Developmental Anatomy Of Genital System And Congenital Anomalies

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Abstract

Sexuality involves the body, the mind, and the spirit. The expression of love between a man and a woman through physical union begets child and the lineage in passed on to the next generation. Fully grown and functional reproductive organs are necessary for greater expression of sexuality. This review describes briefly the developmental anatomy and related anomalies of reproductive organs in males and females.

Introduction

Human sexuality may be defined as the capacity of humans to have erotic experiences and responses. A person's sexual orientation can influence his/her sexual interest and attraction for another person [1]. Sexuality may be experienced and expressed in a variety of ways; including thoughts, fantasies, desires, beliefs, attitudes, values, behaviors, practices, roles, and relationships [2]. These may manifest themselves

in biological, physical, emotional, social, or spiritual aspects. The biological and physical aspects of sexuality largely concern the human reproductive functions, including the human sexual response cycle and the basic biological drive that exists in all species [3].

Opinions differ on the origins of an individual's sexual orientation and sexual behavior. Some argue that sexuality is determined by genetics; some believe it is moulded by the environment, while others argue that both these factors interact to form the individual's sexual orientation [1]. Human sexuality is driven by genetics and mental activity. The biological aspects of humans' sexuality deal with the reproductive system, the sexual response cycle, and the factors that affect these aspects. They also deal with the influence of biological factors on other aspects of sexuality, such as organic and neurological responses, [4] heredity, hormonal issues and gender issues.

The hypothalamus is the most important part of the brain for sexual functioning. This is a small area at the base of the brain which comprises of several groups of nerve cell bodies that receives input from the limbic system. Studies have shown that within lab animals, destruction of certain areas of the hypothalamus causes the elimination of sexual behavior. The pituitary gland is responsible for secreting hormones that are produced in the hypothalamus and pituitary gland itself. The four important sexual hormones are oxytocin, prolactin, follicle-stimulating hormone, and luteinizing hormone [3].

Development of the reproductive system

As a part of prenatal development, the development of the reproductive system is concerned with the stages of sexual differentiation. Embryologically and anatomically, the urinary and genital systems are intimately interwoven. Therefore, the development of them can also be described together as the development of urogenital system.

Sex differentiation is a complex process that involves many genes, including some that are autosomal. The key to sexual dimorphism is the Y chromosome, which contains the testis-determining gene called the SRY (sex-determining regression on Y) gene on its short arm (Yp11). The protein product of this gene is a transcription factor initiating a cascade of downstream genes that determine the fate of rudimentary sexual organs. The SRY protein is the testis-determining factor; under its influence, male development occurs; in its absence, female development is established [5].

The reproductive organs develop from the intermediate mesoderm. The permanent organs of the adult are preceded by a set of structures that are purely embryonic, and which, with the exception of the ducts, disappear almost entirely before the end of fetal life. These embryonic structures are the Wolffian and Mullerian ducts, otherwise known as mesonephric and paramesonephric ducts, respectively.

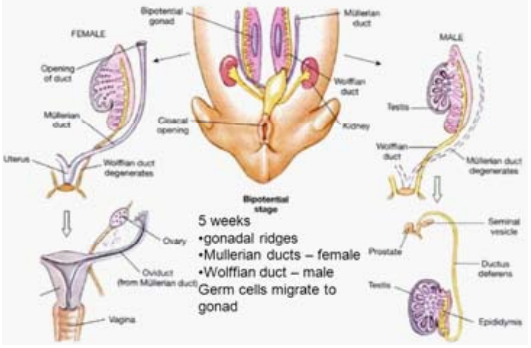

Fig. 1: Differentiation of Mullerian and Wolffian ducts in male and female
(Source : www.soc.hawaii.edu/sexdevel.htm)

Until 8 weeks' gestation, the human fetus is undifferentiated sexually and contains both male (Wolffian) and female (Müllerian) genital ducts. Wolffian structures differentiate into the vas deferens, epididymis, and seminal vesicles. Müllerian ducts develop into the fallopian tubes, uterus, and the upper one-third of the vagina (Fig. 1).

In the male fetus, the genital tubercle enlarges to form the penis; the genital folds become the shaft of the penis; and the labioscrotal folds fuse to form the scrotum. Differentiation occurs during 12-16 weeks of gestation and is the result of testicular hormones acting on the undifferentiated genitalia in two ways.

