

Sonographic Evaluation of the Yolk Sac

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This pictorial essay aims to inform related clinicians by summarizing the normal and abnormal sonographic findings of the yolk sac in the first trimester of pregnancy. An abnormality in the sonographic appearance of a yolk sac can predict subsequent embryonic death or abnormalities. Therefore, the accurate recognition of normal and abnormal sonographic findings concerning the yolk sac can be used to anticipate the course of pregnancy.

Key Words—pregnancy; sonography; yolk sac

The secondary yolk sac is the first extraembryonic structure that becomes sonographically visible within the gestational sac. During embryonic development, the yolk sac is the primary route of exchange between the embryo and the mother. The yolk sac also provides nutritional, immunologic, metabolic, endocrine, and hematopoietic functions until the placental circulation is established.¹ Therefore, the yolk sac is crucial in early embryonic life.

The yolk sac is one of the most important conceptional structures evaluated sonographically in the first trimester. At present, the most important benefit of sonographic evaluation of the yolk sac is confirmation of an intrauterine pregnancy.^{1,2} It has been hypothesized that sonographic features related to the shape, size, and internal structure of the yolk sac can be associated with the gestational outcome.^{1,3}

This pictorial essay aims to inform related clinicians by summarizing the normal and abnormal sonographic findings of the yolk sac during the first trimester of pregnancy.

Imaging Protocols

For this pictorial essay, we reviewed the cases of women who were referred to the radiology clinic for first-trimester sonography. These women were examined in their 5th to 13th weeks of pregnancy. All sonographic examinations were reviewed by two radiologists experienced in obstetric sonography. Sonographic examinations were performed with LOGIQ9 sonographic equipment and a 5- to 8-MHz multifrequency transvaginal probe (GE Healthcare, Milwaukee, WI). The gestational week was determined according to the crown-rump length or gestational sac measurements.

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Structure of the Yolk Sac

At the fourth week of embryologic development, the wall of the yolk sac consists of 3 thin cellular layers (Figure 1). The outermost layer is the ectoderm, which faces the exocoelomic cavity. The ectodermal layer is in fact a distinct layer of flattened cells. However, the innermost layer facing the yolk sac cavity is the endodermal epithelium, which is composed of a single layer of cuboidal epithelial cells. Located between these two layers is the mesodermal layer, which is a very narrow tissue. This mesodermal layer consists of blood island formations in which hematopoietic stem cells can be identified throughout a primitive capillary network. At this embryonic age, hematopoietic cells are also seen for the first time inside the embryonic body. These densely packed hematopoietic cells adhere to the endothelium of embryonic vessels that are surrounded by endothelial cells. Initially, the clusters of hematopoietic cells are located at the cephalic pole of the embryo, near the developing heart. By the end of the fourth gestational week, primitive blood cells are widely scattered in embryonic blood vessels located in the primordium of the heart, mesonephros, and other embryonic organs.^{4,5}

From the fifth gestational week onward, two compartments are clearly distinguished in the wall of the yolk sac. The mesodermal compartment is formed by blood vessels and mesenchymal tissue, whereas the endodermal compartment is made up of the endodermal epithelium and endodermal vesicles or tubules. Both intraembryonic and extraembryonic blood vessels consist of primitive nu-

cleated erythroblasts and basophilic erythroblasts. In addition, the extracellular matrix component surrounding the vessels within the yolk sac wall becomes markedly reduced. After the seventh week of embryologic development, the signs of regression begin on the wall of the yolk sac.^{5,6}

Normal Yolk Sac

A yolk sac can be detected easily by transvaginal sonography when the mean gestational sac diameter is 5 to 6 mm. It is generally accepted that the yolk sac should be observed when a gestational sac measures greater than 8 mm (Figure 2).⁷ The yolk sac is connected to the embryo by the vitelline duct (Figure 3). Normally, the yolk sac appears as a circular structure with an anechoic center surrounded by a uniform well-defined echogenic wall (Figure 4).⁸ Usually the inner diameter of a yolk sac measures 3 to 5 mm. In fact, the yolk sac size progressively increases from the beginning of the 5th gestational week to the end of the 10th gestational week. Afterward, the yolk sac size decreases gradually.⁹

The number of yolk sacs present in a gestational sac can aid in determining the amnionicity of the pregnancy. As a general rule, the number of yolk sacs and the number of amniotic sacs match if the embryos are alive. Thus, there will be 2 embryos, 1 chorionic sac, 1 amniotic sac, and 1 yolk sac in a monochorionic monoamniotic pregnancy.⁷

Figure 1. Diagram shows stages of the yolk sac and embryonic development.

