

Sonography of the Placenta And Umbilical Cord

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One of the earliest medical uses of ultrasound was in the obstetrics specialty. The primary objective of obstetric sonography is to determine the well-being of the fetus and, to some extent, the mother. The placenta and umbilical cord play an essential part in that determination. This Directed Reading examines the origins of the placenta and umbilical cord, their roles in maternal and fetal health and their sonographic appearances.

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After completing this article, readers should be able to:

- Explain the development and functions of the placenta and umbilical cord.
- Describe common abnormalities of these structures.
- Discuss their sonographic appearance.

At fertilization, when a single sperm penetrates an egg cell, a zygote that contains all of the genetic information required to develop a human being forms. As the zygote travels down the fallopian tube toward the uterus, it divides to form a ball of cells and then further divides to form a blastocyst — an inner group of cells with an outer shell.¹ Approximately 5 days after fertilization takes place within the fallopian tubes, the blastocyst reaches the womb.

The outside of the blastocyst is lined with cells called trophoblasts.² Trophoblasts will develop into the different cells found in the placenta.³ In addition, the placenta trophoblasts mediate implantation, stimulate pregnancy hormone production, provide immune system protection for the fetus and increase maternal vascular blood flow into the placenta. When the placenta is fully formed, it provides a vital connection between the mother and the developing fetus, permitting the exchange of essential gases and nutrients. The placenta's sole purpose is survival of the fetus.

The Structure and Function of The Placenta and Cord

Early in gestation, the developing embryo is small and its nutritional and waste disposal needs are minor. At this

point, the embryo absorbs nutrients from the mother's endometrial secretions and expels its waste into the uterus. As time passes, the needs of the embryo increase. As it progresses from embryonic stage to fetal stage, more nutrients are required and a much more sophisticated means of satisfying the nutritional and waste disposal needs must be established. This is accomplished only after the embryo develops a vascular system and can establish an effective and efficient interface (ie, the placenta) between the mother's vascular system and its own.

In addition to nourishing the fetus and providing a means for disposing of its wastes, the placenta secretes a number of hormones, including the steroid hormones estrogen and progesterone. It also secretes protein hormones and is the source of human chorionic gonadotropin (hCG). A luteinizing hormone, hCG is secreted by the syncytiotrophoblasts of the placenta in early pregnancy. It maintains the function of the corpus luteum and stimulates progesterone production in the placenta. Because hCG is found in the blood and urine of pregnant women, it is the basis for most common tests used to diagnose pregnancy.⁴ The placenta secretes the hormone relaxin, as well, which is thought to relax the joints of the pelvis and assist in dilating the cervix during birth.⁵

Besides secreting hormones, the placenta protects the fetus from immune attack by the mother and induces increased maternal blood flow to the placenta. Near the time of delivery, the placenta produces hormones that mature the fetal organs in preparation for life outside of the uterus. The placenta supports essential fetal respiratory functions before lung development, carrying oxygen and nutrients from the maternal blood across the membrane into the fetal circulation by diffusion and allowing carbon dioxide to pass in the opposite direction. The placenta provides the fetus with water, inorganic salts, carbohydrates, fats, proteins and vitamins and carries fetal waste into the mother's circulatory system to be secreted via her urinary system. The placenta also protects the fetus by prohibiting some harmful microorganisms from entering fetal circulation. A portion of the placental membrane called the placental barrier provides this protection. Storage is another function of the placenta. The placenta stores carbohydrates, calcium, iron and proteins for release into fetal circulation.

Two portions make up the placenta: fetal and maternal. The fetal circulation enters the placenta via the 2 umbilical arteries that are embedded within the umbilical cord. Once the fetal arteries enter the placenta, they branch into units called cotyledons, which are structures similar to inverted trees. The tiniest branches of the fetal circulation are made up of capillary loops embedded within the chorionic villi. The fetal circulation continues to branch until it reaches capillaries of the villi. Once nutrients have been absorbed and waste products released, the fetal blood collects in the umbilical vein, where it returns to the fetus.⁵

The maternal portion of the placenta receives blood by way of the spiral arteries of the uterus. When the spiral arteries make contact with the placenta, they end in open channels that pour maternal blood into the intervillous space. The intervillous blood is returned to the maternal circulation through drain-like uterine veins. As much as 35% of the maternal blood will course through the intervillous space to support the fetus until the time of delivery.⁵

The fetal and maternal portions of the placenta connect via the umbilical cord. This sustaining connection between the fetus and the placenta is formed rudimentarily by the fifth week of gestation. At approximately 5 weeks gestation, the embryo and placenta connect through a short stalk that houses the umbilical vessels and allantois. The allantois is developed from the fetal intestine and contributes to the development of the cord and placenta. Loops of blood vessels grow into the stalk

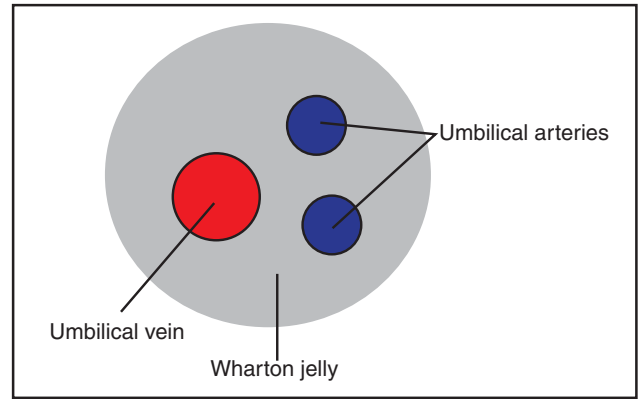


Figure 1. Schematic of a cross-section of the umbilical cord. Note the 3 vessels — 2 arteries and 1 vein — embedded within Wharton jelly.

as the fetus and its heart and circulatory system develop. The stalk becomes longer as the fetus develops, eventually becoming the umbilical cord. The uterine end of the cord attaches to become part of the placenta. The umbilical cord protects the vessels enclosed within it and functions throughout pregnancy. The cord comprises 2 fetal arteries and 1 fetal vein embedded within a spongy, loose proteoglycan-rich matrix called Wharton jelly that has a thin outer covering of amnionic membrane (see Figure 1). The amnionic membrane also covers the fetal surface of the placenta. As the vessels grow they form intertwining spirals. The properties of Wharton jelly make the cord resistant to compression and twisting. The most important function of the umbilical cord is to protect the lifeline vessels that travel between the fetus and the placenta. Any compromise of the fetal blood flow through the umbilical cord vessels can have serious, if not fatal, effects on the fetus and health of the newborn.⁵

