of all it is the physician's duty to elevate the patient's moral tone, to discourage his prurency, and to set his mind upon a clean, decent basis. It is not always possible to insist that the loss of seminal fluid has no connection with the sexual disorder, since the conviction of these patients that such is the case is often absolute. It is better to try to lessen the symptoms while paying little attention to the theory of their cause, though, as a matter of fact, probably seventy-five per cent. of those who complain of sexual weakness due to seminal incontinence possess the sexual weakness, but have not and never have had any spermatorrhea.

XL. IMPOTENCE.—Impotence is inability to perform the sexual act. It is not to be confounded with sterility, which is inability to beget children. Impotence may exist without sterility and sterility without impotence. Three varieties of impotence may be recognized: the organic, the symptomatic, and the neurotic.

Organic Impotence.—This may be caused in six ways:

1. Abnormal size of the penis. If the penis is absent or so small as to make intromission impossible, the patient is relatively impotent. The same is true of an over-developed penis.

2. Hypospadias and epispadias involve impotence, inasmuch as the semen is not thrown into the vagina; thus the more marked the urethral deformity the more likely the impotence. In the same way tight stricture causes impotence, whether by forcing the ejaculated semen back into the bladder or by permitting it to flow out through fistulous openings in the perineum.

3. Imperfect, irregular, or bent erections, whether due to congenital deformity, to injury, or to inflammation, may prevent direct ejaculation.

4. Various external agencies may have the same effect; among these may be mentioned tumors about the genitals, ankylosis of the hip, excessive abdominal fat, etc.

5. Eunuchs and persons with atrophy of both testicles are always sterile and usually impotent.

6. Faulty erection or ejaculation from disease of the brain or of the spinal cord is an exceptional cause of impotence.

Symptomatic Impotence.—Impotence is symptomatic of youth and of old age, as also of many acute and chronic diseases, of debility from sexual excess, from drugs or alcohol, or from any other cause that lowers the patient's tone. Chief among the troubles of which impotence is a symptom may be placed congestion, neuralgia, and inflammation about the prostate and the seminal vesicles.

Nervous Impotence.—Nervous impotence is a state of mind rather than a state of body, and a person with entirely adequate sexual capacity and no organic disease may become temporarily or permanently impotent through some purely functional cause. As subsidiary causes of impotence are ranged chronic prostatitis and vesiculitis and various forms of sexual excess, in particular the solitary vice. That these causes are secondary is obvious from the fact that, of the great number of men who have chronic prostatitis and vesiculitis, and of the still larger number who masturbate habitually, only a very small proportion fall victims to nervous impotence. Such being the case and the essentially neurotic nature of the sexual act being obvious, it is evident that when a patient complains of lost manhood his trouble is mental, although it may have some underlying physical basis. In passing it is to be noted that neither obstruction of both vasa deferentia, nor prostatectomy, nor castration in adult life, necessarily results in impotence.

The nervously impotent may be divided into three classes: (1) Those whose potency, whether normal or congenitally slight, is not up to the mark they would set for it; (2) those who having been adequately potent have lost their powers through sexual excess or other cause; (3) those who have suddenly become impotent as the result of shock or fright.

1. If it can be determined that the patient is setting

himself a sexual pace of which he is incapable relief obviously consists in making him recognize his own sexual coefficient and in impressing upon him that, if he persists in trying to put a quart into a pint measure, he will inevitably reach the far more grave condition of permanently debilitated potency.