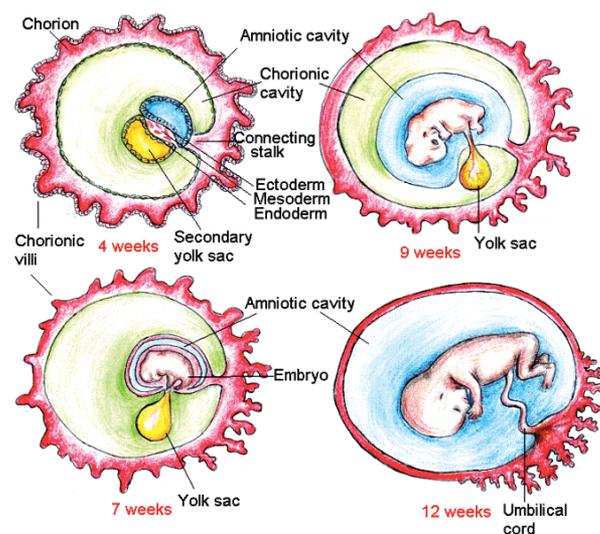


Figure 2. Gestational yolk sac. Transvaginal sonography at 5 weeks shows a yolk sac (arrow) clearly within the gestational sac. No embryo is shown.



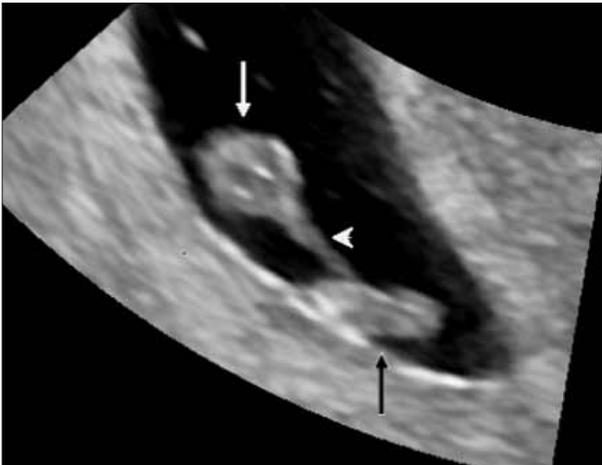
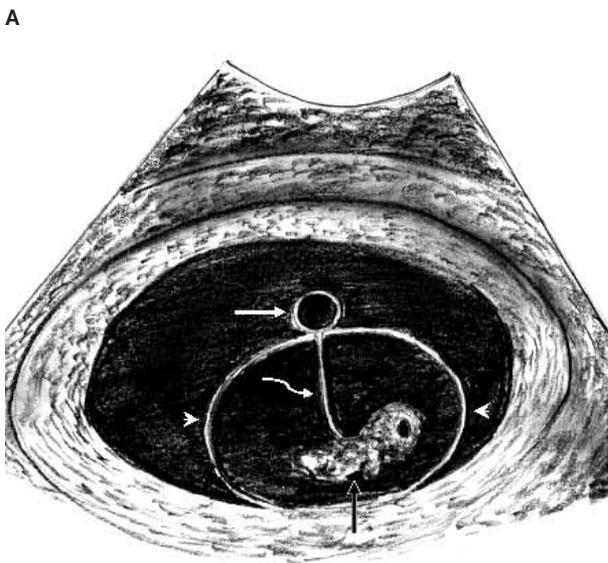


Figure 3. Vitelline duct. Transvaginal sonography at 6 weeks 5 days shows a live embryo (black arrow), vitelline duct (arrowhead), and yolk sac (white arrow).

Actually, it is common to detect a dead embryo due to the absence of a yolk sac. In parallel, it is uncommon to observe a yolk sac and an empty amniotic sac without an embryo. The sequela of embryonic death is probably reabsorption of the very early embryo, the amnion, and the yolk sac. However, these statements are largely anecdotal because, to our knowledge, there are no published studies that report the exact order of the reabsorption process.⁷

Figure 4. Normal yolk sac. **A.** Diagram shows a normal yolk sac (white arrow) within the gestational sac. The embryo (black arrow), amniotic membrane (arrowheads), amniotic cavity, chorionic cavity, and vitelline duct (curved arrow) are also shown. **B.** Transvaginal sonography shows a living embryo (black arrow) at 9 weeks 0 days and a yolk sac with a uniformly thick and echogenic wall (white arrow). The calipers are placed at the inner edges of the yolk sac wall. The amniotic membrane (arrowheads) is also shown.