The fetal heart pumps fetal blood through the umbilical arteries into the placenta, where tiny branches are bathed in maternal blood. These vessels are drained by the tributaries of the umbilical vein, which take the blood back into the cord to the fetus for return to the heart. As a result, used blood is pumped through arteries to the mother and refreshed blood is returned to the fetal circulation by veins. After birth, this job is performed by the lungs. Shortly after birth the cord is clamped and cut and the remnant shrivels and separates from the infant's navel 1 to 3 weeks following birth.⁶

Abnormalities of the Placenta

Unfortunately, several types of abnormalities can affect the placenta and cord, posing complications for

Table 1
Sonographic Criteria Used for Placental Grading

Grade 0:	The earliest of the placental grades (ie, fewer than 28 weeks). The placenta has a smooth well-defined chorionic plate, homogeneous appearance and a regular basal plate. There should be no echogenic densities.
Grade I:	There are subtle indentations in the chorionic plate with calcium deposits (spot-like densities) throughout the parenchyma of the placenta. The basal plate has a regular appearance.
Grade II:	There are numerous indentations along the chorionic plate that are comma-like in appearance. The indentations extend from the chorionic plate into the placental parenchyma, but do not extend into the basal plate. There are also linear densities along the basal plate.
Grade III:	This is the highest grade that can be assigned to the placenta. In this grade the comma-like densities that became apparent in Grade II extend into the basal plate. The placenta shows greater calcium deposits that encompass the lobes, creating complete circles of calcium. Echo-free areas also are observed in the center of the placenta with highly echogenic basal echoes with posterior acoustic shadowing.

the fetus, the mother or both. Some of these abnormalities are not life-threatening, but others pose great risks. The most common abnormalities associated with the placenta are:

- Abruptio placentae.
- Placenta previa.
- Placental insufficiency.
- Cysts, hematomas and infarctions.
- Malignancies and other tumors.
- Multiple gestation placentas.⁵⁻⁷

Most obstetrical sonograms include an evaluation of the placenta and umbilical cord. Among other observations, the placenta is evaluated for its location and grade. Grading involves rating the placenta on a scale of 0 to 3 according to certain characteristics and requires sonographic evaluation of the basal plate, chorionic plate and placental substance. The sonographic criteria used for grading the placenta are listed in Table 1.

The sonographer might observe 2 grades of placenta simultaneously. When this occurs, he or she assigns the highest grade present. The grade III placenta is observed at term in only 15% to 20% of mothers. A grade III placenta prior to 34 weeks might indicate intrauterine growth restriction (IUGR) or preeclampsia. A placenta that is immature in relation to gestation date often is observed in mothers with gestational diabetes or Rh incompatibility. In these mothers, placentomegaly also might be present. This condition is defined as a placental thickness of more than 5 cm.⁷

Placental implantation (location) varies but is always visible on transverse and longitudinal transabdominal scans of the gravid uterus. The placenta might be located along the uterine fundus anteriorly, posteriorly or laterally or along the lower uterine segment near or covering

the internal os of the cervix. Identifying placental location is important because a low-lying placenta near or covering the internal os might prompt diagnosis of a dangerous condition called placenta previa.

Abruptio Placentae

Abruptio placentae, also referred to as placental abruption or ruptured placenta, is described as the separation of a normally located placenta after the 20th week of gestation and prior to birth. Placental abruption occurs globally in approximately 1% of all pregnancies.⁷ It likely is caused by bleeding into the decidua basalis. Formation of hematomas causes additional separation of the placenta from the uterine wall, causing compression that compromises the blood supply to the fetus. Blood behind the placenta can penetrate the uterus and extend into the peritoneum. This is referred to as Couvelaire uterus. When this occurs the myometrium becomes weak and can rupture, especially during uterine contractions. This presents a life-threatening emergency for both the fetus and mother. The extent of fetal distress and survivability are determined by the amount of placental separation. The amount of maternal hemorrhage determines risk to the mother. Fetal and maternal death are caused by hemorrhage and coagulopathy. The perinatal mortality rate from abruptio placenta is approximately 15%. Immediate cesarean delivery is performed to try to save the lives of both fetus and mother.^{7,8}

Patients typically present with the following symptoms:

- Vaginal bleeding (occurs in about 80% of patients).
- Back or abdominal pain with uterine tenderness (70%).
- Fetal distress (60%).
- Abnormal uterine contractions (35%).

- Premature idiopathic labor (25%).
- Fetal demise (15%).⁸

Although placenta abruption is primarily a clinical diagnosis, sonography plays an important role in the diagnosis. Sonographers might observe an abnormality in placenta size and texture. In hemorrhages, the texture of the placenta will vary according to the age of the hemorrhage. An acute hemorrhage will appear isoechoic (ie, having the same echogenicity as the surrounding tissue) or hyperechoic (ie, having increased echogenicity compared with the surrounding tissue). Hemorrhages can be retroplacental or subchorionic. Those occurring in the chorion usually are hypoechoic (ie, having fewer echoes than the surrounding tissue). Abnormal collections of blood also might be visualized. Figure 2 demonstrates a placental abruption. Causes of abruption placentae include:

- Maternal hypertension (occurs in about 44% of cases).
- Maternal trauma (eg, assaults, falls, motor vehicle accidents) (occurs in 1.5% to 9.4% of cases).
- Cigarette smoking.
- Use of alcohol and cocaine.
- Short umbilical cord.
- Sudden decompression of the uterus (secondary to delivery of a first twin or premature rupture of membranes).
- Retroplacental fibromyoma (ie, fibroid).
- Retroplacental hemorrhage from amniocentesis.
- Advanced maternal age.
- Probable abnormalities of the decidua or uterine blood vessels (idiopathic).

