

# UMBILICAL CORD

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## UMBILICAL CORD

**Primary Disciplinary Field(s):** Anatomy, Obstetrics, Developmental Biology

### 1. Core Definition and Structure

The umbilical cord is a fundamental and transient structure essential for mammalian fetal development, serving as the sole physiological and genetic link between the developing fetus and the placenta during a pregnancy. Defined fundamentally as a cord-like structure housing two arteries and a vein, all encapsulated within a cylindrical membrane, its primary responsibility is the bidirectional transport of materials necessary for fetal survival, growth, and waste elimination. This conduit effectively replaces the functionality of the developing fetal lungs, kidneys, and gastrointestinal tract throughout the gestational period, managing gas exchange, nutrient delivery, and metabolic waste removal until the moment of birth.

Anatomically, the cord is characterized by its internal vascular arrangement, typically consisting of three vessels: two smaller, muscular **umbilical arteries** and one larger, thin-walled **umbilical vein**. These vessels are distinct from adult circulation in their function; the vein carries oxygenated and nutrient-rich blood from the placenta to the fetal heart, while the arteries return deoxygenated, waste-laden blood from the fetus back to the placenta for processing and eventual transfer to the maternal circulation. This specialized arrangement highlights the complex adaptations of the fetal circulatory system, necessitating the cord's structural integrity to maintain continuous and efficient blood flow under various intrauterine stresses.

Encasing and protecting these vital vessels is Wharton's jelly, a unique mucoid connective tissue rich in proteoglycans and fibroblasts. This specialized matrix provides **turgor** and mechanical strength, acting as a hydrostatic skeleton that buffers the vessels against external pressure, torsion, and kinking, which could otherwise compromise fetal oxygenation and blood supply. The entire structure is wrapped in an outer layer of amniotic epithelium, continuous with the amnion covering the placenta, creating a smooth, slippery surface that reduces friction within the amniotic cavity, further ensuring the uninterrupted functionality of the cord throughout the nine months of gestation.

### 2. Embryological Development

The genesis of the umbilical cord begins early in embryogenesis, stemming from the fusion of two initial structures: the body stalk and the yolk sac. Around the fifth week of development, as the embryonic body undergoes differential folding, the primitive gut begins to involute, and the connecting stalk, which carries the allantois (a structure involved in early waste disposal), is incorporated into the ventral aspect of the embryo. Concurrently, the vitelline duct, connecting the

yolk sac to the midgut, also becomes integrated, resulting in a primitive cord structure containing remnants of both the allantois and the yolk sac.

As development progresses, the two umbilical arteries, which originate as branches of the fetal internal iliac arteries, and the single umbilical vein, which forms from the confluence of smaller placental veins, become firmly embedded within this developing connective tissue mass. The initial epithelial lining is derived from the amnion, which expands rapidly to enclose the emerging cord components. During this period, transient loops of the developing gut tube may herniate into the proximal portion of the cord (physiological umbilical herniation), a normal developmental phase that resolves spontaneously by the tenth week of gestation as the abdominal cavity expands to accommodate the developing organs.

By the time the fetus reaches term, the cord typically attains a length of 50 to 60 centimeters and a diameter of approximately 1 to 2 centimeters. Variations in length are clinically significant; excessively short cords may restrict fetal movement and lead to placental abruption or structural defects, while overly long cords increase the risk of knot formation or entanglement (nuchal cords). Furthermore, the natural spiral or helical twisting often observed in the cord is an important structural adaptation; this torsion is believed to confer increased mechanical resilience, providing additional tensile strength and elasticity necessary to withstand fetal movements without occluding the critical vascular flow.

### 3. Fetal-Maternal Exchange Dynamics

The primary physiological function of the umbilical cord is to facilitate **hematological communication** between the fetus and the maternal circulation via the placenta, acting as the circulatory 'highway' for all essential physiological exchanges. Blood traveling through the umbilical vein delivers oxygen (O<sub>2</sub>) and essential metabolic substrates--most critically glucose, amino acids, and lipids--from the intervillous space of the placenta directly into the fetal systemic circulation via the ductus venosus, bypassing the fetal liver to ensure high-priority organs like the brain receive immediate nourishment.

In the reverse direction, the deoxygenated and nutrient-depleted blood returns via the two umbilical arteries, which branch extensively within the placenta's chorionic villi. Here, waste products such as carbon dioxide (CO<sub>2</sub>), urea, and creatinine diffuse across the placental barrier into the maternal blood. This intricate system of diffusion and active transport means that the fetus maintains a closed circulatory system; fetal blood and maternal blood do not typically mix, relying solely on the concentration gradients maintained across the highly specialized placental membranes for effective gas and waste transfer.

Beyond simple nourishment and waste management, the cord also serves an immunological role crucial for fetal survival in the early postnatal period. During the latter half of pregnancy, the

placenta actively transports **Immunoglobulin G (IgG)** antibodies from the maternal circulation across to the fetal blood carried by the umbilical vein. This process provides the neonate with essential passive immunity against pathogens the mother has previously encountered, affording a protective layer while the infant's own immune system matures. The efficiency of this transfer underscores the critical nature of continuous, unimpeded blood flow through the umbilical circulation.

#### 4. Clinical Considerations and Pathology

A number of pathological conditions and anatomical variations associated with the umbilical cord can significantly impact fetal health and necessitate careful obstetrical management. One of the most common vascular anomalies is the **Single Umbilical Artery (SUA)**, present in approximately 0.5-1% of all pregnancies. This condition, where one artery is absent, mandates further detailed fetal assessment as it is frequently associated with an increased risk of congenital anomalies, particularly affecting the cardiac, renal, and skeletal systems, although many infants with isolated SUA are born healthy.