In a case series by Levi et al,¹⁰ 4 monochorionic monoamniotic pregnancies with a single yolk sac were evaluated. One of these pregnancies was a conjoined twin, whereas another pregnancy included an ectopic twin. Both of these pregnancies were terminated. The remaining 2 pregnancies delivered normally at the 34th week of gestation. Of the 4 cases, 2 had a larger-than-normal yolk sac (>5.6 mm), whereas the yolk sac was normal in the other pregnancies. Embryonic cardiac activity was noted in all of the investigated pregnancies.¹⁰

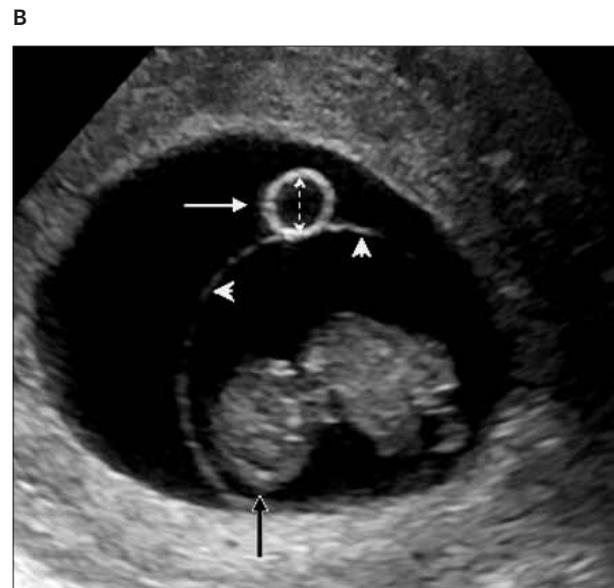
Abnormal Yolk Sac

Absence of the Yolk Sac

The yolk sac performs important functions for embryonic development during organogenesis. On transvaginal sonography, absence of the yolk sac in the presence of an embryo is always abnormal and in general is associated with subsequent embryonic death (Figure 5).^{1,7,11}

Large Yolk Sac

Although there is no clearly identified consensus, most authors accept either 5 or 6 mm as the upper limit for the size of a normal yolk sac in pregnancies with a gestational age from the 5th to the 10th weeks.¹ A recent study has shown that a yolk sac diameter of greater than 5 mm is associated with an increased risk of spontaneous abortion.¹² How-



ever, a few authors have mentioned the existence of a very large yolk sac (eg, 8.1 mm) in a normal live pregnancy.¹³ Generally, it has been suggested that an abnormally large yolk sac may indicate a poor obstetric outcome; therefore, close follow-up with sonography is recommended for these pregnancies (Figure 6).

Small Yolk Sac

The literature presents scant knowledge about the clinical importance of small yolk sacs. It has been claimed that a very small yolk sac may be a normal finding during early periods of normal embryologic development. On the other hand, a much earlier published study, with certain limitations, suggests that a yolk sac diameter of 2 mm or less may be associated with an adverse outcome in pregnancies with a gestational age of 8 to 12 weeks (Figure 7).¹⁴

It is well known that the yolk sac size begins to decrease during the late weeks of the first trimester.^{1,12} This process is why gestational age should be taken into account when the size of the yolk sac is assessed. However, it would be prudent to perform serial sonographic examinations within a short period whenever a smaller-than-expected yolk sac has been visualized.

Calcified Yolk Sac

A calcified yolk sac may appear as an echogenic ring on sonography. It has not been reported to be associated with a live embryo before the 12th week of gestation.⁷ Indeed,

a calcified yolk sac would be observed only with a dead embryo because the yolk sac would undergo calcification within a few days after embryonic death has occurred (Figures 8 and 9).¹⁵

