Introduction

The primary target of an effective and efficient prenatal care system is to differentiate low from high risk pregnancies. A low risk pregnancy reflects a physiological course of gestational events, which requires distant monitoring for any abnormalities that would detect an abnormality that allows for reclassification of the gestation. Conversely, a high risk pregnancy requires a closer follow-up performed in specialized prenatal care facilities, thus reducing the probability of perinatal morbidity and mortality [1–3].

Two of the primary targets of prenatal surveillance is diagnosing abnormalities such as ectopic pregnancies, and detecting early pregnancy loss.

Abbreviations

Abbreviation | Description
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β-hCG | β subunit of human chorionic gonadotrophin
CRL | Crown rump length
CDC | Centers for Disease Control and Prevention
i.m. | Intramuscular
i.v. | Intravenous
MSD | Mean sac diameter

Abstract

This review article presents recent evidence on early pregnancy loss and ectopic pregnancy. In the light of recent evidence, the β-hCG discriminatory zone may be extended in clinically stable cases without evidence of bleeding. A possible cut-off is 4300 mIU/ml, which corresponds to when a sonographer should detect an intrauterine pregnancy. Embryonic demise can be confirmed when a transvaginal ultrasound finding shows no heartbeat in an embryo of more than 7 mm CRL, no embryo in a gestational sac having a mean sac diameter of more than 25 mm, or no appearance of an embryo within 7–10 days after the primary examination. These are considered definitive signs of embryonic demise. Suggestive signs of embryonic demise require closer monitoring of the pregnancy.

Zusammenfassung

An important and possibly lethal abnormality is ectopic pregnancy. It is crucial to acquire medical skills and knowledge to differentiate early between an intrauterine and an ectopic pregnancy. The incidence of ectopic pregnancies in cases presented to the gynecology emergency department due to first trimester bleeding and/or pain ranges from 6 to 16%. According to the Centers for Disease Control and Prevention (CDC), the absolute number of hospitalizations due to ectopic pregnancy rose from 17800 cases in 1980 to 88400 in 1989 [4]. Due to the increasing incidence of tubal pathology, secondary to pelvic inflammatory diseases, the overall occurrence of ectopic pregnancy is also increasing [5]. According to the national data collected by the CDC, the overall occurrence of ectopic pregnancies is approximately 20 to 1000 pregnancies [4].

### Significant of Amenorrhea

Amenorrhea is the absence or abnormal cessation of the menses. It is sub-classified into primary and secondary amenorrhea according to the time of occurrence. Primary amenorrhea is defined as the absence of menses by the age of 15 in the presence of secondary sexual characters and normal growth. This is also known as the absence of menarche [13]. Secondary amenorrhea is defined as the absence of menses for more than three cycles or six months in women who previously had menses. The most common cause of secondary amenorrhea is pregnancy, making it a cardinal sign of pregnancy. Lactation, pregnancy, and menopause cause secondary amenorrhea in 96–97% of cases. The remaining 3–4% are due to pathological causes [14,15]. It is therefore important to rule out pregnancy in cases of secondary amenorrhea, even if a patient reports having sexual intercourse during a safe period, under hormonal or barrier contraception. Confirming or ruling out a pregnancy is most reliably done by determining or detecting β-hCG in maternal serum or urine.

### Positive β-hCG in the Urine and/or Serum

β-hCG is secreted by the conceptus in the maternal circulation after implantation. After fertilization, between the 8th and 10th day post ovulation, the conceptus migrates towards the uterine cavity, usually implanting itself by an aggressive burrowing action the day post ovulation, the conceptus migrates towards the uterine cavity, usually implanting itself by an aggressive burrowing action. After fertilization, between the 8th and 10th day post ovulation, the conceptus migrates towards the uterine cavity, usually implanting itself by an aggressive burrowing action the day post ovulation, the conceptus migrates towards the uterine cavity, usually implanting itself by an aggressive burrowing action. After fertilization, between the 8th and 10th day post ovulation, the conceptus migrates towards the uterine cavity, usually implanting itself by an aggressive burrowing action.
β-hCG can be detected as early as six days after presumed conception and peaks between 56 and 68 days, with a nadir at 18 weeks. In a normal, intrauterine pregnancy, during the first 30 days after implantation, the β-hCG measured doubles every 29 to 53 hours. An ectopic or unhealthy pregnancy shows a slower rise or even decline of the level in maternal serum [18–20] and no secondary rise of β-hCG levels can be seen [21]. Based on this, measurement of the β-hCG can indirectly give a hint of the vitality of the pregnancy.

