

# Anatomy and embryology of umbilicus in newborns: a review and clinical correlations

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**Abstract** Umbilicus is considered a mirror of the abdomen in newborns. Despite its importance, the umbilicus has been stated in literature and textbooks as discrete subjects with many body systems, such as the urinary, digestive, and cardiovascular ones. This article aimed to address the basic knowledge of the umbilicus in relation to clinical disorders under one integrated topic to aid physicians and surgeons in assessing newborns and infants. The umbilicus appears as early as the fourth week of fetal life when the folding of the embryonic plate occurs. The umbilicus appears initially as a primitive umbilical ring on the ventral aspect of the body. The primitive umbilicus contains the connecting stalk, umbilical vessels, vitelline duct and vessels, allantois, and loop of the intestine. Changes occur to form the definitive cord, which contains three umbilical vessels, namely, “one vein and two arteries,” embedded in Wharton’s jelly. After birth, the umbilical vessels inside the body obliterate and gradually form ligaments. Congenital disorders at the umbilicus include herniation, bleeding, and discharge of mucous, urine, or feces. Some of these disorders necessitate emergent surgical interference, whereas others may be managed conservatively. The umbilicus has many embryological remnants. Thus, the umbilicus is prone to various clinical disorders. Detecting these disorders as early as possible is essential to prevent or minimize possible complications.

**Keywords** anatomy; embryology; newborns; umbilicus

## Introduction

Umbilicus, commonly known as navel, is a localized depressed area that marks the previous connection of an individual with his or her mother during fetal life. In the abdomen, the umbilicus embryologically represents the neck of the bottle, which contains the umbilical vessels and structures related to the digestive and urinary systems. After the fall of the umbilical stump a few days after birth, its scarred tissue remains as the belly button.

The umbilicus is considered a mirror of the abdomen and should be carefully checked, particularly for newborns. A basic understanding of its anatomy and embryology is essential to identify and manage its disorders. Investigating the abnormal conditions at the umbilicus is crucial [1] because corrective surgical interventions may be required and conducted as soon as possible.

The umbilicus also represents a relatively weak point in the anterior abdominal wall that is prone to herniation or bulging as a result of increased intra-abdominal pressure. Moreover, most abnormal conditions observed at the umbilicus are attributed to developmental disorders [2]. Thus, focusing on the development of the umbilicus and its congenital anomalies and correlating these conditions with clinical findings are necessary. Most textbooks and works in the literature discussed the umbilicus in many systems, such as the urinary, digestive, and cardiovascular systems.

The current article aimed to highlight the anatomy and embryology of the umbilicus and its clinical correlations in one topic to aid physicians, surgeons, and other healthcare professionals in examining newborns.

## Anatomy

### Position

The umbilicus is rarely absent, and its absence may be attributed to congenital causes, such as gastroschisis,

cloacal exstrophy, and omphalocele. This condition may be caused by acquired factors, including surgical procedures, e.g., umbilical herniorrhaphy and skin cancer ablation surgery [3,4].

The umbilicus is centrally located at the midpoint of the anterior abdominal wall in adults; however, it may be lower or higher in a small proportion of the population [5]. Despite the variability of the umbilicus position, it lies typically at the level of the highest points of the iliac crests, opposite the disk between the lumbar three and four vertebrae [6] or opposite the L4 vertebra. This position represents an important landmark in anesthesia [7]. However, the umbilicus was reported to be situated at approximately 60% of the line extending from the xiphisternum to the superior border of the symphysis pubis in newborns [8]. This finding is used as a guide to improve the cosmetic results at repairing the exomphalos major. The umbilicus lies opposite one of the transverse tendinous intersections of the rectus abdominis muscle [9].

## Contents

The umbilicus contains the obliterated orifices of three umbilical vessels, namely, one vein with a thin wall and wide lumen and two arteries with thick walls and narrow lumens. The vein lies at the 12 o'clock position, whereas the two arteries are located at the 4 and 8 o'clock positions when facing the umbilicus [9].

From a clinical point of view, the umbilicus is commonly colonized by *Staphylococcus aureus* soon after birth because it is a depressed portion of the skin surface. Thus, the umbilicus must be strictly sterilized before surgical operations [10].