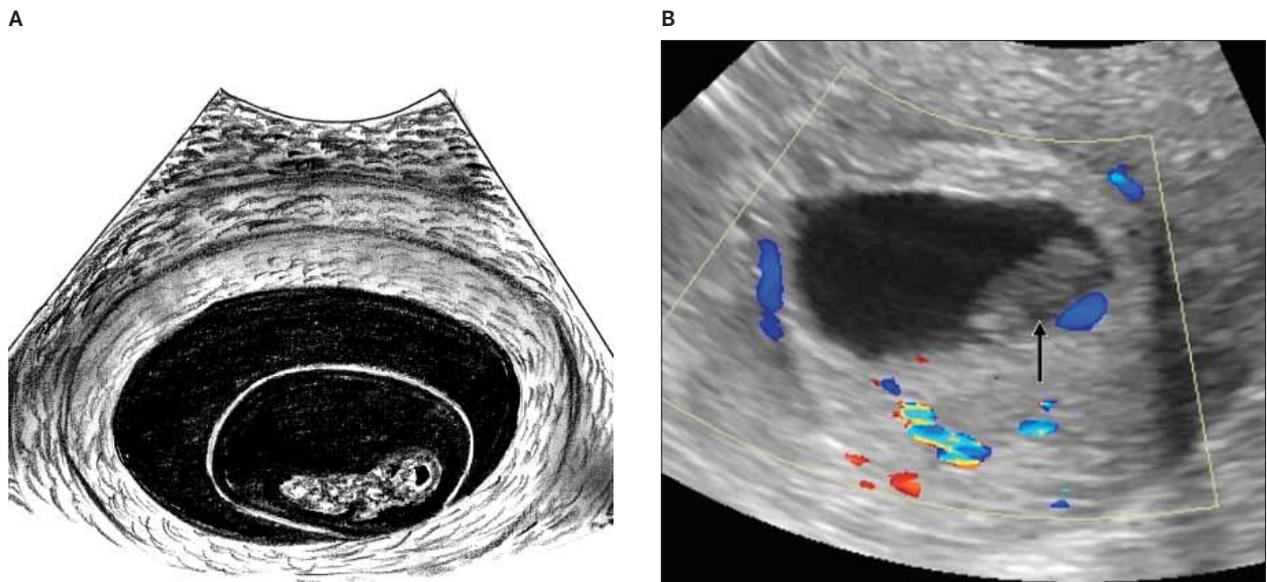
Echogenic Yolk Sac

An echogenic (rather than anechoic) yolk sac is different from a calcified yolk sac in that echogenicity may represent various types of materials other than calcium (Figure 10). However, tissue harmonic imaging may be more useful for confirmation of this finding. To our knowledge, only 1 study reported that an echogenic yolk sac can be associated with fetal death or abnormalities.¹⁶ As for our experience, however, an echogenic yolk sac is not associated with anomalies or a poor pregnancy outcome. In the related literature, it has also been anecdotally emphasized that an echogenic yolk sac does not predict an embryonic anomaly or death.⁷ In fact, large-scale prospective studies are anticipated to clarify the prognostic importance of echogenic yolk sacs.

Irregular Yolk Sac Shape

Yolk sacs with mainly wrinkled margins, indented walls, or both are usually identified as having an irregular shape (Figures 11 and 12).³ The clinical importance of an abnormal yolk sac shape is controversial and thus still under debate. There are a number of clinical studies that have declared that the persistence of an irregular yolk sac shape

Figure 5. Absence of a yolk sac. **A.** Diagram shows absence of a yolk sac within the gestational sac. **B.** Transvaginal sonography at 6 weeks 6 days shows embryonic death (arrow) with absence of a yolk sac in the extraembryonic area.



may be used to indicate an adverse gestational outcome.^{1,17} Just the same, a newly published study suggests that an irregular yolk sac shape is unrelated to an increased risk of spontaneous abortion.³

Persistent Yolk Sac

When the 10th or 11th week of gestation is completed, the yolk sac begins to shrink rapidly and eventually disappears.^{12,17} However, sometimes the yolk sac can persist between the amnion and the chorion even after 12 weeks' gestation (Figure 13). The persistent yolk sac usually stands close to the site where the umbilical cord enters the placenta. The clinical importance of a persistent yolk sac is unknown.

Conclusions

Assessment of the yolk sac should be part of a complete first-trimester sonographic examination. An abnormality in the sonographic appearance of a yolk sac can predict subsequent embryonic death or abnormalities. Therefore, accurate recognition of the normal and abnormal sonographic findings related to the yolk sac can be used to anticipate the course of pregnancy.