β-hCG can be detected in the serum long before the pregnancy is visible using ultrasound techniques. Many studies were conducted to determine the minimum and maximum levels by which an embryo has to be seen. The serum level of β-hCG above which a gestational sac should be visualized is called the discriminatory zone for β-hCG [22], which is considered to be between 1500 to 2000 mIU/ml [23]. This level is obviously higher (6500 IU/L) using transabdominal ultrasound. In earlier publications thresholds of 1000, 1500, and 2000 mIU/ml were published, which might seem contradictory [23,24].

Due to some confounding variables, β-hCG levels may be elevated above expected, thus crossing the 2000 mIU/ml level without any sonographic evidence of gestation. While measuring β-hCG alone can be an indirect test to assess the vitality of the pregnancy, a combination with sonographic examination can improve the accuracy of this method. The variations in resolution, transducer frequencies, manufacturers of ultrasound scanners and sonographers play a significant role in the detection of small gestational sacs [8,27]. The German guidelines, AWMF, state that a chorionic sac should be detected starting from a β-hCG level of 1500 mIU/ml. A cut-off after which the absence of an intrauterine pregnancy should be suspected is not given [55].

There are conflicting opinions about the upper limit of the discriminatory zone using β-hCG when combining it with transvaginal ultrasound. Recent trials tend to lift the upper limit of the discriminatory zone in order to avoid erroneously destroying healthy pregnancies [27]. Mehta et al. analyzed 676 pregnancies and showed that taking a cut-off of 2000 mIU/ml would miss one third of the intrauterine pregnancies [8]. In another study, Dubilet et al. examined 202 cases, where transvaginal ultrasonography showed no intrauterine evidence of pregnancy with a positive β-hCG test on the same day; 4.5% of the cases showed a β-hCG of above 2000 mIU/mL. In this series, none of the cases were diagnosed with extraterine gestation. The highest value that preceded a live-born term baby was 4336 mIU/mL. In this cohort, 13.8% of cases had an “uncertain” first trimester outcome, 77.2% were vital pregnancies by the end of the first trimester, and 9% had spontaneous first-trimester pregnancy loss; 66.8% of all the gestations were live born. The authors concluded that in cases when sonographic findings are inconclusive, the β-hCG discriminatory level should not be used to determine the management of a hemodynamically stable patient with suspected ectopic pregnancy [27].

**Sonographic Evaluation of an Intrauterine Early Pregnancy**

**Prerequisites for establishing a proper diagnosis**

A technically adequate exam, using high resolution transvaginal ultrasound devices performed by an experienced sonographer, is the basic requirement for a proper diagnosis. As the uterus is inside the bony pelvis, the best visualization is achieved by transvaginal sonography. As the pregnancy continues and the uterus rises outside the pelvis, transabdominal sonography becomes the method of choice [28].

**Physiological sonographic findings in early embryonic development**

Basically, the sonographic structures appear in sequence. The first sonographic sign is the gestational sac, which is usually visible at 4.5 to 5 weeks of gestation. It is characterized by an echolucent sac surrounded by two concentric echogenic rims, also called double sac sign, appearing at 5.5 to 6 weeks [29]. This sac is usually round in shape and the echogenic rim represents the chorionic cavity. The intra decidual sign describes a fluid collection inside an echogenic rim located within a markedly thickened decidua on the lateral aspect of the uterine cavity [30]. Once this gestational sac is detected in an intrauterine location, an intrauterine pregnancy is diagnosed. Except for rare cases of heterotopic pregnancies, a normal course of events is expected [31]. Since the sac grows by approximately 1 mm/d, measuring the sac can be used to date the pregnancy. Therefore, calipers should be placed inside the sac, not including the echogenic rim. Most modern ultrasound devices can calculate the gestational age based on the sac diameter. Measuring the mean sac diameter (MSD) is done by calculating the mean of three orthogonal sac diameters measurements. However, with progressive pregnancy, this procedure is less accurate.