2. When the patient, as the result of excessive sexual indulgence, of prolonged gonorrhœa, or of quack doctoring, complains of loss of manhood, and tells the routine sad story of a debauched youth, it is necessary not only to discover his sexual coefficient, as in the first class of cases, but also to encourage him to look for a return of his sexual powers and to make him recognize that this return will come only as a result of total abstinence from all sexual excitement. For in these cases, even though there be no history of overworked passions, the long months and years during which the patient has moped over his sexual incapacity have had a like effect. All this must be dropped as far as the patient can drop it, and to assist him in this it is necessary to ply him with drugs of which damiana, strychnine, belladonna, and monobromated camphor are among the best, as much for the reason of making him feel that he is being treated, as for the rather dubious end of actually stimulating the sexual nerve centres. Yohimbin has been recently advocated for the treatment of these cases, but I cannot say that I have seen any good results from its use. Finally, it is often a great help if some physical cause can be found for the disorder. The cure of a chronic vesiculitis is of all things the most likely to set such a patient sexually straight. And if this can be once accomplished, if the physician recognizes that his patient has reached about as high a plane of sexual capacity as can be expected, he should immediately insist that this can be retained only by absolute sexual regularity. Celibacy is quite beyond the aspirations of such a patient; matrimony is an ideal state for him if he can muster the courage to attempt it and can develop sufficient moral sense to look upon the marriage state from a decent point of view. But sexual relations outside of marriage are inevitably harmful and, in the end, pull him down to his lowest plane, both morally and physically.

3. Of the cases coming under this head by far the greatest number occur among the newly wed. For one reason or another the young husband fails in his first attempt at sexual intercourse, and the result is so deep a discouragement that subsequent success is temporarily impossible. To handle such a case successfully it is only necessary to separate the couple at night, to administer some light stimulant to the man, and to bid him make no attempt whatever at sexual intercourse until a morning erection, which will sooner or later occur, gives him the opportunity of the hurriedly proving his capacity, and this once done the disease is cured.

XLI. STERILITY IN THE MALE.—*Definition.*—Sterility in the male is inability to produce healthy spermatozoa or to discharge them from the urethra; conversely, in order to be fertile, a man must be able to discharge semen containing healthy spermatozoa.

Etiology.—Thus the causes of sterility are interference with the production of spermatozoa, interference with their health, and interference with their discharge. These causes may be tabulated as follows:

Interference with production. (Azoospermia.)	}	Physiological—youth and extreme age.
		Local—atrophy, or disease of testes.
Interference with health. (Oligozoospermia or azoospermia.)	}	General—Systemic disease. Excess of any kind.
		Congenital deficiency.
Interference with discharge.	}	Testicular—excess of any kind especially sexual.
		Prostatic and vesicular inflammation.
}	}	Urethral or deferential
		Organic } Stricture of vas (azoospermia).
}	}	Stricture of urethra (aspermia).
		Functional—(oligospermia or aspermia).

The seminal fluid is made up of the spermatozoa, which are the transformed epithelial cells of the testicular seminal tubules, combined with the secretions of the prostate and the seminal vesicles. The production of spermatozoa by the testicle begins at puberty and con-

tinues until old age is reached; and the sexual age of a man depends primarily upon heredity, secondarily upon surroundings. Recorded instances of fertility at the age of eighty and of ninety contrast with the accepted sterility after the seventieth year.

Of the causes interfering with the production of spermatozoa, the local ones require no comment. Of the general causes systemic disease is the most common. Such wasting diseases as tuberculosis and diabetes commonly check testicular activity, the system withdrawing this function in favor of more vital ones. Similarly, excess of any kind, be it excessive debauchery, alcoholism, even excessive exercise, worry, and nervous tension, equally result in azoospermia (absence of spermatozoa from the semen). Thus a finely trained athlete often keeps himself in a condition of temporary sterility, while the overworked business man, the drunkard, and the victim of sexual excess suffer in the same way. Finally, there are a certain few who suffer what is apparently a congenital absence of spermatozoa; in all respects healthy, except that they are usually the neurotic products of over-civilization, their seminal fluid never contains any spermatozoa.