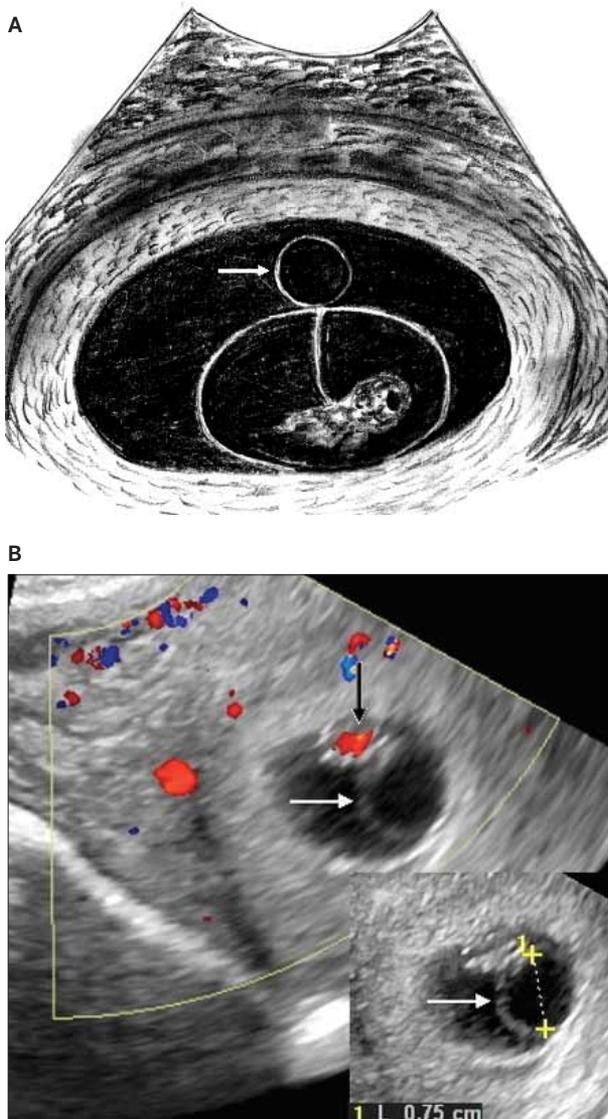


Figure 6. Large yolk sac. **A.** Diagram shows a large yolk sac (arrow) within the gestational sac. **B.** Transvaginal sonography at 7 weeks 1 day shows an embryo with cardiac activity (black arrow) and a large yolk sac (white arrows) with a mean diameter of 7.5 mm. **C.** On a follow-up examination 7 days later, no cardiac activity was identified, indicating embryonic death (black arrow), and the yolk sac (white arrow) had become larger (9.5 mm).

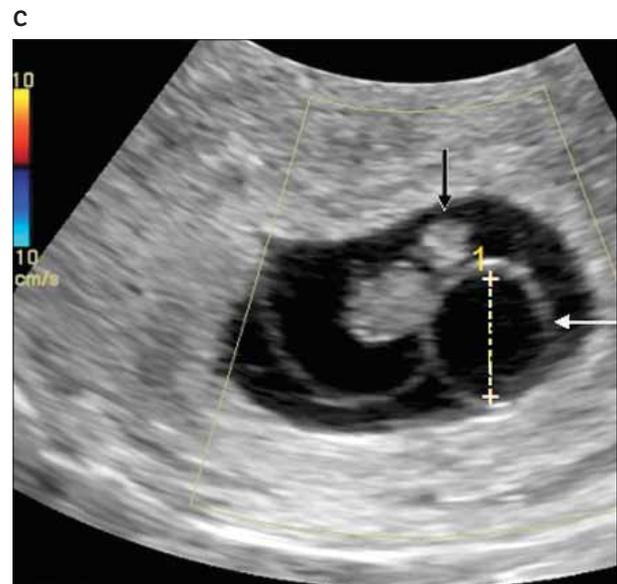


Figure 7. Small yolk sac. **A.** Diagram shows a small yolk sac (arrow) within the gestational sac. **B.** Transvaginal sonography at 7 weeks shows embryonic death (black arrow) and a small yolk sac (white arrow) with mean diameter of 1.9 mm.