First, through testicular secretion of Antimüllerian Hormone (AMH), also known as Müllerian Inhibiting Substance (MIS), which leads to regression of the female müllerian structures. Second, through testosterone and its active metabolite, dihydrotestosterone, which determine full differentiation and stabilization of internal and external genitalia.

In the female fetus, without the influence of the AMH, the müllerian ducts complete their differentiation, whereas the wolffian structures involute. In the absence of testosterone and dihydrotestosterone, the genital tubercle develops into the clitoris, and the labioscrotal folds do not fuse, leaving labia minora and majora (Fig. 2).

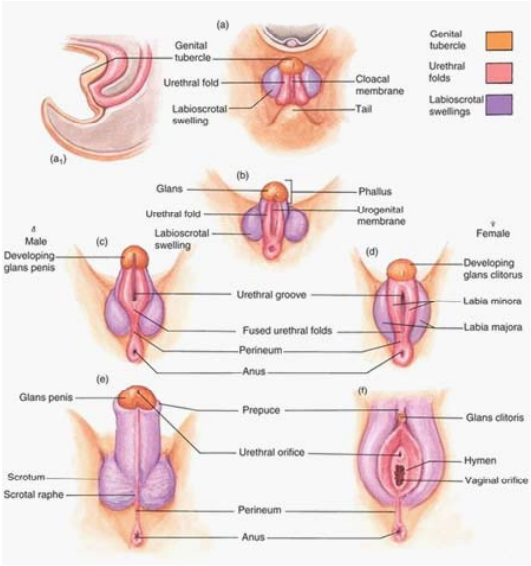

Fig. 2: Development of male and female external genitalia
(Source : www.studyblue.com/hlc3-foetaldevelopmment-embryology)

Disorders of the external genitalia are especially troubling for parents because of the emotional significance of these reproductive structures and, probably, the consequent impact of deformities on future generations.

Congenital anomalies of the genitalia

Congenital anomaly of the genitalia is a medical term referring to any physical abnormality of the male or female internal / external genitalia present at birth. This is a broad category of conditions; while some are common, others are rare.

Causes

Some congenital anomalies of the genitalia result from excessive or deficient androgen effect, others result from teratogenic effects, or are associated with anomalies of other parts of the body in a recognizable pattern . The cause of many of these

birth defects is unknown. Some simply represent the extremes of the normal range of size for body parts.

Developmental abnormalities of the female reproductive organs

An understanding of congenital anomalies as they are encountered in clinical practice has been greatly enhanced by not only the knowledge of normal embryology and the mechanism of formation of normal infants, but also an insight into the processes that result in the development of anomalies [6, 7, 8, 9] .

Uterine anomalies

The most frequent uterine anomalies (Fig. 3) are those resulting from varying degrees of failure of fusion of the müllerian ducts.

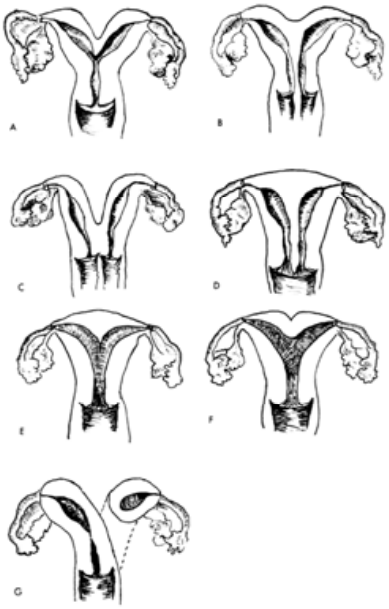

Fig. 3:Uterine anomalies **A**. Uterus duplex unicollis **B.** Uterus duplex bicollis **C.** Uterus didelphys **D.** Uterus septus with single vagina **E.** Uterus subseptus **F.** Uterus arcuatus **G.** Uterus unicornis with rudimentary contralateral hemiuterus
(Source : http://resources.ama.uk.com/glown)

Uterus duplex or the bicornuate uterus, is the most frequent uterine anomaly. The unicollis type in which there is a single cervix with a septum that does not reach the cervix is the most frequent type, occurring in over one-third of all patients with uterine anomalies. Uterus duplex bicollis, in which two cervices are present, is less frequent. Obstetric complications are frequent, but live births do occur.