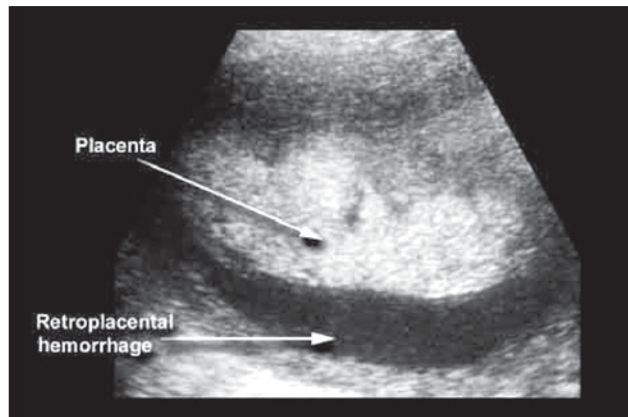


Figure 2. Sonogram of an abruptio placentae. Note the retroplacental hemorrhage. Image courtesy of Virlene Guzman, RDMS.

Table 2

Types and Characteristics of Placenta Previa

Type	Description
Complete or total	Placenta covers internal os completely
Partial	Placenta only partially covers the internal os
Marginal	The edge of the placenta extends to the margin of the internal os, but does not cover the internal os (edge within 2 cm of the os)
Low-lying	Placenta lies low in the uterus, but its edge does not approach the internal cervical os (edge 2 to 3 cm away from os)

- Previous abruption (5%-16% of subsequent pregnancies).⁷

Placental abruptions can be described as either retroplacental or marginal. Retroplacental abruptions are referred to as “high-pressure” bleeds because they are caused by rupture of the spiral arteries. Retroplacental abruptions are associated with maternal hypertension or other vascular disease. Marginal abruptions are called “low-pressure” bleeds because they dissect below the placental membranes and generally do not cause detachment of the placenta. In marginal abruptions, a subchorionic hemorrhage collects at a site remote from the placenta.⁷

Placenta Previa

In placenta previa, the placenta implants over or near the internal os of the uterine cervix. Placenta previa usually is diagnosed prior to 20 weeks gestation; serial sonography is performed to document the placenta’s location throughout the pregnancy. In almost 90% of cases the diagnosis of previa is resolved prior to term.⁹ Placenta previa is diagnosed in 1 out of every 200 pregnancies.⁷

Several terms are used to classify the types of placenta previa: complete or total, partial, marginal and low-lying.⁷ Table 2 describes each of the 4 classifications and Figure 3 is a schematic of the different types.

In 20% of pregnancies, the placenta totally covers the internal os (see Figure 4).^{9,10} When this occurs, the fetus and mother are at high risk for grave birth complications, particularly life-threatening maternal hemorrhage. There are other complications associated with this disorder, including premature delivery, increased

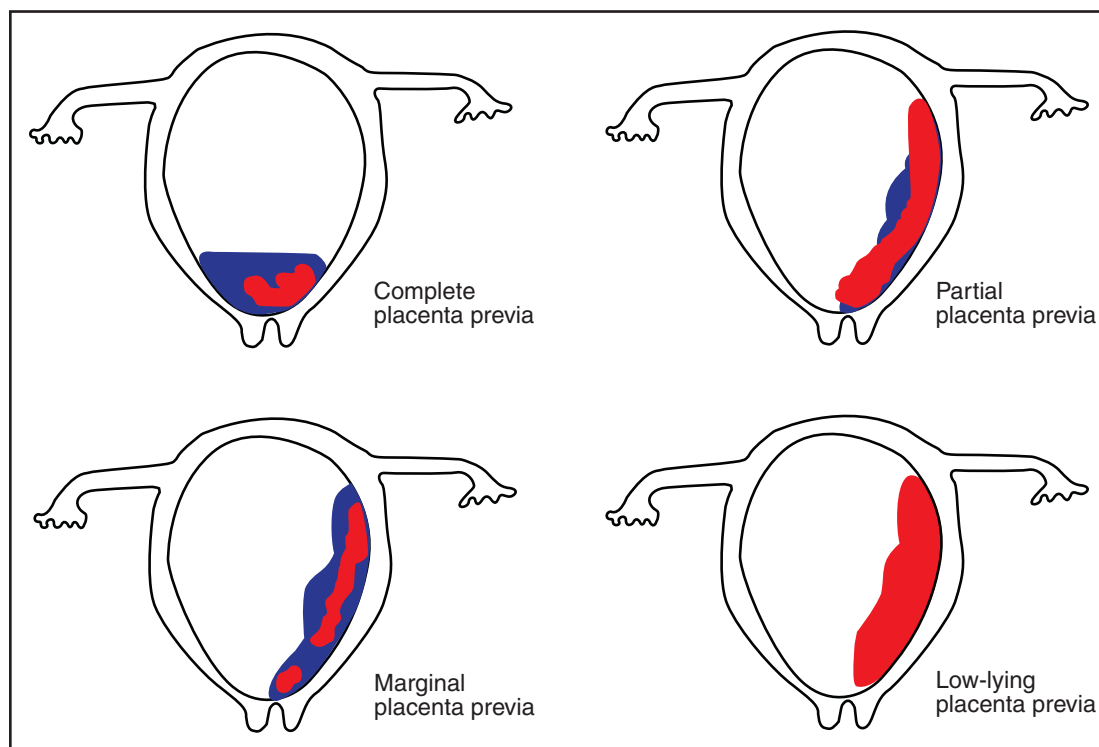


Figure 3.
Schematic showing the types of placenta previa.

risk of IUGR and increased occurrence of placenta accreta. Placenta accreta is associated with the abnormal adherence of all or part of the placental villi to the wall of the uterus (myometrium). The forms of this condition include placenta accrete, placenta increta and placenta percreta. Placenta accrete is the most serious form, demonstrated by an abnormally firm attachment of the placenta superficially to the myometrium. Placenta accrete accounts for the majority of all abnormal placental attachments. In placenta increta, the placenta has a deep attachment into the myometrium, while the placental attachment in placenta percreta involves a complete invasion of tissue through the myometrium. Any form of placenta accreta can cause an incomplete separation of the placenta from the uterine wall at birth and can result in hemorrhage, infection or other serious complications.¹¹