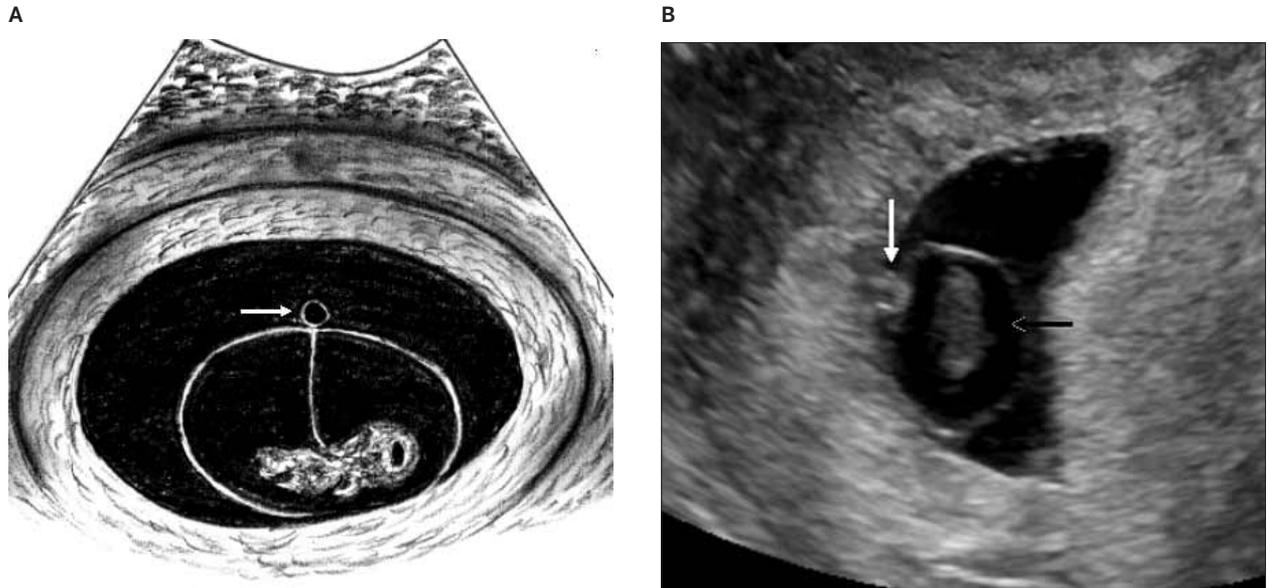


Figure 8. Calcified yolk sac. **A.** Diagram shows a calcified yolk sac (arrow) within the gestational sac. **B.** Transvaginal sonography at 6 weeks 5 days shows embryonic death (black arrow) and a calcified yolk sac (white arrow).

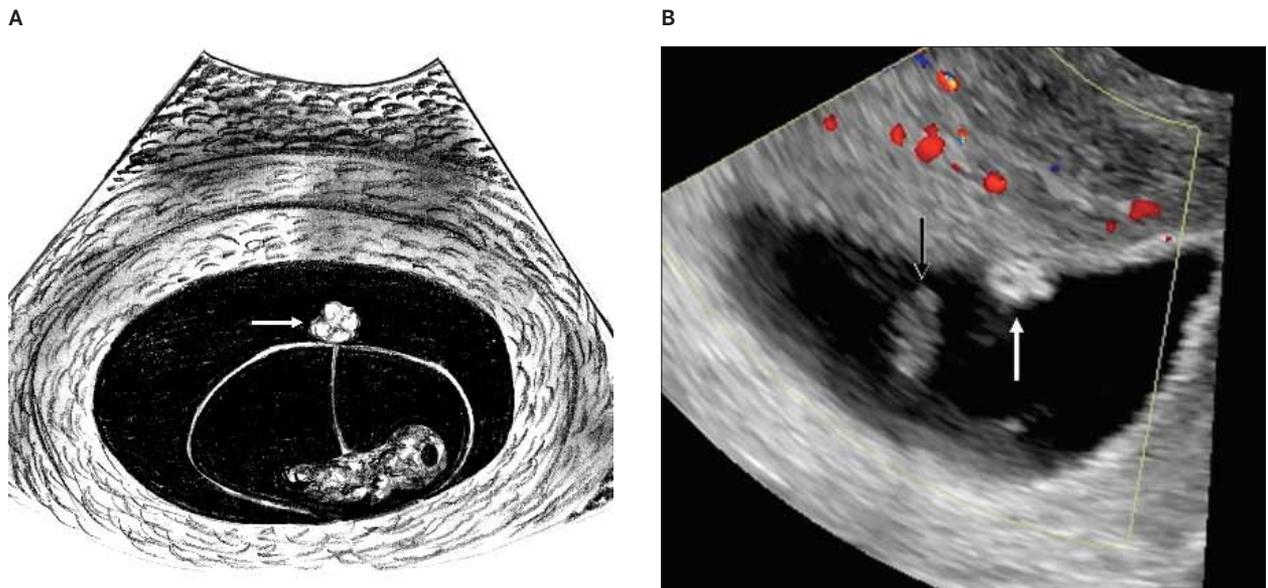


Figure 9. Calcified yolk sac. Transvaginal sonography at 8 weeks 2 days shows an embryo without cardiac activity (black arrow). The yolk sac is calcified (white arrow).