Mechanical complications pose acute risks during labor and delivery. A **nuchal cord**, where the cord wraps around the fetal neck, occurs frequently (in about 20-30% of births) and is usually benign; however, if the cord is tightly compressed or forms multiple loops, it can lead to intermittent or sustained reduction in blood flow, resulting in fetal distress necessitating immediate intervention. More dangerous is the formation of a **true knot**, a relatively rare but high-risk occurrence that can suddenly tighten during labor or fetal movement, causing severe hypoxemia or fetal demise due to complete vascular occlusion.

The most severe obstetric emergency involving the cord is **umbilical cord prolapse**, which occurs when the cord descends through the cervix into the vagina before the presenting fetal part. This condition subjects the cord to severe, crushing pressure from the fetal head or body, leading to immediate fetal bradycardia and hypoxemia. Furthermore, **vasa previa**, a condition where unprotected fetal vessels traverse the membranes over the cervical os, places these vessels at high risk of rupture upon membrane tearing, resulting in catastrophic fetal hemorrhage and requiring mandatory prenatal diagnosis and planned cesarean delivery.

#### 5. Management at Birth and Delayed Clamping

The management of the umbilical cord immediately following birth has evolved significantly, moving from a standard practice of immediate clamping to the current recommendation of **Delayed Umbilical Cord Clamping (DCC)** in most term and preterm infants. Historically, the cord was cut and clamped within seconds of delivery, often to expedite placental delivery or facilitate immediate neonatal resuscitation. However, this practice abruptly terminates the physiological blood transfer

that naturally occurs during the transitional phase immediately postpartum.

The rationale underlying DCC is the crucial process of **placental transfusion**, whereby gravity and uterine contractions help transfer a substantial volume of blood--up to 100 mL, or about one-third of the infant's total blood volume--from the placental reservoir back into the neonate's circulation. Current evidence-based guidelines generally recommend clamping the cord no sooner than 30 to 60 seconds after birth, or until pulsations cease, provided the infant does not require urgent resuscitation efforts that necessitate immediate access.

The health benefits associated with DCC are now widely recognized. For both term and preterm infants, DCC is linked to significantly higher hemoglobin levels at birth and substantially improved iron stores throughout the first six months of life, which translates directly into a reduced incidence of **iron deficiency anemia**. Furthermore, for preterm infants, DCC has been shown to reduce the rates of intraventricular hemorrhage and necrotizing enterocolitis. The practice noted in source materials regarding the cord "not cut at birth, but instead given the chance to fall off on its own in the days or weeks following birth" is known as **Lotus Birth**, an extreme variant of delayed management where the cord and placenta remain attached until natural separation, a practice lacking established medical benefits and carrying potential infection risks, thus distinguishing it from evidence-based DCC protocols.

## 6. Contemporary Applications and Research

Beyond its physiological role in utero, the umbilical cord has become a valuable biomedical resource, primarily due to the discovery of its rich reservoir of **stem cells**. The blood contained within the cord at birth, known as umbilical cord blood, is a potent source of hematopoietic stem cells (HSCs), which are identical to those found in bone marrow and are capable of regenerating the entire blood and immune system. This has led to the widespread practice of cord blood banking, where the collected blood is cryopreserved for potential use in treating various hematological malignancies, immune disorders, and genetic diseases, either through autologous donation (for the child themselves) or allogeneic donation (for unrelated recipients).

Further research has revealed the therapeutic potential of the cord tissue itself. Wharton's jelly, the protective matrix, is rich in **mesenchymal stem cells (MSCs)**. Unlike HSCs, MSCs are multipotent and can differentiate into various cell types, including bone, cartilage, and fat cells, making them subjects of intense investigation in the field of regenerative medicine. Their unique immunomodulatory properties also suggest significant promise for treating autoimmune diseases, repairing damaged tissues, and managing chronic inflammatory conditions, positioning the cord as a dynamic source for novel cell-based therapies.

Ongoing research continues to explore the correlation between cord structure and fetal outcomes. Variations in cord thickness, insertion point, and degree of spiraling are increasingly studied as

potential non-invasive biomarkers for identifying fetuses at risk for growth restriction, placental insufficiency, or adverse neurodevelopmental outcomes. Such studies aim to refine prenatal diagnostics, leveraging the observable characteristics of the umbilical cord as a predictive indicator of the underlying health and functional capacity of the fetoplacental unit.

## 7. Etymology and Cultural Context

The term **umbilical** derives from the Latin word *umbilicus*, which translates directly to "navel" or "belly button," referencing the site of the cord's insertion into the fetal abdomen. The cord is the structure that facilitates the eventual formation of the navel, or omphalos, which represents the anatomical remnant of this crucial connection after birth. The term **cord** is self-explanatory, referencing its cylindrical, rope-like structure.

The umbilical cord, and specifically the resultant dried stump, holds profound symbolic and cultural significance across various global societies. For many cultures, the severed cord stump represents the physical severing of the prenatal connection, symbolizing the infant's independent existence, yet also marking their enduring link to their ancestors or birthplace. Traditions range widely, including the preservation of the dried cord stump in specialized boxes, symbolic burial (often near a tree or the home) to ensure stability or connection to the land, or even ritualistic disposal intended to influence the child's future destiny, demonstrating the deep-seated cultural importance attributed to this biological structure far beyond its medical function.

### Further Reading

[Wikipedia: Umbilical Cord](#)

[Wikipedia: Obstetrics](#)

[Wikipedia: Hemoglobin](#)