Every woman diagnosed with placenta previa, particularly those who have had previous cesarean deliveries, should be examined for potential placenta accrete. There are several prominent factors associated with placenta previa: advanced maternal age, cigarette smoking, prior cesarean delivery or other uterine surgeries, and multiparity.^{9,10}

Placenta previa is a relatively common finding on second trimester sonograms, but rarely continues to term. Although present on 4% of sonograms performed at 20 to 24 weeks, only about 0.4% are present at term. In these cases, placental migration away from the lower uterine segment and cervical os is thought to be due to growth in placental trophoblasts toward the uterine fundus where there is a much richer blood supply.⁹ Placenta previa can be asymptomatic or cause symptoms that include painless vaginal bleeding in the second or third trimester and painless vaginal bleeding following intercourse.^{7,10,12}

Transabdominal, transvaginal and transperineal ultrasound, all with Doppler, are used in the diagnosis of placenta previa. Transabdominal sonography is the least favored of these because important structures and their relationship to other structures cannot be visualized in many instances. The transperineal approach allows for evaluation of the lower uterine segment. The transvaginal approach also is useful because it places the transducer at a better vantage point for viewing the maternal bladder, internal os, lower segment of the uterus, fetal head and potential placenta previa. The transvaginal approach frequently is used because it simulates the normal vaginal exam performed by the physician.

Manual vaginal exams are contraindicated in suspected placenta previa. Doppler evaluation can visualize unusually intense blood flow within the placenta, hypervascularization, highly pulsated venous flow patterns within the placental blood lakes and the subplacental venous complex. Prenatal diagnosis is essential to the well-being of the fetus and mother; hemorrhage is a real threat to both. When placenta previa persists, delivery by cesarean section is indicated.¹²

Placental Insufficiency

Placental insufficiency is described as the inability of the placenta to provide oxygen and nutrients to the fetus. This leads to fetal hypoxia with resulting growth restriction; IUGR is second only to prematurity as the most common cause of fetal demise. Placental insufficiency is a complication experienced in up to 6% of all pregnancies. Fetuses that survive can experience problems with cardiovascular, metabolic and neurologic development into adulthood.¹³ The IUGR resulting from placental insufficiency is thought to be associated with oligohydramnios. Oligohydramnios is a reduction in the normal amount of amniotic fluid. When there is placental insufficiency, the placenta directs fetal blood flow away from the fetal kidneys and toward the fetal brain to counteract the effects of hypoxia. As this occurs, fetal urine output is reduced, resulting in oligohydramnios.¹⁰ Placental insufficiency might be suspected when oligohydramnios is present; however, it also can occur when the membranes rupture prematurely during the second

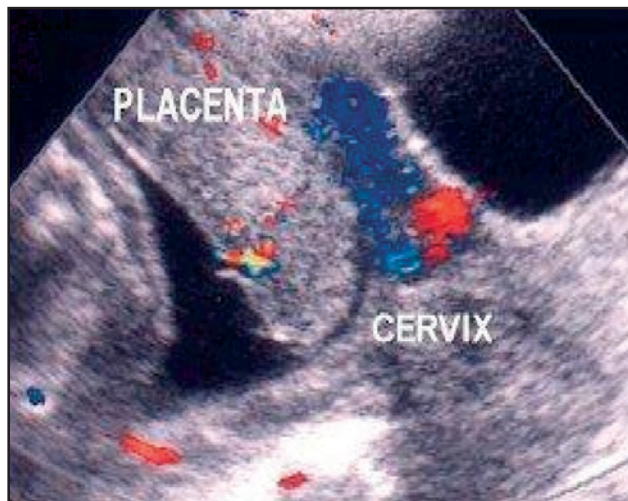


Figure 4. Sonogram of a total placenta previa with color Doppler. Image courtesy of Virlene Guzman, RDMS.

trimester, when IUGR is present or when the pregnancy extends beyond 42 weeks.¹³

Sonographic findings in placental insufficiency include oligohydramnios prior to 28 weeks' gestation without evidence of fetal renal anomalies, compression of the fetal head and abdomen secondary to the oligohydramnios, abnormal facial features, abnormal limb development, pulmonary hypoplasia and umbilical cord compression.¹⁰

Cysts, Hematomas and Infarctions

Placental cysts are described as sonolucent areas within the placenta. They are typically round or oval in appearance and echo-free. Cysts generally are isolated from placental circulation and contain a gelatin-like substance on histologic examination. There are 2 types of cysts associated with the placenta: septal and subchorionic. Septal cysts are located within the substance of the placenta, while subchorionic cysts are located beneath the fetal plate (chorion). Placental cysts that are detected sonographically usually are benign in nature and pose no significant risks to fetus or mother. When cysts measure 4.5 cm or larger or more than 3 cysts are present, IUGR may be indicated.¹⁴ Figure 5 shows a solitary placental cyst on a sonogram.

Placental hematoma or thrombus is defined as the presence of clotted blood within the intervillous space.⁷ As with most clots or thrombi, those in the placenta are the result of hemorrhage. In this case the hemorrhage is intraplacental and caused by breaks or tears in the villous capillaries. Placental hematomas generally pose

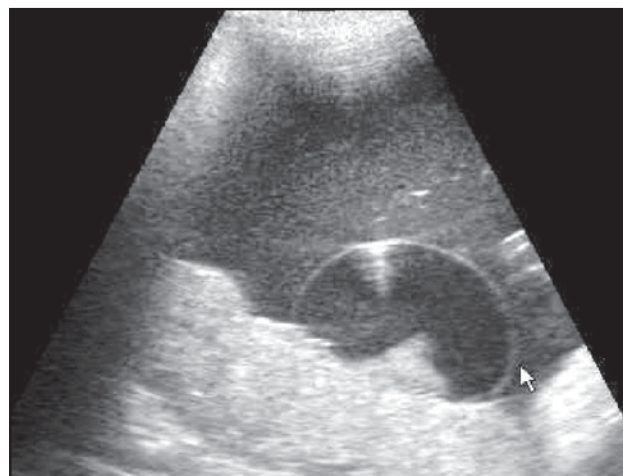


Figure 5. Sonogram of a large placental cyst. Image from the author's teaching files.