Figure 10. Echogenic yolk sac. **A,** Diagram shows an echogenic yolk sac (arrow) within the gestational sac. **B,** Transvaginal sonography at 6 weeks 6 days shows a live embryo (black arrow) and an echogenic yolk sac (white arrow).

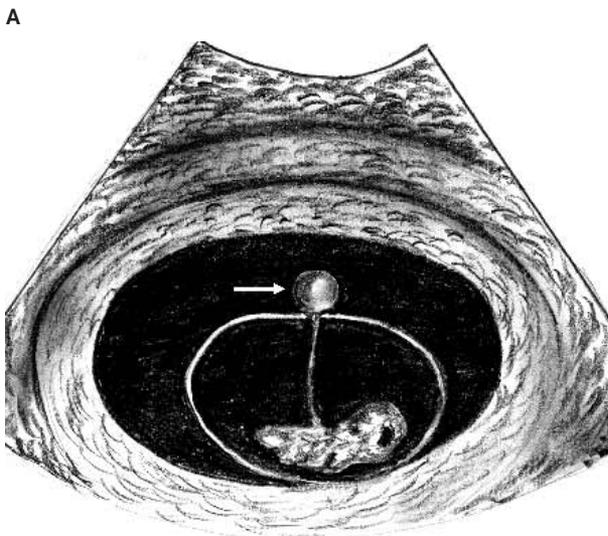


Figure 11. Irregular yolk sac. **A**, Diagram shows an irregular yolk sac (arrow) within the gestational sac. **B**, Transvaginal sonography of a live embryo at 6 weeks 6 days shows a yolk sac with an irregular shape (arrow).

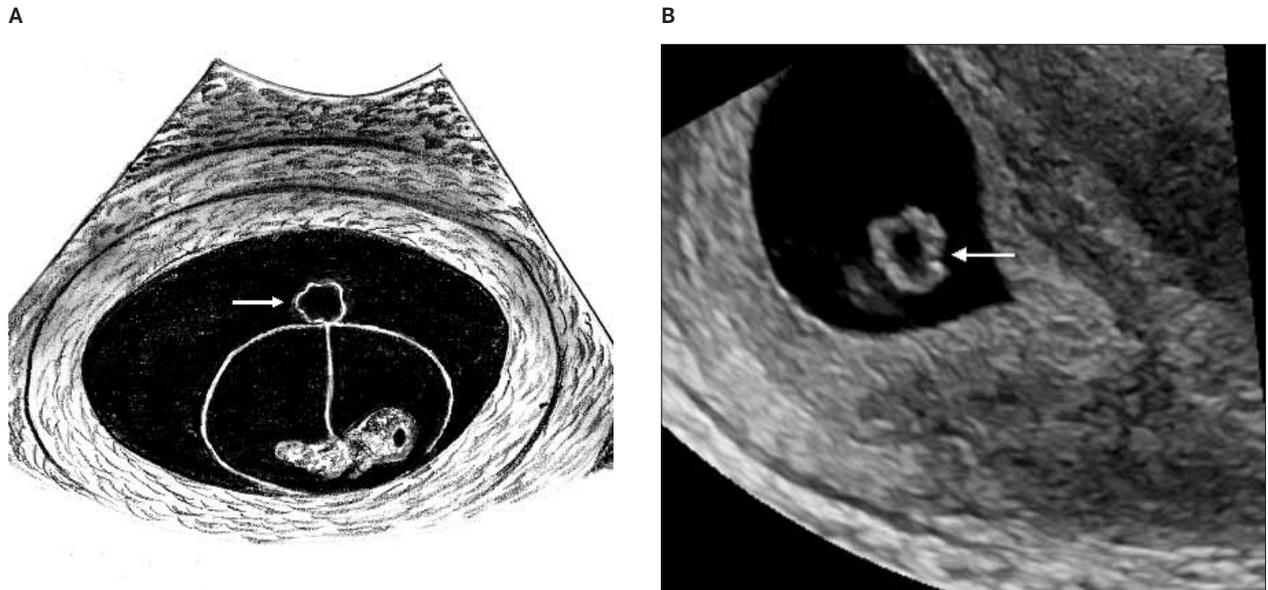


Figure 12. Irregular yolk sac. Transvaginal sonography at 7 weeks 1 day shows a live embryo (black arrow) and an irregular yolk sac (white arrow). The vitelline duct (arrowhead) is also shown.