The next structure that appears during the embryonic development is the yolk sac. It can be detected at the start of the 5th gestational week confirming an intrauterine healthy pregnancy. Morphologically, it is described as a round structure with an echoluent center and echogenic periphery [32]. The yolk sac reaches a maximal diameter of 6 mm at the age of 10 weeks [33], then it migrates to the periphery of the sac and disappears [34]. Thereafter, the embryo appears, which has also been designated as the embryonic pole or embryonic disc [35]. With ongoing pregnancy, the CRL can be measured. It is the standard biometric measurement of the embryo in the first trimester, defined as the longest straight line from the cephalic (rump) end of the embryo [36]. It can determine the gestational age with an accuracy of plus/minus three days [37,38]. Within this embryo, the embryonic heartbeat appears between 5.5 and 6 weeks of gestation, after which the risk of an abortion is reduced. However, after the 15th week of pregnancy, the accuracy of the CRL is reduced to within ± 8.4 days [40]. Between the 11 + 0 and 13 + 6 weeks of pregnancy, the nuchal translucency can be measured and correlated with patient and biochemical data to calculate the risk for trisomy 13, 18 and 21 [39].

**Pathological sonographic findings in early embryonic development**

Despite technical advances and sonographer training, human errors and physiological variations can result in over- and underestimation of the gestational age, which may lead to misdiagnosis. Different equations are used to curtail errors, yet cannot eliminate them [41,42]. Extensive research has been conducted to reduce errors and avoid the misdiagnosing an early pregnancy loss. Therefore, signs of fetal demise have been subdivided into definitive and suggestive signs. Definitive signs are indicators of a missed abortion, and the presence of one of the signs is enough for such a diagnosis. Each definitive sign and its reasoning is described below [12] (see Fig. 1):
No embryo in the gestational sac with mean sac diameter of more than 25 mm. The previous cut-off for the gestational sac diameter used for case of an empty sac, using transvaginal ultrasound, was 16 and 20 mm. Setting the cut-off at 16 mm will have a 4.4% false positive rate, i.e. 4.4% will be pregnancies falsely terminated, while setting a cut-off at 20 mm will give a 0.5% false positive rate [12]. One study found an 18.78% interobserver variation when measuring a mean sac diameter of 20 mm with an interobserver variation span from 16.8 to 24.5 mm. Taking this observation into account, the cut-off of the gestational sac diameter could be extended to 25 mm to reduce the false positive rate to 0.5% [12].

No heart beat in an embryo of more than 7 mm CRL in current practice, a pregnancy is labeled as a missed abortion if no appearance of an embryo after 7–10 days follow-up. In contrast to the definitive signs, the suggestive signs of fetal demise have not proven to be as powerful in the prediction of embryonic demise as definitive signs in larger studies. Thus, these signs are taken as warning signs of possible miscarriage and indicate the need for serial sonographic monitoring. The more suggestive signs found in a pregnancy, the worse the prognosis. Below is an explanation of the suggestive signs:

### Embryonic bradycardia
As mentioned before, the embryonic heartbeat should be seen using transvaginal ultrasound by 6 weeks post-menstrualis. Thereby, the embryonic heart rate increases between 5.5 to 10 weeks from 100 to 150–140 beats per minute. Embryonic bradycardia between 6 to 8 weeks of gestation, defined as less than 110 beats per minute, is suggestive of a poor prognosis. Again, a sonographic follow up is recommended within three to four weeks [43].

### First trimester oligohydramnios, small gestational sac
Sonomorphologically, a small sac is relative to the size of the embryo being observed. The quantitative method to estimate a small gestational sac is by subtracting the CRL in mm from the mean sac diameter in mm. If it is less than 5 mm, subsequent demise can be predicted in 94% of cases [44]. Although often having a poor outcome, studies have shown a 35% survival rate, making it only a suggestive sign and not a definitive sign for termination [45].