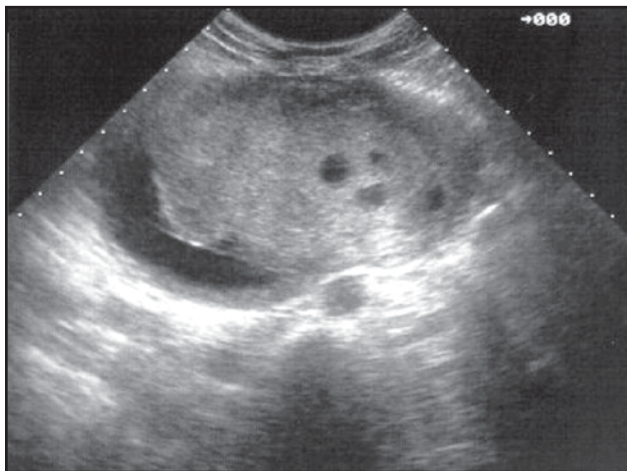


Figure 6. Sonogram of a hydatidiform mole (molar pregnancy). Note the grape-like structures within. Image from the author's teaching files.

little risk to fetus or mother, although they may be associated with Rh sensitivity and elevated alpha-fetoprotein levels due to hemorrhage.¹⁰

Placental infarcts are relatively common, occurring in approximately 25% to 30% of pregnancies. Literature suggests that these infarcts pose no deleterious effects to fetus or mother, although large infarcts are thought to be associated with maternal vascular disorders.¹⁰

Malignancies and Other Tumors

Placental tumors are described as solid masses located within the placenta. The 2 most common of these include the mole and the chorioangioma. Known as molar pregnancy, the mole tumor is really gestational trophoblastic disease. Molar pregnancies are rare, occurring in 1 in every 1250 pregnancies.^{7,10,15} Most are benign and are contained within the uterus. These are called hydatidiform moles. Hydatidiform moles contain abnormal placental tissue with clusters of tissue swollen with fluid (villi) that resemble clusters of grapes (see Figure 6). Fetuses that coexist with moles, if they survive, often are born with multiple malformations.¹⁵ Moles occur when placental tissue grows abnormally and forms a mass that can extend beyond the uterus. There are 3 types of molar pregnancies: complete, partial or incomplete, and coexisting mole and fetus. The complete mole normally does not contain any fetal tissue. In 15% to 25% of cases, a complete mole may develop into choriocarcinoma.¹⁰ Although rare, choriocarcinoma

is a malignant disorder, occurring in 1 of every 40 000 pregnancies.¹⁶ Fifty percent of choriocarcinomas are formed during a molar pregnancy.¹⁵ They arise from the trophoblastic epithelium. The tumor invades uterine blood vessels and muscles, creating areas of hemorrhage and necrosis. Columns and sheets of trophoblastic tissue invade normal tissue and spread to distant sites such as the brain, kidneys, lungs, pelvis and vagina.¹⁷

Chorioadenoma destruens is another invasive mole associated with molar pregnancies. It is described as a type of cancer that grows into the muscular wall of the uterus and can spread into the vagina, vulva and lungs.¹⁶ Chorioadenoma destruens also is called an invasive hydatidiform mole. Partial or incomplete moles normally are benign and are associated with an abnormal fetus, fetal and placental tissue, and umbilical cord and membranes. Chorioadenoma occurs much less frequently than a complete mole. The fetus usually dies within 9 weeks after the last menstrual period, although occasionally it can survive to term.¹⁷

Chorioangioma is the second most common type of placental tumor, occurring in 1% of all pregnancies.¹⁰ The chorioangioma is usually quite small and benign. This tumor is characterized by a proliferation of blood vessels — mostly capillary hemangiomas. The vessels originate beneath the chorionic plate. Fetal cardiomegaly, polyhydramnios, IUGR, fetal hydrops and fetal demise are complications of chorioangioma. Premature labor is a complication of large chorioangiomas. Maternal serum alpha-fetoprotein often is elevated.¹⁸

According to the Women's Cancer Information Center, all forms of placental tumors, including malignant masses, are considered curable. All forms of molar pregnancies are more common in women of Asian or African descent.¹⁸ Symptoms of molar pregnancy and choriocarcinoma are listed in Table 3.

Sonographic findings in molar pregnancy can include an unusually large uterus for gestation date, inhomogeneous placental texture and bilateral theca lutein cysts. In chorioangioma, sonographic findings include a well-circumscribed complex or solid mass protruding from the fetal surface of the placenta, polyhydramnios and fetal hydrops. Fetal hydrops is characterized by an excessive and extensive accumulation of fluid within fetal tissue and body cavities.

Multiple Gestation Placentas

One in approximately 100 births in the United States is a multiple birth, and this is due at least in part to assisted reproductive techniques. The placenta plays

Table 3

Maternal Symptoms Associated With Molar Pregnancy and Choriocarcinoma

Molar Pregnancy	Choriocarcinoma
Absence of menses	Absence of menses
Symptoms of pregnancy	Symptoms of pregnancy
Vaginal bleeding during first 21 weeks	Abnormal vaginal bleeding
Pain in lower abdomen	Abdominal or pelvic pain
Hypertension (prior to 24 weeks)	Intra-abdominal bleeding (due to rupture of the liver)
Excessive nausea or vomiting	Shortness of breath, cough, hemoptysis (secondary to lung metastasis)
Uterus large for gestation date	Loss of blood, anemia, massive hemorrhage (due to spread to the intestine)
Absent fetal heartbeat	Symptoms of stroke or brain tumor (due to brain metastasis)
Expulsion of cysts	

as essential a role in multiple births as in single births. Placentas in multiple gestations can exhibit all of the abnormalities common in single births, but also have unique pathologies of their own.¹⁹ Twin gestations are associated with higher percentages of perinatal morbidity and mortality.

There are 2 different types of twins: fraternal and identical (dizygotic and monozygotic, respectively). Fraternal twins often are referred to as nonidentical twins and are formed when 2 fertilized eggs are implanted into the wall of the uterus at the same time. Each implants separately and forms its own amniotic sac, chorion and placenta. These placentae can implant in different parts of the uterus and remain distinctly separate or implant next to each other and fuse.¹⁰ Even when the placentae fuse, the blood and nutrient supply to each fetus remains distinct and separate. Because there are 2 eggs and thus 2 zygotes, fraternal twins are referred to as dizygotic. Dizygotic twins have a relatively small chance of having the same chromosomes and can be the same sex or different sexes. Studies have shown a genetic basis for fraternal twinning, with nonidentical twins running in families. Only the mother influences the chances of having fraternal twins because this type of pregnancy requires the simultaneous release of more than 1 ovum.