Uterus didelphys, with completely separate uterine cavities, is also frequent. The cervices are externally united and the uterine fundi are externally separate. In most patients, the vagina is septate, causing a double vagina. The halves of such a uterus are often of different sizes. If there is an asymmetric vaginal septum which occludes one vagina, mucocolpos or hematocolpos may result. Communicating uteri, involving an incomplete uterine septum with part of the fetus in each uterine cavity, do occasionally occur.

Uterus septus is an essentially normal uterus with a septum reaching to the cervix. Uterus subseptus involves a partial septum that does not reach the cervix. Twins apparently occur approximately three times more often in women with this condition than in women with normal uteri.

Uterus arcuatus is a normal uterus without a septum. The fundus, however, is notched or flattened. There is usually no interference with normal pregnancy in this case.

Uterus unicornis is a uterus with a single horn. A normal vagina and a single normal tube are usually present. The other half of the uterus is usually absent or is rudimentary. In most patients the kidney is missing on the side of the missing uterus. Successful pregnancy can occur in this case.

Separate hemiuteri with separate vaginas is a rare condition that is usually associated with duplications of urethra and bladder or of the colon and anus. Pregnancy in each of the two hemiuteri in the same woman at different times has been reported.

These anomalies result from failure of fusion of the paired müllerian ducts, but in some instances there is true duplication of the ducts on one or both sides. Such duplications result from splitting of the müllerian duct during the seventh week of development. Accessory tubes or ovaries may be present.

Tubal anomalies

Absence of one or both tubes may occur and is almost always associated with absence of the uterus as well as with other anomalies. Occasionally, ostia are duplicated or an accessory tube may be present.

Ovarian anomalies

Ovarian anomalies other than the streak ovaries of gonadal dysgenesis are quite rare. Complete absence of an ovary is extremely rare and is usually associated with renal agenesis and absence of the ipsilateral fallopian tube. True ovarian duplication is rarely reported; it occurs in conjunction with duplication of genital ridge and a duplicated müllerian duct. Excess ovarian tissue near the normal ovarian tissue which develops from it (and may be connected with it) is classified as an accessory ovary. Lobulation of an ovary is not infrequent and is of little clinical importance. Supernumerary ovaries or the presence of ovarian tissue not connected to the tubes or uterus is very unusual.

In women, the most common cause of gonadal dysgenesis is Turner syndrome, 45X. Phenotypic females with streak gonads can also have XX gonadal dysgenesis, XY gonadal dysgenesis or mixed gonadal dysgenesis. In case of phenotypic females with a Y chromosome, there remains a high risk of the development of gonadoblastoma.

Mesonephric remnants

A number of structures may persist to various degrees in the normal adult female (Fig. 4).

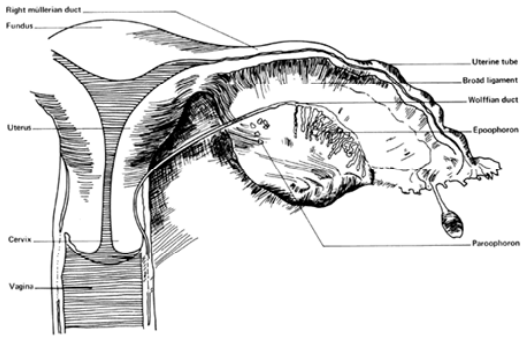

Fig. 4: Mesonephric vestiges
(Source : http://resources.ama.uk.com/glown)

1. Hydatid of Morgagni (probably of Müllerian origin)
2. Vesicular appendage
3. Epoophoron (organ of Rosenmuller)
4. Paroophoron (Kobeit's tubules)
5. Gartner's duct or canal (ductus epoophori longitudinalis)

In the lateral third of the mesovarium lies the epoophoron, consisting of eight to thirteen tubules running from the mesonephric duct toward the ovary. They are of little clinical significance, although benign cysts are believed to occasionally arise in them. Farther caudal along the regressing mesonephtic duct may be found a small group of mesonephric tubules called the 'Paroophoron'.

Farther along the course of the vestiges

of the mesonephric duct can be found remnants of the duct, here called 'Gartner's duct'. Coiled tubes frequently occur in the lower part of the supravaginal cervical wall, where they are called the 'Ampulla'. Although believed to be paramesonephric rather than mesonephric in origin, clear pedunculated hydatid or cystic structures arising at the ostium at the end of the tube are found frequently. These are called the 'Hydatids of Morgagni' (appendix vesiculosa) and are usually harmless but are removed when encountered since they can undergo torsion.