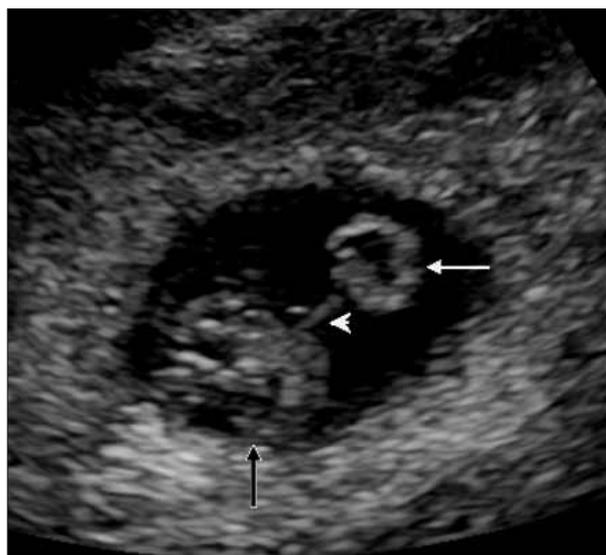
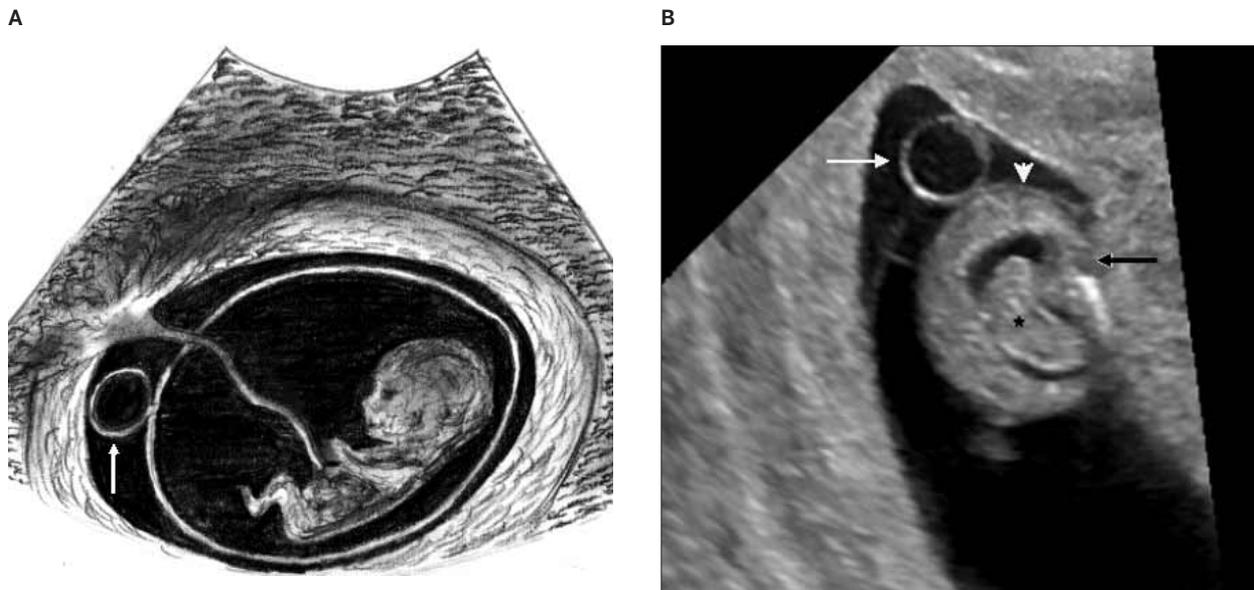


Figure 13. Persistent yolk sac. **A**, Diagram shows a persistent yolk sac (arrow) within the gestational sac. **B**, Transvaginal sonography at 12 weeks 3 days shows a live fetus with a persistent yolk sac (white arrow). The fetal head (black arrow), choroid plexus (star), and amniotic membrane (arrow-head) are indicated.



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