## Blood supply

The middle of the anterior abdominal wall, including the umbilicus, is supplied by the branches of the superior and inferior epigastric arteries. The surface anatomy of these vessels lies lateral to the umbilicus [7]. The two epigastric arteries anastomose together on each side and form an important alternative channel for blood flow in case of aortic coarctation [11]. The superficial veins form a venous network radiating from the umbilicus. A few small veins called the paraumbilical veins connect this network with the portal vein through the umbilicus and along the ligamentum teres. This connection forms an important portosystemic venous anastomosis [9].

## Innervations

The ventral rami of the nerves T7–L1 supply the anterior abdominal wall through the lower five intercostal (T7–11) and subcostal (T12) nerves, as well as the iliohypogastric and ilioinguinal nerves carrying L1. The umbilicus is segmentally innervated by T10 [9].

## Lymph drainage

The lymph drainage of the skin of the abdominal wall above the umbilicus drains into the anterior (pectoral) axillary lymph nodes, whereas that below it drains into the superficial inguinal lymph nodes [9]. The lymphatics of deep tissue, including the muscles and fascia above the umbilicus, drains into the parasternal lymph nodes, whereas that below the umbilicus pass through the external iliac lymph nodes to reach para-aortic nodes [11].

## Embryology

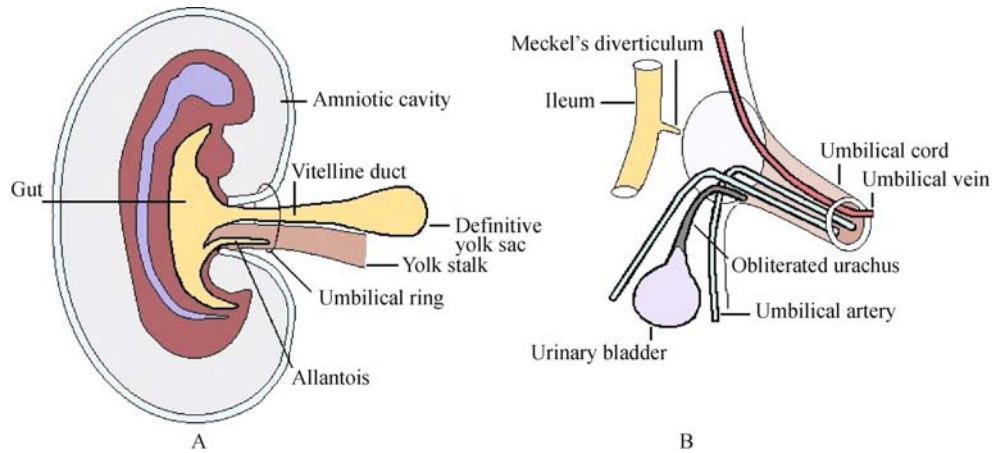
### Prenatal development

The development of the umbilicus begins as early as the fourth week of fetal life as an umbilical ring when the embryonic disk shows folding to become cylindrical in shape. This folding divides the yolk sac into two parts—a part inside the body of the fetus forming the gut and another part outside the body, called definitive yolk sac. The two parts are connected together by the vitelline duct [12], which is also called omphalomesenteric duct that recedes during the fifth to ninth weeks of fetal life, leaving a solid cord remnant extending from the ileum to the umbilicus [1].

The expansion of the amnion approximates the connecting stalk containing a diverticulum from the hindgut called allantois, the vitelline duct, and yolk sac neck in a sheath of amniotic membrane forming the umbilical ring and the cord (Fig. 1). As the umbilical cord elongates, the vitelline duct narrows and the yolk sac outside the body of the embryo reduces in size, forming a pear-shaped body within the umbilical sheath [13]. During the sixth week of fetal life, the intestine herniates or bulges, forming a protrusion in the umbilical cord. This physiological herniation is reduced by the 10th to 12th weeks because of the enlargement of the abdominal cavity of the fetus causing withdrawal of the bulged intestinal loop. The umbilical cord is formed by three umbilical vessels, namely, one vein and two arteries, embedded in Wharton's jelly (loose mesoderm of the connecting stalk) and covered by a sheath of amniotic membrane; the resulting structure is called the definitive umbilical cord [12].