The health of the spermatozoa may be interfered with in their production, and this is the common result of sexual excess. Repeated ejaculations empty the seminal vesicles and call upon the testicles for renewed supplies, which are elaborated hurriedly and imperfectly; yet this condition is commonly an ephemeral one. An exceptional cause of interference with the health of the spermatozoa is inflammation of the canals through which the semen passes—*i.e.*, the vas deferens and the urethra, whose acrid discharges interfere with the vitality of the organisms. But prostatitis and vesiculitis are the usual causes of reduced spermatic vitality; for the vitality of the spermatozoa depends primarily upon the normal alkalinity and consistence of the prostatic and vesicular secretion in which they abide. It has been frequently observed that acidulation of the semen promptly kills the spermatozoa, and concentration seems temporarily to paralyze them; while the addition of a drop of warm water to a specimen of such concentrated semen under the microscope has the immediate effect of reviving the still organisms.

Gonorrhœal occlusion of the epididymis, following acute epididymitis, is probably the commonest cause of sterility in the male. Urethral stricture causes sterility but rarely. Functional derangements of ejaculation are most uncommon. Certain neurotic individuals are unable to effect ejaculation in sexual intercourse no matter how long this be continued, although they may have frequent and copious nocturnal emissions.

According to the estimates of good authorities, one-third of matrimonial sterility is due to the male.

Symptoms and Diagnosis.—The evidence of sterility is absence of ejaculation, lessened vitality of the spermatozoa, or absence of spermatozoa from the semen. Absence of ejaculation and absence of spermatozoa are readily determined. Malformation of the spermatozoa shows itself as oligozoospermia, in which condition the spermatozoa, instead of swarming throughout the microscopic field, are very few, generally immobile and frequently deformed. Such a condition suggests either malproduction of the semen or interference with their health by prostatitis or vesiculitis. The diagnosis of sterility is therefore not difficult, though the diagnosis of its cause is not so easy. The usual causes of sterility are gonorrhœal epididymitis (double), vesiculitis, and prostatitis; most other cases are due to dissipation, to overwork, etc., or to a congenital weak sexuality.

Treatment.—The treatment of sterility consists in the removal of its cause. Many cases tend to spontaneous cure. Others are by their nature incurable; but in a large proportion of cases, whether due to prostatic-vesiculitis or to a run-down general condition, a cure may be expected to result from intelligent treatment. One of the latest triumphs of surgery is the operation of Dr. Edward Martin, of Philadelphia, of suturing the vas

defers into the globus major of an epididymis having an obstructed globus minor. The result of this operation was the appearance of spermatozoa in the expressed secretion of the seminal vesicles, from which they had previously been absent.

Edward L. Keyes, Jr.

SHADOW TEST.—“Keratotomy,” “Retinoscopy,” “Retinoskiascopy,” “Korescopy,” and other names. An objective method of determining the refraction of the eye.

When, from a certain distance, an observer throws light into an eye by means of a perforated mirror, on looking through the hole in the mirror he sees the entire pupil illuminated with a reddish light. If, now, the mirror is slightly rotated, a dark segment (“shadow”) comes into view and, increasing as the mirror is rotated, presently extends over and darkens the entire pupil. The direction in which the “shadow” grows—*i.e.*, the direction in which the border of the shadow moves, whether in the same or in the opposite direction to that in which the mirror is rotated—depends, with certain limitations, on the refraction (hypermetropia, emmetropia, or myopia) of the observed eye, and affords a means, when the necessary conditions are fulfilled, of measuring its refraction.

The perforated mirror used in the shadow test may be either plane or concave.

1. We will assume that a plane mirror is used, and that the observer's eye, which is immediately behind the perforation, is stationed at a distance of one metre from the observed eye. The mirror is now adjusted to reflect light, preferably from an Argand burner, directly upon the observed eye, whose pupil is seen filled with a uniform red light. On rotating the mirror to the right (*i.e.*, turning the left side of the mirror forward) a dark “shadow” appears at the left side (*i.e.*, to the observer's left) of the pupil and passes over it, increasing from left to right, until the entire pupil is darkened. Similarly, on rotating the mirror to the left, the shadow appears at the right side of the pupil and passes over it from right to left.