Vaginal anomalies

The vagina is formed between the 16th and 20th weeks by the development of lacunas; complete canalization later occurs to form the vaginal lumen (Fig. 5).

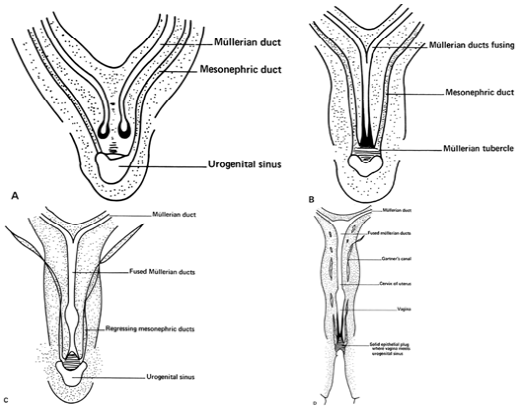

Fig. 5: A. Müllerian and Wolffian ducts B. Fusion of Müllerian ducts C. Regression of mesonephric ducts D. Uterus, cervix, and vagina
(Source : http://resources.ama.uk.com/glown)

The principal congenital anomalies of the vagina include the following (Fig. 6)

- Longitudinal septum
- Transverse septum
- Vaginal agenesis
- Mesonephric remnants

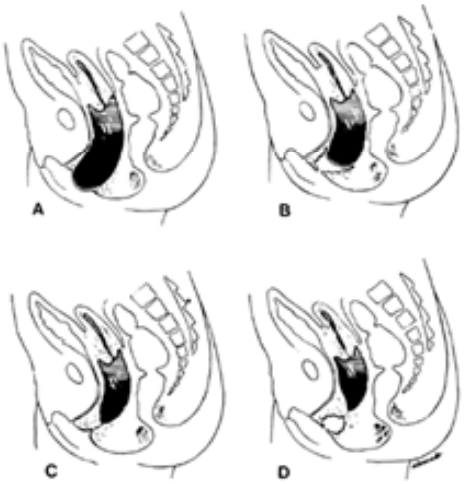

Fig. 6: Diagram of various lesions causing hydrometrocolposA. Imperforate hymen B. Transverse septum C. and D. Low and high atresia of vagina[10]

Other anomalies in females

Labial adhesion

Labial adhesion is an anomaly frequently encountered in young girls. Generally, it results from chronic inflammation of the vulva. This condition must be distinguished from labial fusion, a different lesion attributed to virilization of the female external genitalia.

Labial adhesion usually is asymptomatic, but when the introitus is completely sealed, vaginal micturition with consequent dribbling can occur; moreover, urinary stasis can predispose the child to infection.

Clitoral hypertrophy

Hypertrophy of the clitoris is observed in cases of fetal exposure to androgens. The disorder is usually the result of congenital deficiencies of the adrenal enzymes of cortisol synthesis; more rarely, it is caused by idiopathic virilization or exposure to progestational agents in utero.

Hydrocolpos or Hydrometrocolpos

Accumulation of fluid due to congenital vaginal obstruction is the cause of hydrocolpos (distention of the vagina) and hydrometrocolpos (distention of the vagina and uterus). The obstruction is frequently caused by imperforate hymen or, less commonly, transverse vaginal septum. Obstructing genital anomalies may present at birth with mucocolpos, but the obstructive anomaly is often asymptomatic and escapes detection.

An imperforate hymen is often difficult to diagnose perinatally because of the small size of the genitalia and the influence of maternal estrogens, which cause thickening and enlargement of the labia minora. The neonate with hydrocolpos related to congenital vaginal obstruction can present with a bulging interlabial cyst, associated with a mass in the lower abdominal quadrants, often inducing urinary tract obstruction.

Persistent urogenital sinus and cloaca

Congenital malformation involving the urogenital sinus and cloaca remains one of the most severe birth defects compatible with life. Moreover, management of this malformation is one of the greatest challenges of pediatric surgery and urology. Development of the lower urinary tract and genital and anorectal systems is correlated closely in females. Consequently, abnormal embryologic development can involve all three systems.

Devlopmental abnormalities of the male reproductive organs

Penile agenesis

Congenital absence of the penis (aphallia), is a rare anomaly caused by developmental failure of the genital tubercle. Its approximate incidence is 1 case per 30 million population. The phallus is completely absent, including the corpora cavernosa and corpus spongiosum; however, some children reportedly have small portions of corpora cavernosa. Usually, the scrotum is normal and the testes are maldescended. The urethra opens at any point of the perineal midline from over the pubis to, most frequently, the anus or anterior wall of the rectum.

