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Chromosomal and genetic sex is established at fertilization and depends upon whether an X-bearing sperm or a Y-bearing sperm fertilizes the X-bearing ovum. The type of gonads that develop, gonadal sex, is determined by the sex chromosome complex (XX or XY).

Sex differentiation is a complex process that involves many genes, including autosomal ones. The key to sexual dimorphism is the Y chromosome. This chromosome has a strong testis-determining effect on the medulla of the indifferent gonad. It contains the testis-determining gene, the SRY (sex-determining region 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. When the transcription factor is expressed in the somatic support cells of the indifferent presumptive gonad, male development occurs. This step is called primary sex determination. If the factor is absent or defective, female development takes place.

The sexual genotype is responsible for directing gonadal development (testis versus ovary). The type of gonads present then determines the type of sexual differentiation that occurs in the genital ducts and external genitalia. It is the androgen testosterone, produced by the testes, that determines maleness.

Although the chromosomal and genetic sex of an embryo is determined at fertilization by the kind of sperm that fertilizes the ovum, male and female morphological characteristics of sex do not begin to develop until the 7th week.

The early genital systems in the two sexes are similar, and this initial period of early genital development is referred to as the indifferent stage of sexual development.

Gonads

The gonads (testes/ ovaries) are derived from three sources:

→ Mesodermal epithelium (mesothelium) lining posterior abdominal wall, from lateral somatic mesoderm;

→ Underlying mesenchyme, from intermediate mesoderm;

→ Primordial germ cells;

During the 5th week, a thickened area of mesodermal epithelium develops on medial side of mesonephros. Proliferation of the mesothelial cells and condensation of underlying mesenchyme produces a bulge known as Gonadal/Genital Ridge. Germ cells do not appear in the genital ridges until the 6th week of development.

Primordial germ cells originate in the epiblast, migrate through the primitive streak, and by the 3rd week reside among endoderm cells in the wall of the yolk sac near the origin of the allantois. During the 4th week, folding of the embryo takes place and the dorsal part of the yolk sac is incorporated into the embryo. As this incorporation occurs, primordial germ cells migrate by ameboid movement along the dorsal mesentery of the hindgut. They arrive at the primitive gonads at the beginning of the 5th week and invade the genital ridges in the 6th week. During the 6th week, cells from coelomic epithelium form aggregates of somatic supporting cells that completely invest the germ cells. Somatic support cells are very important for germ cell development within the gonad. If this cells do not invest the germ cells, they will degenerate.

Primordial germ cells have an inductive effect on development of the gonad into ovary or testis. Shortly before and during arrival of primordial germ cells, epithelium of genital ridge proliferates, and epithelial cells penetrate the underlying mesenchyme. Soon, finger-like epithelial cords primitive sex cords are formed. The indifferent gonad now consists of an outer cortex and an inner medulla. In embryos with an XX sex chromosome complex, the cortex normally differentiates into an ovary and the medulla regresses. In embryos with an XY sex chromosome complex, the medulla differentiates into a testis and the cortex regresses.

Testes

Testes are a pair of oval organs that are present in the scrotal sac, which is situated directly behind the penis. Their function is to produce hormones (mainly testosterone) and spermatozoa (male reproductive cells). If the embryo is genetically male (contains both sex chromosomes, X and Y chromosome), the signal for testis development is mediated by the SRY gene on the Y chromosome. Under the influence of this gene, primitive sex cords develop and continue to proliferate and penetrate deeper and deeper into the medulla to form the testis/medullary cords. Then, tubules of the rete testis arise, towards the hilum of the gland, due to break up of these cords into very small cell strands. As development continues, a dense layer of fibrous connective tissue is formed, the tunica albuginea, which divides the testis cords from surface epithelium. In the 4th month major changes happens: testis cords become horseshoe-shaped with their extremities continuous with those of the rete testis and, at this time, they are composed of two types of cells – sustentacular cells of Sertoli, involved in support and protection, and primitive germ cells, both derived from the surface epithelium of the gland. Interstitial cells of Leydig, start developing shortly after the beginning of the differentiation of testis cords and are derived from the original mesenchyme of the gonadal ridge, which is present between the testis cords. Their function is to produce testosterone. This production starts around the 8th week, time in which the testis are already able to influence sexual differentiation of the genital ducts and external genitalia. At the time of puberty testis cords acquire a lumen and form the seminiferous tubules. Then, after being canalized the seminiferous tubules join the rete testis tubules, which in turn enter the ductuli efferentes. These efferent ductules are the remaining parts of the excretory tubules of the mesonephric system. They link the rete testis and the mesonephric/wolffian duct, which becomes the ductus deferens.

Ovaries

Ovaries are almond shaped bodies, found in pairs in the female reproductive system whose main functions are: the production of hormones (estrogen and progesterone) and oogonia (the female reproductive cells). In this case, the embryo is a female, having in this way 2 X chromosomes. In the female, the primitive sex cords divide into irregular sex cords and, then, disappear and are replaced by a vascular stroma (protective/supportive framework of a biological cell, tissue or organ) that forms the ovarian medulla.

By the time of the 7th week, a new generation of cords appears, the cortical cords, due to the constant proliferation of the surface epithelium of the female gonad (in male this proliferation does not happen). These cords penetrate the underlying mesenchyme (any loosely organized tissue containing fibroblast-like cells and extracellular matrix regardless of the origin of the cells) but remain close to the surface.

By the time of the third month, primordial follicles are generated as the cortical cords divide into isolated cell clusters that proliferate and later start to surround the primordial female reproductive cells (oogonia) with a layer of epithelial cells called follicular cells. Together, the oogonia and the follicular cells constitute a primordial follicle.

Contrary to the male embryos, the medullary cords of the gonads of the female embryos regress and a secondary generation of cortical cords develops. In embryos with an XY sex chromosome complex, medullary cords develop into testis cords and secondary cortical cords fail to develop.

References

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