This movement of the border of the shadow in the direction of the rotation of the mirror occurs whenever the focus of the observed eye for pencils originating at its fundus (*i.e.*, the far-point of the observed eye) falls elsewhere than between the observer's and the observed eye. When, as we have assumed, the observer's eye is stationed at a distance of one metre, the observed eye may be either hypermetropic, emmetropic, or myopic in any degree less than 1 D.

2. On rotating the (plane) mirror to the right, the “shadow” appears at the right side of the pupil and passes over it from right to left; or, on rotating the mirror to the left, the shadow appears at the left side of the pupil and passes over it from left to right.

This movement of the border of the shadow in a direction opposite to that of the rotation of the mirror occurs when the focus of the observed eye for pencils originating at its fundus (*i.e.*, the far-point of the observed eye) falls within the distance at which the observer's eye is stationed. In our assumed case this distance is taken equal to one metre; the observed eye is therefore myopic in some degree greater than 1 D.

3. On rotating the (plane) mirror in any direction, no “shadow” is seen, but the illumination of the pupil fades gradually into darkness. This fading out of the illumination of the pupil in its totality, without any appearance of a moving shadow, occurs only in the case in which the focus of the observed eye for pencils originating at its fundus (*i.e.*, the far-point of the observed eye) falls at the exact distance at which the observer's eye is stationed, which in our assumed case has been taken equal to one metre; the observed eye is therefore myopic, and its myopia is equal to 1 D.

4. If a concave mirror of short focus is substituted for

*The writer desires again to acknowledge his indebtedness to Dr. John Green, of St. Louis, for assistance most kindly rendered in revising the present article for the press.

the plane mirror, in which case a real image of the flame is formed between the observer's and the observed eye, the “shadow” is seen to move in a direction opposite to that in which it moves when the plane mirror is used.

These facts have been utilized for the practical determination of the refraction in several different ways, two of which have been especially cultivated.

I. The observer, stationed at a distance of one metre, and using a concave mirror preferably of about 20 cm. focus, throws light from an Argand burner placed beside or above the patient's head, into the eye whose refraction is to be investigated. If on rotating the (concave) mirror in any direction, he sees the “shadow” moving in the opposite direction, he concludes that the eye is either hypermetropic, emmetropic, or myopic in some degree less than 1 D. Convex glasses, of progressively increasing strength, are then placed, one after another, in a trial frame before the observed eye, until a glass is found through which no shadow movement is discernible in the transition from the illuminated to the darkened state of the pupil. The combination of the observed eye and this convex glass represents myopia of 1 D., and the subtraction of 1 D. from the value of the glass gives the refraction of the eye. For example, if the convex glass measures 3.5 D., the refraction is $H = 2.5$ D.; if the convex glass measures just 1 D., the eye is emmetropic; if without a glass no moving shadow is seen, the refraction is $M = 1$ D.

If, on rotating the (concave) mirror, the shadow is seen moving in the same direction, the presence of myopia of a higher grade than 1 D. is established; concave glasses, of progressively increasing strength, are then placed, one after another, in front of the observed eye, until a glass is found through which no shadow movement is seen. The combination of the observed eye and this concave-glass represents myopia of 1 D., and the addition of 1 D. to the value of the glass gives the actual myopia.

This is the method advocated by Cuignet, Parent, and others.

II. The observer uses a plain mirror, and does not keep at a fixed distance from the observed eye. We will suppose that he first stations himself at a distance of one-half metre, and sees the “shadow” moving in the same direction as that in which the mirror is rotated, thus establishing the fact that the eye is either hypermetropic, emmetropic, or myopic in some degree less than 2 D. A convex glass of sufficient strength to render the observed eye myopic in excess of 2 D. is then placed before it in a trial frame, thus causing an image of its fundus to be formed in front of the eye of the observer. The observer next approaches the observed eye until he reaches a point at which no moving shadow is discernible—*point of reversal*. The observer's eye is now at the far-point of the observed eye as modified by the convex glass, and the distance from eye to eye is measured by means of a rule or a tape measure. The reciprocal of the fractional part of a metre thus measured represents, in dioptres, the refraction of the observed eye plus the convex glass, and the subtraction of the value of this glass gives the refraction of the eye.