### Postnatal changes

Towards birth, the vitelline duct and its vessels, as well as the yolk sac, normally disappear, leaving only three umbilical vessels, namely, two arteries and one vein, embedded in Wharton's jelly. The mesenchymal tissue called jelly is rich in proteoglycans that protect the umbilical vessels. The wall of these vessels are rich with elastic fibers that function in the rapid contraction and constriction of the vessels after tying the cord at birth [14].



**Fig. 1** Diagrams showing the (A) folding of the embryo and formation of the primitive umbilical cord and (B) definitive umbilical cord.

The intra-fetal umbilical vessels become obliterated and fibrosed by time to form ligaments. The umbilical vein forms the ligamentum teres (round ligament) that connects the umbilicus with the liver [12]. The liver receives its arterial blood supply mainly from the left umbilical vein during fetal life [15]. Portal hypertension may open and recanalize this ligament, thus forming a portosystemic collateral vessel [16]. Therefore, the umbilicus represents a site for portosystemic anastomosis. During portal hypertension, the vessels at the umbilicus dilate and radiate like spokes of a wheel. This structure is called “caput medusae” [6].

The umbilical arteries originate from the internal iliac arteries. These arteries pass one on each side of the urinary bladder and run upward and medially toward the umbilicus. These arteries carry fetal blood to the placenta. After birth, the distal ends of these arteries become obliterated and form two umbilical ligaments, whereas their proximal parts remain patent to form the superior vesical arteries supplying blood to the urinary bladder. The obliterated portions are called the lateral umbilical ligaments [9,12]. However, other authors identify these parts as medial umbilical ligaments [14,17]. For complete-

ness, the authors regarded the peritoneum covering the inferior epigastric vessels as the “lateral umbilical ligaments” because these vessels are situated on the lateral sides of the obliterated portions of umbilical arteries “medial umbilical ligaments” [18].

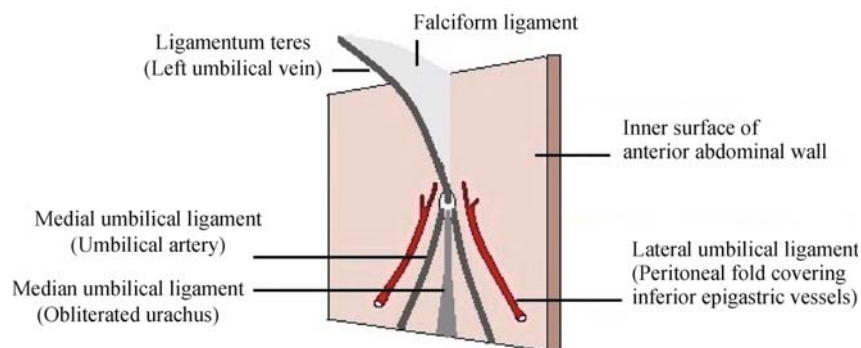
At the same time, the urachus “remains of fetal allantois” is obliterated and forms the median umbilical ligament. This single median ligament, which is approximately 10 cm long, passes upward in the midline connecting the apex of the urinary bladder with the umbilicus [9,18] (Fig. 2).

**Congenital abnormalities at the umbilicus**

These abnormalities are caused by the defects in the normal development of the umbilical region and mostly manifest in newborns and individuals at the early stages of life. These abnormalities include the following.

*Absence of the umbilicus*

This condition occurs in some congenital abnormalities caused by the defects in the folding of the embryonic disk.



**Fig. 2** Diagram showing the arrangement of the ligaments at the umbilicus.

The umbilicus is absent in exstrophy of the bladder (also known as cloacal exstrophy) and in other disorders, such as exomphalos or severe epispadias [13]. In these cases, umbilicoplasty or reconstruction is recommended for most patients. The difficulty in these cases is the mobilization of deficient skin. This condition is addressed by using tissue expanders underneath the skin [2].

#### *Abnormal position of the umbilicus*

Abnormally high umbilicus may be observed in some rare cases, such as Robinow syndrome and other anomalies, e.g., dwarfism, fetal facies, and short forearms. Abnormally low umbilicus may be detected in some variants of bladder exstrophy, e.g., vesico-intestinal fissure [2].

