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Anatomy and Pathology of the Umbilical Cord and Major Fetal Vessels

DEVELOPMENT

The development of the umbilical cord is closely related to that of the amnion (see Chapter 11). Throughout the last days of the second week p.c., the blastocystic cavity is being filled by a loose meshwork of mesoderm cells, the extraembryonic mesoblast, which surrounds the embryoblast (Figure 12.1a, day 13). The embryoblast at that time is composed of two vesicles: the amnionic vesicle and the primary yolk sac. When these two vesicles are in contact with each other, they form the double-layered embryonic disk. During the following days the extraembryonic mesoderm cells are rearranged in such a way that they line the inner surface of the trophoblastic shell as chorionic mesoderm. They also cover the surface of the two embryonic vesicles (Figure 12.1b, day 18). Between the two mesoderm layers the exocoelom cavity forms. It largely separates the embryo and its mesodermal cover from the chorionic mesoderm. The exocoelom is bridged by the mesoderm in only one place, which lies basal to the amnionic vesicle. This mesenchymal connection is referred to as the connecting stalk (Figure 12.1, day 18). It fixes the early embryo to the membranes and is the early forerunner of the umbilical cord. During the same period (around day 18 p.c.) a duct-like extension of the yolk sac, originating from the future caudal region of the embryo, develops into the connecting stalk. This structure is the transitory allantois, the primitive extraembryonic urinary bladder. Heifetz (1996) estimated that some 20% of umbilical cords at term contained remnants of allantoic or omphalomesenteric duct, primarily near the fetal end.

The three subsequent weeks are characterized by three developmental processes.

1. The embryo rotates in such a way that the yolk sac vesicle, originally facing the region opposite the implantation site, is turned toward the implantation pole.
2. The amnionic vesicle enlarges considerably, extending around the embryo.
3. The originally flat embryonic disk is bent in the anteroposterior direction and rolled up in the lateral direction. It thus “herniates” into the amnionic vesicle. As the embryo bends, it subdivides the yolk sac into an intraembryonic duct (the gut) and an extraembryonic part (the omphalomesenteric or omphalomesenteric duct), which is dilated peripherally to form the extraembryonic yolk sac vesicle.

Both the allantois and the extraembryonic yolk sac extend into the mesenchyme of the connecting stalk (Figure 12.1, day 22). Between days 28 and 40 p.c., the expanding amnionic cavity has surrounded the embryo so far that the connecting stalk, the allantois, and the yolk sac are compressed to a slender cord, which is then covered by amnionic epithelium (Figure 12.1c, day 28). They thus form the umbilical cord. The cord lengthens as the embryo “prolapses” backward into the amnionic sac (Hertig, 1962). During the same process of expansion, the amnionic mesenchyme locally touches and finally fuses with the chorionic mesoderm, thus occluding the exocoelomic cavity. This process persists until the middle of pregnancy when, at approximately 12 weeks, the amnionic cavity completely occupies the exocoelom so that amnionic and chorionic mesenchyme have fused everywhere.

During the 3rd week p.c. the extraembryonic yolk sac, the omphalomesenteric duct that connects with the embryonic gut, and the allantois become supplied with fetal vessels. All mammals use either allantoic or yolk sac vessels for vascularization of the placenta. The human allantoic vessels, two allantoic arteries originating from the internal iliac arteries, and one allantoic vein that enters the hepatic vein, invade the placenta and become connected to the villous vessels. The allantoic participation in placental vascularization is the reason for the name “chorioallantoic” placenta. In contrast, in the choriovitelline or vitelline placentaion (e.g., of rodents and bats), the yolk sac vessels establish fetoplacental vascular connections.

The development of the cord has been treated in great detail in the classical text by Cullen (1916). Unfortunately, this book is so in accessible that it is rarely cited, let alone read. Another major review with special reference to comparative anatomy is that by Arvy and Pilleri (1976a). This volume brings together an enormous amount of material and is of particular interest because so many features considered to be abnormal in human placentas are normal features in some other species. Thus, many animals have pronounced squamous metaplasia on the cord’s surface and nodules, not only near its abdominal end, which make the surface feel somewhat sandy. Blackburn and Cooley (1993) have also contributed a major review of all aspects of umbilical cord anatomy and pathology that should be consulted for additional considerations; it is richly illustrated and has major relevance to the relationship of cord anomalies to congenital malformations of the fetus.

Amnionic Epithelium

The cord is covered by amnionic epithelium. Near the umbilicus, a largely unkeratinized, stratified squamous epithelium provides the transition from the abdominal wall to the cord’s surface. Farther away from the umbilicus, the epithelium transforms into a stratified columnar epithelium (two to eight layers) and finally into a simple columnar epithelium (Hoyes, 1969; Sinha, 1971; Hempel, 1972). The latter continues developing into the simple...