Identical twins are formed when 1 fertilized egg forms 1 zygote and then divides into 2 separate embryos. Because there is only 1 zygote, this type is referred to as monozygotic. There may be 1 or 2 amniotic sacs, chorions or placentas, depending on how early or late the fertilized egg divided. When identical twins share the same amnion, they are called monoamniotic twins. If

they do not share the same amnion, they are diamniotic. This depends on the stage of zygote division. Identical twins also can share the same placenta (monochorionic) or not share a placenta (dichorionic). All monoamniotic twins are monochorionic. Monochorionic and monoamniotic twins always are identical.²⁰

Monozygotic twins can have all 3 combinations of placental and amniotic membranes: dichorionic/diamniotic (called di/di), monochorionic/diamniotic (mo/di) or monochorionic/monoamniotic (mo/mo), depending on when twinning occurred.¹⁰ Late twinning increases the number of structures that will be shared by the twins. Twins that occur before 4 days after fertilization will be di/di. Those that form between 4 and 8 days postfertilization are usually mo/di. When twinning occurs between 8 and 12 days, the outcome is generally mo/mo. Twinning after 12 days normally results in conjoined twins. Conjoined twins are connected anatomically. This connection can occur at the abdomen, head, pelvis or thorax, as well as other anatomical structures.⁷

The sharing of the amnion, placenta or both can result in pregnancy complications. The umbilical cords can become entangled so that 1 or both twins might not receive adequate nutrients and oxygen. About 50% of mo/mo twins die from umbilical cord entanglement.²⁰ When twins share 1 placenta, they also share the same blood supply. In some cases, more blood is passed to 1 twin than to the other, causing a condition known as twin-twin transfusion syndrome.

When performing a sonogram of a known twin pregnancy or when a twin pregnancy is discovered on an early obstetrical sonogram, it is extremely important that sonographers perform an even more meticulous



Figure 7. Sonogram of a twin gestation. Note the 2 gestational sacs and the twin-peak sign. Image from the author's teaching files.

and thorough exam than might be performed otherwise. It has been suggested that an evaluation of the chorionic and amniotic status can help establish the risk of fetal and maternal morbidity and mortality.²¹ Sonography of twin gestations should include but is not limited to the following steps:

- Count the number of gestational sacs and fetal heartbeats.
- Identify 1 or 2 separate amniotic sacs within the chorionic cavity (particularly when a mono chorionic twin pregnancy is suspected).
- Determine sex(es).
- Determine the number of placentas.
- Search for the so-called "chorionic peak."
- Evaluate for presence of the intertwin membrane and determine its thickness.

Sonographic evaluation of the first 2 criteria is performed specifically in gestations up to 10 weeks. Identification of 1 gestational sac indicates a mono chorionic twin gestation; evidence of 2 sacs usually indicates dichorionic/diamniotic twins (see Figure 7). When there is evidence of 2 gestational sacs but only 1 live fetus (as identified by heartbeat), there is increased risk for vanishing twin. The diagnosis of a twin pregnancy can be confirmed only by the presence of 2 heartbeats. There also should be a determination as to whether or not 2 amniotic sacs are present within the chorionic cavity. Both twins developing within 1 amnion is proof of a monoamniotic gestation.²¹

When the sex of twins is determined to be opposite,

there is assurance that they are dizygotic, thus also diamniotic and dichorionic. In addition, determining the number of placentas present can help with identifying the zygosity, chorionicity and amniocity. A single placenta can occur in either a mono chorionic twin pregnancy or when 2 dichorionic twin placentas fuse.²¹ When a single placenta is identified on ultrasound examination, sonographers search for the twin peak sign or "chorionic peak." The twin peak sign is demonstrated by the presence of a triangular-appearing piece of tissue in cross-section. The tissue has a similar echogenic appearance to the placenta and extends into and tapers to a point within the intertwin membrane.²¹ The twin peak sign only occurs in dichorionic twin pregnancies.

Failure to identify a separating membrane is problematic in that it can be indicative of monoamniotic/mono chorionic twinning. It also can be indicative of the presence of a condition called "stuck twin." Stuck twin is a part of twin-twin transfusion syndrome (TTTS). This syndrome occurs in monoamniotic/mono chorionic or mono chorionic/diamniotic twins. Union of vascular structures (arteriovenous communication) within the placenta results in the transfusion of blood from a donor twin to a recipient twin. The sac containing the donor twin becomes oligohydramnic, or deficient in amniotic fluid, while the recipient donor sac becomes polyhydramnic (ie, it contains excessive amniotic fluid).²² When severe oligohydramnios is present, the donor twin might appear sonographically to be stuck to the wall of the uterus.^{21,22}

The presence of TTTS does not bode well for either twin. Without medical intervention, perinatal mortality exceeds 90% for the donor twin and 85% for the recipient twin.²¹ Meticulous sonographic evaluation of twins is essential to facilitating early medical intervention.

Umbilical Cord Abnormalities

Abnormalities involving the umbilical cord include:

- Abnormal insertion.
- Vasa previa.
- Abnormal composition.
- Cysts, hematomas and masses.
- Umbilical cord thrombosis.
- Coiling, collapse, knotting and prolapse.^{6,7}

Umbilical cord evaluation with sonography includes the appearance, composition, location and size of the cord. A normal cord has a single vein and 2 arteries that have a twisted, rope-like appearance (see Figure 8). Absence of twisting often is associated with a decrease in fetal movement and a poor pregnancy prognosis.⁷

Abnormal Insertion

The fetal umbilical cord normally attaches near the center of the placenta. Abnormal attachment of the cord is divided into 2 types: battledore and velamentous. The battledore cord attachment is an umbilical cord insertion along the margin or border of the placenta.²³ Battledore cord insertion is not normally clinically significant unless avulsion (tearing) of the cord occurs during labor or delivery. A velamentous cord insertion is of more concern than the battledore. A velamentous placental cord insertion refers to a cord that is inserted into the membranes prior to connecting to the placenta.^{7,10} The estimated occurrence of velamentous cord insertion is 1% in single gestations and 15% in monochorionic twins. The condition also is common in triplet gestations.²⁴

In a small number of velamentous cord insertion cases, significant fetal hemorrhage is possible. There is also an increased risk for cord thrombosis and cord rupture during labor and delivery. The possibility of hemorrhage increases if the cord is positioned over the internal os of the cervix.²⁴ This condition is known as vasa previa.