#### *Significant delay in the separation of the cord*

After its cutting at birth, the remaining stump of the cord normally separates within one or two weeks, leaving behind a depressed scar known as the umbilicus. A marked delay of its drop may be associated with defects in neutrophil functions [2,19]. This defective function is caused by leukocyte adhesion deficiency, a rare immunologic disorder. This disorder is commonly associated with high morbidity and mortality. Therefore, early detection is recommended. This condition should be suspected in case of marked delay of cord separation after birth [19].

#### *Weeping umbilicus*

In this condition, watery fluid is discharged after the cord falls off. The umbilicus appears bright red. This condition is attributed to the implantation of the intestinal epithelium at the umbilicus during the reduction of its physiological herniation during fetal life. This condition is treated by scrapping away the epithelium [6].

#### *Umbilical hernias*

##### *Infantile umbilical hernia*

Infantile umbilical hernia is a protrusion of abdominal contents, usually of the intestine into the umbilical ring. This

condition is caused by the failure of the normal development of the umbilical ring, resulting in the persistence of the early communication between the fetal peritoneal cavity and the extraembryonic mesoderm. This abnormality leads to the failure of reducing physiological herniation in fetal life [20]. The vast majority of cases are spontaneously resolved during childhood as the umbilical ring continues to contract during the early years of life. These cases need only reassurance and observation unless the hernia is more than 1.5 cm; in this case, surgical repair is deferred to children aged four years to six years [21]. Umbilical hernia is commonly encountered in cases of prematurity, Down syndrome, and mucopolysaccharidosis [2].

##### *Exomphalos (omphalocele)*

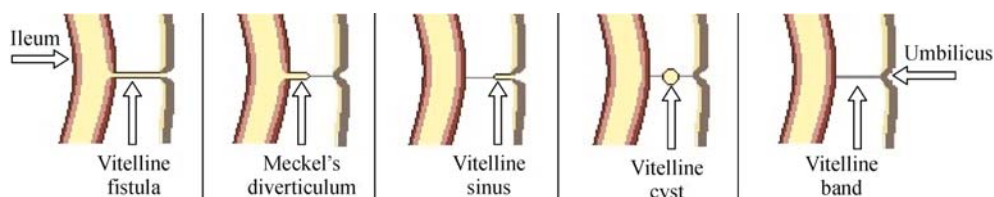
In exomphalos, the abdominal contents bulge outside the neonatal body. The defect in the umbilical ring is more than 5 cm and reaches 15 cm in length [2,20]. This condition may be classified into minor and major exomphalos, depending on size. The protruded intestine is covered with a membrane consisting of Wharton's jelly, peritoneum, and amnion. Exomphalos is not covered by skin. Thus, its contents are easily seen. This case is usually discovered prenatally by ultrasound examination. Once the baby is born, the viscera should be protected with saline-soaked gauzes and transferred to the neonatal unit for preoperative assessment. Surgery for its repair is conducted within hours after birth, except when the sac ruptures, which requires emergent operation [22].

##### *Vitelline duct's remnants*

The failure of the duct to disappear at birth results in some defects, which include the following (Fig. 3).

##### *Vitelline (umbilical) fistula*

Vitelline fistula is a patent vitelline duct caused by the failure of its normal obliteration. The fistula communicates to the cavity of the ileum with the exterior at the umbilicus. The fistula may be manifested clinically by the discharge of ileal (fecal) contents at the umbilicus. This condition is



**Fig. 3** Diagrams showing vitelline duct's remnants.

treated surgically by its excision through the umbilicus. Thus, the continuity of the ileum is restored and the umbilicus is closed [2].

#### Meckel's diverticulum

Meckel's diverticulum is a small diverticulum arising from the ileum that is caused by the failure of the obliteration of the proximal portion of the vitelline duct. This condition occurs in approximately 2% of the population. Clinically, its inflammation may be misdiagnosed as appendicitis [12].

#### Vitelline sinus

Vitelline sinus is a small blind sinus opening at the umbilicus and is caused by the failure of the obliteration of the distal (outer) portion of the vitelline duct. Clinically, this condition may lead to the discharge of mucous at the umbilicus [2,12].

#### Vitelline cyst

This condition is caused by the failure of the obliteration of the middle portion of the vitelline duct. This cyst may be infected and rupture at the umbilicus, leading to the discharge of pus.

#### Vitelline band

This band connects the intestine with the umbilicus and is caused by the obliteration of the vitelline duct but its persistence as a fibrous band. This band may lead to intestinal volvulus, obstruction, and strangulation [12].