#### The expanded amnion sign
This sign can be detected sonographically since a relation is observed between the amniotic sac and the embryo. Normally the amnion grows in direct linear proportion to the CRL. Seeing the amniotic cavity indirectly implies the presence of an embryo with a positive heartbeat. An absence of a heartbeat suggests embryonic demise, yet the sign by which the termination of pregnancy is recommended must be the absence of a heartbeat in an embryo with a CRL of more than 7 mm. Other amniotic abnormalities with poor embryonic outcomes are amniotic cavities with a wavy outline and a thick amnion that approaches the yolk sac thickness [46, 47] (Fig. 2).

#### Embryonic growth rate
A growth rate of less than 0.673 mm a day used to be a cut-off for expecting a miscarriage. This observation was reported to have a specificity of 90.1% and a sensitivity of 61.7% for diagnosing miscarriage. Reports suggest using a cut-off ≤ 0.2 mm per day to predict a miscarriage to minimize the false positive diagnosis to zero [48]. In contrast, clinical practice takes into account that a slow or even absent growth rate of the gestational sac is not necessarily associated with miscarriage. The new cut-off value for CRL growth of 0.2 mm a day is always linked with embryonic demise. Yet, it is not recommended to use the growth rate abnormalities of the gestational sac alone as a marker of fetal demise [48].

#### Yolk sac abnormalities
Yolk sac abnormalities affect the size (size more than 6 mm), the number (more than one per embryo), the shape (irregular) or the echogenicity (solid or calcified). In the literature, a yolk stalk sign was described. This sign occurs when an embryo, smaller than 5 mm, is identified without a visible heartbeat yet the embryo is not immediately adjacent to the yolk sac. In healthy pregnancies, the yolk stalk does not exist in the early phases. In contrast, the mentioned sign was observed in pregnancies that ended in fetal demise [49].

#### Presence of blood in the uterine cavity
Blood seen sonographically as echogenic debris or a fluid level in the uterine cavity is also a negative predictor. A chorionic bump is an uncommon finding during pregnancy that may be a hematoma bulging into the gestational sac or a resorbing twin. This
should draw the attention of obstetricians to closely follow up the pregnancy [50]. It was also reported that subchorionic bleeding may correlate with embryonic demise. However, this is not clear cut [51] (Fig. 3).

**Low implantation site of the embryo or gestational sac**
A low implantation position may indicate an abortion in progress. This is detected sonographically by caudal movement of the sac and clinically by vaginal bleeding and dilatation of the cervix. In addition, it may also indicate cervical ectopic pregnancy, which is associated with a negative maternal and embryonic outcome, a nabothian cyst, or a normal sac with a uterine contraction [52].

**Heterotopic pregnancy**
Finally, a pregnancy being intact and intrauterine does not exclude a concurrent extrauterine pregnancy. This is termed as an heterotopic pregnancy. The incidence of heterotopic pregnancy ranges between 1/3889 to 1/30 000 in the general population, heterotopic pregnancy. The incidence of heterotopic pregnancy during a 28 year period and the role of pelvic inflammatory disease. Sex Transm Infect 2000; 76: 28–32

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**Conclusion**
Based on the retrospective studies reviewed, the diagnosis of early pregnancy loss and ectopic pregnancy could be made more accurate with a reduction in unnecessary terminations of physiological gestations. The new extensions of β-HCG, definitive and suggestive signs could therefore reassure the physician in offering a more confident diagnosis for the patient.

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**Conflict of Interest**
None.

**References**
8. Mehta TS, Levine D, Beckwith B. Treatment of ectopic pregnancy: is a human chorionic gonadotropin level of 2,000 mIU/mL a reasonable threshold? Radiology 1997; 205: 569–573

Hamza A et al. Diagnostic Methods of... Geburtsch Frauenheilk 2016; 76: 377–382
34 Hadlock FP, Shah VP, Kanon DJ et al. Fetal crown-rump length: reevaluation of relation to menstrual age (5–18 weeks) with high-resolution real-time US. Radiology 1992; 182: 501–505
40 Hadlock FP, Shah VP, Kanon DJ et al. Fetal crown-rump length: reevaluation of relation to menstrual age (5–18 weeks) with high-resolution real-time US. Radiology 1992; 182: 501–505