Vasa Previa

Vasa previa is a life-threatening condition that often is undiagnosed until the amniotic membrane ruptures.^{10,24,25} Vasa previa occurs when the umbilical cord lies over the internal cervical os and the cord is thus trapped between the fetus and the os. Vasa previa can be detected via transvaginal sonography with color Doppler as early as 16 weeks of gestation.²⁵ Early diagnosis can be life-saving because medical intervention can prevent massive hemorrhage due to vessel rupture during labor and delivery. When vasa previa is diagnosed prior to labor, a cesarean delivery can increase the likelihood of fetal survival.

Abnormal Composition

Abnormal cord composition is another problematic disorder in pregnancy. The most common disorder of

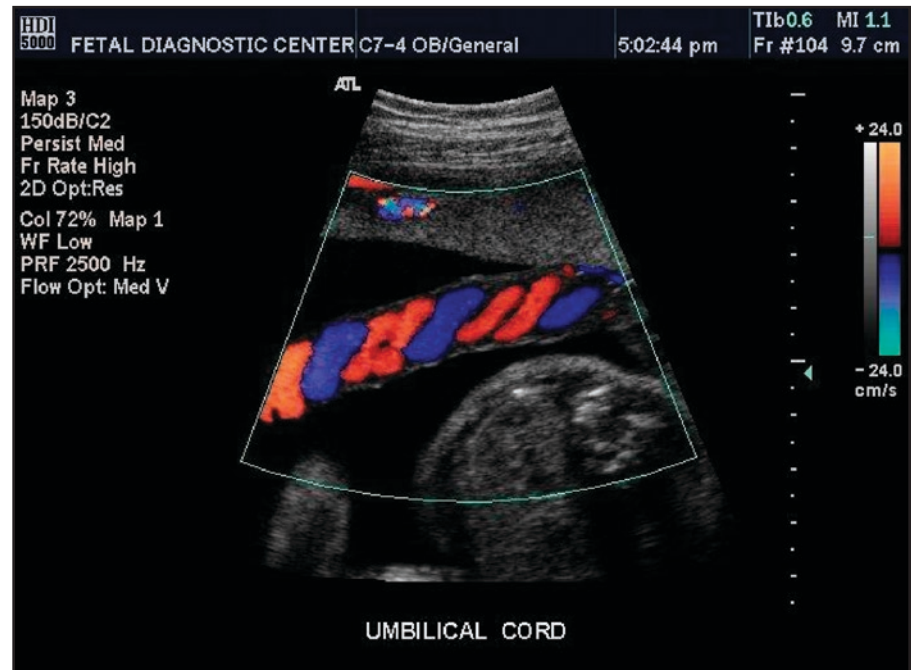


Figure 8. Sonogram with color Doppler of a normal 3-vessel umbilical cord showing its rope-like appearance. Image courtesy of Virlene Guzman, RDMS.

the umbilical cord is the presence of 1 artery vs the 2 arteries normally present in the umbilical cord. This disorder carries with it the chance of more anomalies than occur with normal, 2-artery cords.²⁴ Abnormalities associated with abnormal cord composition are usually cardiac or genitourinary in nature.^{10,21}

Single umbilical artery occurs in less than 1% of cords in single gestations and 5% of cords in multiple gestations. Single umbilical arteries are found more often in fetal demise than in live births, and they occur twice as often in white women as in African American and Japanese women. Diabetes increases the risk significantly.^{21,24} Careful sonographic examination of the cord with color Doppler can lead to prenatal diagnosis of this abnormality. When this condition is discovered sonographically, care should be taken to examine the fetus thoroughly for cardiac and genitourinary abnormalities.

Cysts, Hematomas and Masses

Umbilical cord cysts can be categorized as either true or false and can occur at any location along the cord. These cysts are found in 0.4% of all pregnancies.²⁴ True cysts occur from remnants of the allantois or umbilical vesicle and are usually rather small. They are normally

irregular in shape and located between the vessels of the cord. True cysts are lined with epithelium, occur at the fetal end of the cord and usually resolve during the first trimester. They are associated with conditions such as hydronephrosis, patent urachus, omphalocele and Meckel diverticulum.

False cysts can be as large as 6 cm and contain liquified Wharton jelly. False cysts are not lined with epithelium and most commonly are found at the fetal end of the cord. Pseudocysts are associated with chromosomal anomalies such as omphalocele and patent urachus.²⁶ Among all types of umbilical cord cysts, 20% are associated with structural or chromosomal anomalies.^{24,26}

The abdominal wall near the cord insertion is the most likely location for cysts. They can be visualized most easily using color Doppler during the first trimester, when the umbilical vessels are still small. When large cysts are present, cesarean delivery normally is performed as soon as fetal lung maturity has been documented. This can help prevent harm to the fetus from cyst rupture during labor.²⁶

Umbilical cord hematomas rarely are seen in infants born alive.^{10,21,24} Umbilical cord hematoma is caused by the extravasation of blood into Wharton jelly and can occur after the rupture of a varix. A varix is the dilatation of the intra-abdominal part of the umbilical vein.²¹ Effusion of blood into the cord occurs subsequent to varix rupture. Invasive prenatal procedures such as amniocentesis can cause hematomas, but they also can occur spontaneously and in association with cord cysts. Cord cysts might appear on sonograms as masses, but color Doppler can be used to demonstrate vascular resistance, leading to the diagnosis of cord hematoma vs a true cord mass.^{21,24} Fetal distress has been associated with umbilical cord hematoma.