#### Mucosal remnants

Mucosal remnants may occur with an umbilical polyp or an umbilical cyst. The most commonly encountered ectopic mucosa is of gastric or pancreatic origin; colonic mucosa may also be observed [23]. Tamilselvan *et al.* observed that the acidic discharge produced by the gastric mucosa caused the appearance of chemical dermatitis [1]. The acidity of the discharge led to the inflammation and ulceration of the skin of umbilicus, thus causing the blood staining of the discharge observed in this case.

#### *Urachal remnants*

##### Urachal fistula

The urachal fistula connects the umbilicus with the apex of the urinary bladder and is caused by the complete failure of

urachal obliteration. This condition leads to the discharge of urine at the umbilicus. The urachal fistula may be treated by cauterization with local cauterizing agents, such as silver nitrate, or surgically by its ligation and excision if it persists [24].

##### Urachal diverticulum

Urachal diverticulum arises from the apex of the urinary bladder and is caused by the failure of the obliteration of the proximal part of the urachus. This condition is commonly an asymptomatic case.

##### Urachal cyst

This cyst appears as a mass between the umbilicus and symphysis pubis and is caused by the failure of obliteration of the middle portion of the urachus. This cyst may be infected and treated by drainage [2].

#### *Umbilical granuloma*

The mass of this granuloma is approximately 1 mm to 10 mm in diameter and represents the most common neonatal anomaly, which is mainly caused by delayed irregular separation of the cord stump. The granulation tissue results in the failure of epithelialization with inflammation and drainage [25]. This case is commonly treated with the application of 75% silver nitrate sticks or by surgical excision [26].

#### *Vascular remnants and anomalies*

The left umbilical vein forms the ligamentum teres (round ligament) of the liver, which connects it with the umbilicus (as mentioned previously).

The two umbilical arteries form umbilical ligaments—one on each side of the median umbilical ligament. These arteries connect the superior vesical vessels with the umbilicus. These arteries function to support the urinary bladder anterolaterally [11]. The arteries may be an abnormally remained patent that causes bleeding at the umbilicus according to the size of patency.

Single umbilical artery is a rare case and detected in 1% of infants. Fetuses with a single umbilical artery (therefore single ligament) are commonly associated with other congenital abnormalities, such as trisomy 18 and renal and cardiac anomalies [2]. These cases are also accompanied with the increased risk of adverse pregnancy outcomes [27].

#### *Gastroschisis*

Gastroschisis is a local defect in the anterior abdominal

wall. In this case, the umbilicus is normal. However, paraumbilical herniation usually occurs to the right of the umbilicus [28]. Gastroschisis occurs in 3.5/10 000 births, and its incidence increases in mothers who use cocaine. The intestine, stomach, or other abdominal contents may protrude through the defect in the anterior abdominal wall. The protruded parts are not surrounded by a membrane, thus have no sac. Unlike omphalocele, this case is not associated with chromosomal abnormalities or other severe defects, except atresia of intestine may occur [14]. Management includes fluid resuscitation and emergent reduction of the herniated parts to the abdomen [2].

## Clinical uses of the umbilicus in newborns

The umbilicus could be used as a route of injection through the cannulation of the umbilical vessels in case of intravascular monitoring and fluid resuscitation [2]. The umbilicus may be used to measure the body temperature of infants less than three months old as an alternative to the rectal route [29].

The umbilicus also represents a preferred site for laparoscopic surgery and provides a more or less safe site to introduce an instrument, as well leaves a minimal cosmetic scar after the procedures [5]. Ramstedt's pyloromyotomy for cases of pyloric stenosis could be conducted through the umbilicus without resulting in a subsequent obvious scar [2]. The umbilicus could be used as a site for temporary colostomy for infants with imperforate anus or Hirschsprung's disease. This site provides a better-looking scar than that in other sites [30].

## Conclusions

The umbilicus is one of the strategic points in newborns to check after assessing the vital signs. The umbilicus should be carefully investigated to properly manage any congenital anomalies affecting it.

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## Compliance with ethics guidelines

Abdelmonem A. Hegazy declares that he has no conflict of interest. This manuscript is a review article and does not involve a research protocol requiring approval by the relevant institutional review board or ethics committee. All diagrams were made by the author.

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