When the observed eye is myopic in excess of 2 D., so that its far-point lies within the distance of one-half metre at which the eye of the observer is stationed, the movement of the shadow is in the direction opposite to that in which the mirror is rotated, and the distance of the point of reversal from the observed eye gives the measure of the myopia.

When the myopia of the observed eye is in excess of 4 D. or 5 D., the point of reversal falls too near the eye for an entirely trustworthy measurement of its distance. In such a case a concave glass, of sufficient strength to carry the far-point back to a distance of from one-quarter metre to one-half metre, is placed before the observed eye, and the value of this (concave) glass must be added to that obtained by measuring the distance of the point of reversal.

This is the method advocated by Chibret, Schweigger, and others.

In emmetropia, and in simple ametropia (hypermetropia and myopia), the movement of the mirrored image of the flame, whether virtual or real, and that of the “shadow” are always in one and the same plane passing through the observer's and the observed eye. The same is true also in astigmatism whenever the plane in which the image moves, as determined by the direction in which the mirror is rotated, passes through either of the two principal meridians of the observed eye. The shadow test is, therefore, perfectly adapted to the measurement of the refraction of an astigmatic eye in each of its two principal meridians. If, however, the shadow is seen to move in a plane other than that determined by the direction of the rotation of the mirror (see Fig. 4266), it is certain both that the observed eye is astigmatic, and that the plane in which the mirrored image moves does not pass through either of its principal meridians. To find a principal meridian, whether of greatest or least refraction, it is then only necessary to vary the direction in which the mirror is rotated, until the shadow is seen to move in the same or in the opposite direction. The statement made by different writers, that the direction of the obliquely moving shadow corresponds to that of one or the other of the two principal meridians, is erroneous.

The idea of utilizing the direction of the movement of the “shadow” in the pupil for the practical determination of the refraction originated with Cuignet (1873), but he gave a wrong explanation of the phenomenon and so was led to give to the procedure the very unsuitable name “keratotomy.” Landolt (1878) was the first to propose a nearly correct theory, and his and Parent's descriptions have contributed largely to the popularization of the method. Credit must also be given to Chibret (1882) for the important modification of the procedure in which the plane mirror is used at a varying distance. Leroy and Monoyer have further developed the theory, which, strange to say, had been erroneously, or at best inadequately, stated during a number of years.

The theory of the shadow test will be best understood if we consider a few special cases:

I. We will assume that the observed eye is emmetropic, and that the test is made with a plane mirror at a distance of one-half metre. An image of the source of light (Argand burner) is formed at the fundus of the observed eye, which, within the limits of this image, is strongly illuminated so that every point gives out rays of light as if it were self-luminous. The details of this illuminated area at the fundus are, however, indistinguishable, or at best imperfectly distinguishable, inasmuch as, by the conditions of the test, the observer's eye is accommodated, not for the fundus, but for the pupil of the observed eye. The illuminated area is seen, therefore, in circles of confusion, consequently as a more or less diffuse red light shining through the pupil.

How much of the illuminated area is, in any case, visible to the observer, is determined in part by the diameter of the pupil of the observed eye, and in part also by the size of the hole in the mirror, or, if this is rather large, by the diameter of the pupil of the observer's eye. Let $a a'$ (Fig. 4267, I) represent a portion of the illuminated area (image of the flame) at the fundus of the observed eye, which we assume to be directed upon the hole in the mirror, consequently upon the pupil of the eye of the observer. Let $a P p \pi$ represent a limiting ray passing out of the pupil of the observed eye to enter the pupil of the observer's eye; similarly, let a' represent the origin of another limiting ray, as determined by the points P and p' , meeting the retina of the observer's eye at π' . Now $P P'$ and $p' p$ represent, respectively, the diameters of the two (circular) pupils, consequently $a a'$ and $\pi \pi'$ must also represent diameters of circles. We will call the circular area $a a'$ the *visible circle*. Inasmuch as the illuminated area (image of an Argand burner when the distance of the mirror is taken anywhere between the limits of one metre and one-quarter metre) is considerably larger than that of the visible circle, the entire pupil $P P'$ will be lighted up, and the visible circle $a a'$ will coincide