Hemangiomas and teratomas are the other 2 most common cord masses, although they do not occur with significant frequency. Hemangiomas of the umbilical cord are hyperechoic complex masses located primarily at the maternal end of the cord. These tumors also are referred to as angiomyxomas and are made up of endothelial cells from the vessels of the umbilical cord.²¹ They can grow up to 15 cm in diameter and contain nodules of endothelial cells surrounded by edematous tissue and degenerated Wharton jelly.²⁴ Umbilical cord hemangiomas are associated with polyhydramnios and fetal hydrops. Alpha fetoprotein (AFP) levels also tend to be elevated with the presence of these masses. Cord hemangiomas can appear as solid fusiform structures on sonograms, but this appearance does not guarantee

that the mass is a hemangioma because umbilical cord teratomas can have the same appearance or be mostly cystic in nature.

Umbilical cord teratomas are germ cell tumors that can be located at any place along the length of the umbilical cord. Teratomas contain structures from all 3 germ cell layers and are totally disorganized. Neither umbilical cord hemangiomas nor teratomas can be specifically diagnosed prenatally.^{10,21,24} Sonographic monitoring for interval growth, fetal hydrops and fetal well-being throughout pregnancy should be considered when a cord tumor is suspected or identified. This sonographic monitoring also should include monitoring for vascular compression by an enlarging tumor; however, this is not specifically indicative of the presence of hemangioma or teratoma.

Umbilical Cord Thrombosis

Thrombosis of the umbilical cord vessels is rare, and most thrombi that occur within the cord are venous in nature. Thrombosis within the vein of an otherwise normal umbilical cord often is associated with fetal demise, but the condition is not always fatal.²¹ Some umbilical cord thrombi seem to be associated with cord varix, although cord thrombi also are associated with maternal disease. For example, an association has been documented between antiphospholipid syndrome in the mother and umbilical cord thrombosis.²⁷ Antiphospholipid syndrome is associated with lupus.

Thrombosis of an umbilical artery can be the result of an extension of a thrombus in the aorta. On ultrasound, the thrombus normally appears echogenic and might contain calcifications. Umbilical cord artery thrombosis is not always fatal, especially in fetuses with the normal 3-vessel cord, but it is almost always fatal in those with 2 vessels.^{24,28}

Other Umbilical Cord Disorders

Umbilical cord coiling, collapse, knotting and prolapse are other disorders that can occur during gestation. There are 2 classes of abnormal umbilical cord coiling: hypercoiling and noncoiling. Both of these abnormalities occur with greater frequency in women with gestational diabetes and preeclampsia, although their occurrence also is associated with thrombosis of the vessels of the chorionic plate, thrombosis of the umbilical vein and umbilical cord stenosis.^{24,28} Noncoiled cords generally are less able to withstand external compression forces and are associated with:

- Intrauterine demise.

- Preterm delivery.
- Repetitive intrapartum fetal heart rate deceleration.
- Cesarean delivery due to fetal distress.
- Meconium staining.
- Aneuploidy.
- IUGR.²⁸

Both hypercoiling and noncoiling can be depicted sonographically. The use of color Doppler facilitates identification of the cord and its vessels.

Prolapse of the umbilical cord is a birth complication that occurs in approximately 1 out of every 300 births. The condition occurs when the umbilical cord slips through the cervical os into the vagina after the membranes have ruptured. When this happens the fetus can put pressure on the cord during delivery, essentially shutting off the fetal blood supply and causing hypoxia. This condition can be fatal unless the fetus is delivered promptly.^{24,29}

A condition referred to as occult prolapse occurs when the cord lies alongside the presenting part. Causes of umbilical cord prolapse include abnormal fetal presentation in which the fetus does not fill the lower uterine segment, a long umbilical cord, prematurity and multiparity.²⁴ Transabdominal or transvaginal sonography with color Doppler can assist in visualization of the cord and its positional relationship to the presenting fetal anatomy and internal cervical os.

Knots in the umbilical cord can be classified into 2 types: true and false. True umbilical cord knots can occur in single gestations or in 1 or 2 cords in a twin gestation.²¹ True knots occur in approximately 1% of pregnancies, with the highest rate occurring in monoamniotic twins. False knots are more common.²⁴ False knots are simply kinks in the umbilical cord and are not associated with pregnancy complications.

True knots occur as the result of fetal movement. These knots are thought to develop during early pregnancy when there is more amniotic fluid and the fetus is small enough to perform quite acrobatic maneuvers. True knots also are associated with advanced maternal age, multiparity and lengthy umbilical cords.

There is a 4-fold increase in fetal demise when a true knot is present. This is probably caused by compression of the cord vessels when the knot tightens. Umbilical cord knots can be readily identified sonographically (see Figure 9). When a true umbilical cord knot is identified, cesarean delivery often is performed.

Conclusion

The placenta and umbilical cord are vital to the

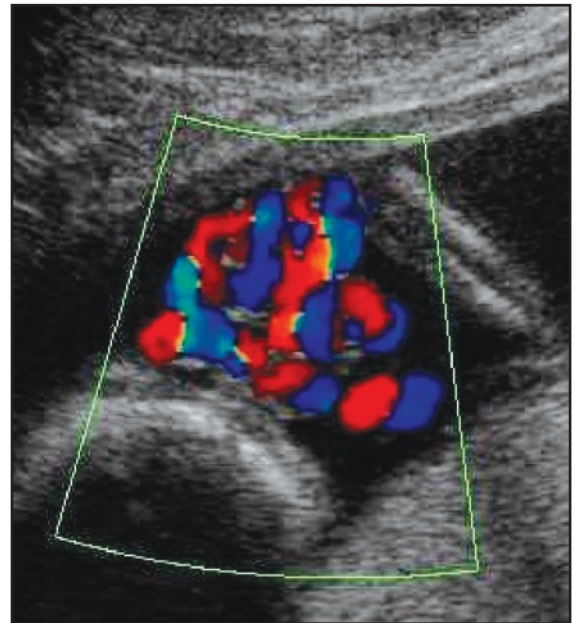


Figure 9. Sonogram of an umbilical cord knot. Image courtesy of Virlene Guzman, RDMS.

health of the fetus and mother and to a positive pregnancy outcome. There are many abnormalities associated with the placenta and umbilical cord. Some of these do not cause significant complications for the fetus or the mother, but others pose grave risks. Knowledge of the development and functions of the placenta and cord and of the abnormalities associated with both is essential for sonographers.

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