More than 50% of patients with penile agenesis have associated genitourinary anomalies, the most common of which is cryptorchidism; renal agenesis and dysplasia may also occur. Reports indicate that aphallia may be associated with pregnancy complicated by poorly controlled maternal diabetes.

Hypospadias

Hypospadias are the most common penis abnormality (1 in 300) and result from a failure of male urogenital folds to fuse in various regions. This, in turn, leads to resulting in a proximally displaced urethral meatus (Fig. 7).

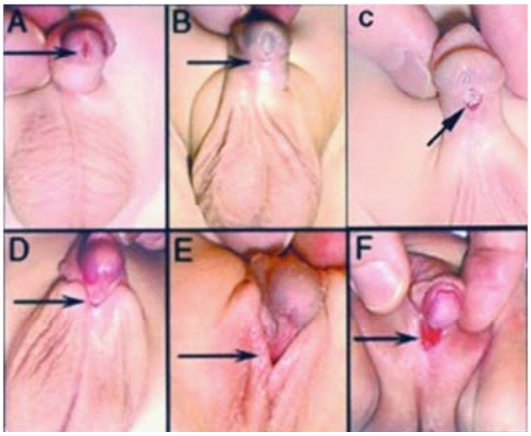

Fig. 7: Classification of Hypospadias[11]

	Hypospadia Classification	Meatus Opening
A	Anterior	on inferior surface of glans penis
B	Coronal	in balanopenile furrow
C	Distal	on distal third of shaft
D	Penoscrotal	at base of shaft in front of scrotum
E	Scrotal	on scrotum or between the genital swellings
F	Perineal	behind scrotum or genital swellings

Table 1: Meatus opening in hypospadias

Penile duplication

Duplication of the penis (diphallia) is another rare anomaly resulting from incomplete fusion of the genital tubercle. Two distinct forms of penile duplication are recognized, as follows:

The most common form is associated with bladder-exstrophy complex. In this case, the patient exhibits a bifid penis, which consists of two separated corpora cavernosa that are associated with two independent hemiglands.

The second form (true diphallia) is an extremely rare congenital condition that presents in many ways, ranging from duplication of the glands alone to duplication of the entire lower genitourinary tract; the urethral opening can be in normal position or in a hypospadiac or epispadiac position.

Microphallus

The term microphallus, or micropenis, is applicable only to a normally formed yet abnormally short penis. Specifically, the term applies to a penis with a stretched length that is more than 2.5 standard deviations (SD) below the mean for age.

This condition may be considered a minor form of ambiguous genitalia with correlated medical and psychological problems similar to those of the major intersex form. The scrotum is usually normal, but testes are often small and undescended. In a few cases, the corpora cavernosa are severely hypoplastic. Measurement (i.e. stretched penile length) is very important in differenting the various types of pseudomicropenis, particularly, the buried penis in the obese infant and the penis concealed by an abnormal skin attachment.

Penile torsion

The embryologic abnormality is often an isolated skin and dartos defect that can be remedied simply by freeing the penile shaft of its investing tissue. The rotation is usually to the left in a counterclockwise fashion. The urethral meatus is placed in an oblique position, and the median raphe makes a spiral curve from the base of the penis to the meatus. However, in some cases, penile torsion is associated with mild forms of hypospadias or hooded prepuce.

Webbed and buried penis

Webbed penis is a common congenital abnormality in which a web or fold of scrotal skin obscures the penoscrotal angle.

Conclusion

In view of the complexity and duration of differentiation and development of the genital and urinary systems, it is not surprising that the incidence of malformations involving these systems is one of the highest (10%) of all body systems. Etiologies of congenital

malformations are sometimes categorized on the basis of genetic, environmental, or genetic-environmental (polyfactorial inheritance) factors. Known genetic and inheritance factors reputedly account for about 20%, aberration of chromosomes for nearly 5%, and environmental factors for nearly 10% of anomalies detected at birth. The significance of these statistics must be viewed against reports; an estimated one-third to one-half of human zygotes are lost during the first week of gestation and the cause of possibly 70% of human anomalies is unknown. Even so, congenital malformations remain a matter of concern because they are detected in nearly 3% of infants, and 20% of perinatal deaths are purportedly due to congenital anomalies.

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