throughout with the two pupils, $P P'$ and $p p'$, and with the circle $\pi \pi'$ at the fundus of the eye of the observer. But we have already seen that the visible circle $a a'$ is pictured at $\pi \pi'$ in circles of confusion; hence the impression made on the observer is rather that of the illuminated pupil $P P'$ than of the circle $a a'$.

To explain the phenomenon of the moving “shadow” we will suppose that the observer, whose attention is

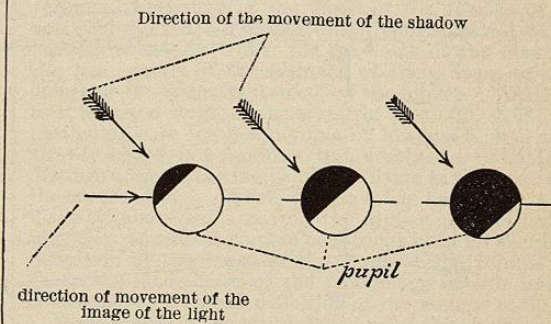


FIG. 4266.

fixed on the illuminating pupil $P P'$ of the observed eye, now rotates the mirror a little to the right (see Fig. 4268), thus displacing the mirrored (virtual) image of the flame to the left, consequently displacing the real image of the flame at the fundus of the observed eye to the right. The displaced image of the flame, as it passes over the visible circle, presently leaves a segment of the latter without illumination, consequently a segment of the pupil $P P'$ darkened (see Fig. 4269). As already explained, the border of this dark segment is seen somewhat imperfectly defined, thus suggesting a shadow with its penumbra, and accounting, in a way, for the name “shadow test.”

It will be observed that in this case (emmetropia of the observed eye) the growth of the darkened segment of the pupil (movement of the shadow) is in the same direction as that in which the (plane) mirror is rotated, the reversed movement at π , or at π' , being perceived as a direct movement at a or at a' , consequently at P or at P' .

II. We will now assume that the observed eye is hypermetropic, the other conditions remaining as before (see Fig. 4267, II). Comparing I and II, Fig. 4267, it is evident that nothing essential has been changed, as regards either the formation of the “shadow” or the direction of its movement. The illuminated area (image of the flame) is, however, smaller, and the visible circle larger, than in the case of emmetropia of the observed eye. The dark border of the illuminated area will therefore pass the limit of the visible circle more quickly (the rate of rotation of the mirror being assumed to be unchanged), but more time will be required for its transit. We have seen that the apparent diameter of the visible circle is the same as that of the pupil; the rate of passage of the shadow across the pupil is therefore slower in hypermetropia than in emmetropia.

In hypermetropia of the observed eye the conditions for obtaining a clearer view of the details of the fundus, when the eye of the observer is accommodated for its pupil, are more favorable than in emmetropia, and the higher the grade of the hypermetropia (*i.e.*, the less the distance at which the virtual image, $h h'$, of the visible circle lies behind the plane of the pupil) the more clearly will the retinal vessels, etc., be seen. On the other hand, hypermetropia of the observed eye is unfavorable for the accurate focusing of the image of the flame on its retina, and for this reason the outlines of this image are less sharply defined than in emmetropia. The advantage, to the observer, of the clearer view which he obtains of the image of the flame is, however, greater than the disadvantage resulting from its less perfect definition; hence the free border of the shadow, as it traverses the pupil, appears more sharply defined in hypermetropia than in