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Use of ultrasound in the labor and delivery

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Abstract

Ultrasound machines are nowadays part of the armamentarium of all modern Labor and Delivery Suites. Due to their portability, these machines are ideal for use in emergencies which can occur at any of the labor and delivery rooms. Many of the emergencies in Labor and Delivery can be life threatening; thus, maternal and fetal safety requires efficient and timely ultrasound evaluation. The purpose of this article is to provide guidelines for quick and efficient use of ultrasound based on both the authors' experience and the published literature.

Keywords: *Ultrasound in Labor and Delivery*

Introduction

Ultrasound was introduced in the obstetrical practice more than three decades ago. Since then, there have been numerous articles describing the use of obstetrical ultrasound for conditions seen in an outpatient-office setting. As a result, very little emphasis has been given to the use of ultrasound in emergency conditions, such as those encountered in the Labor and Delivery Suite. Labor and delivery is a unique area for two reasons: first, residents in Obstetrics and Gynecology obtain a significant part of their ultrasound training there; and second, it is imperative for patient safety to obtain accurate ultrasound information very quickly. However, the ultrasound training and practice should be based on an appropriate framework. Therefore, the purpose of this article is to provide a framework of guidelines, based on both the literature and the authors' experience, which can be used as a quick reference with respect to the use of ultrasound in the Labor and Delivery Suite. The clinical uses for ultrasound exam in labor and delivery are described below.

Estimation of gestational age and fetal weight

One of the most important achievements of obstetrical ultrasound is accurate estimation of gestational age and fetal weight, especially in borderline viable gestational ages in the setting of preterm labor, premature rupture of the membranes (PROM) and other pregnancy complications that may necessitate early delivery.

For gestational age prediction, most ultrasound software programs use an average of a combination of biometric parameters including biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC) and femur length (FL). However, fetal transcerebellar diameter (TCD) is the most accurate dating parameter, even in the third trimester, and it is the least affected parameter in the presence of fetal growth abnormalities [1].

The pediatric and neonatal literature is saturated with survival statistics of very low-birth weight newborns according to birth weight and gestational age. Ultrasound can provide quick and accurate information about both fetal weight and gestational age. As the actual birth weight is not known but only after birth, neonatal charts may not be appropriate for management or patient counseling, unless there is strong and accurate correlation between estimated fetal weight (EFW) and birth weight. Indeed, since the 1980s, it is known that there is strong correlation between EFW and actual birth weight, as well as survival rates in very low birth weight fetuses [2].

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Thus, EFWs are very accurate and indeed they can be used for patient management and/or counseling in very low birth weight fetuses. Of course, the parents' wishes are of paramount importance in determining 'obstetrical viability' in borderline viable cases. However, the following rule of thumb can also be used. Fetuses greater than 24 completed weeks gestation are viable, whereas fetuses less than 23 weeks are not viable. Between $23-23+3/7$ weeks, fetuses are viable if the EFW is greater than 600 g, whereas between $23+4/7-24$ weeks, fetuses are viable if the EFW is greater than 500 g.

It should be noted that one of the factors that may influence the accuracy of intrapartum estimation of fetal weight is fetal dolichocephaly, as frequently seen in breech presentations or prolonged preterm PROM. In such cases, it is preferable to use formulas that incorporate fetal HC measurements rather than BPD measurements in estimating fetal weight. If the fetal head is engaged and optimal head measurements cannot be obtained, it is preferable to use formulas that incorporate AC and FL without head measurements. If there is oligohydramnios, there is a tendency to underestimate fetal weight.

In term gestations, it appears that intrapartum estimation of fetal weight by ultrasound is more accurate than maternal perception or clinical estimation by resident or attending physicians [3]. However, the obstetrical literature is replete with articles showing that neither clinical estimation nor estimation of fetal weight by ultrasound is accurate in diagnosing fetal macrosomia (actual birth weight >4000 g) [4–12]. The reality is that, in labor and delivery, there is no clinical usefulness-except in very rare circumstances—in predicting the actual birth weight across a wide range of birth weights ranging from 600 to 4000 g. In labor and delivery, only in both extremes of birth weight (gestations complicated by borderline viability or macrosomia), accurate prediction is crucial in management. Prediction of fetal macrosomia may alter management because of its association with shoulder dystocia and branchial plexus injury. However, in clinical practice, the link among birth weight, shoulder dystocia and branchial plexus injury is not very strong, as 50% of shoulder dystocia cases occur in fetuses with birth weights less than 4000 g and only 1 in 2000 macrosomic fetuses will develop permanent branchial plexus injury [13]. Thus, it is unreasonable to expect to reliably predict shoulder dystocia and permanent branchial plexus injury based only on EFW by ultrasound or even actual birth weight. Fetal macrosomia and its complications may be better predicted by evaluating, in addition to EFW, other ultrasound predictors of fetal (fat) overgrowth, such as decreased HC/AC ratio (<80), increased AC (>35 cm), decreased FL to AC ratio (<20), increased cheek-to-cheek diameter (>8 cm), increased abdominal subcutaneous tissue thickness (>1 cm), increased amniotic fluid index (>20) and increased cross-sectional area of the umbilical cord (>240 mm^3) [14–20].

Determination of presentation and position of the occiput

As the rate of obesity increases, the correct identification of fetal presentation and position becomes problematic, even by the most experienced obstetricians, especially in women presenting with conditions which contraindicate a digital examination (i.e. preterm PROM). In such instances, where maternal obesity is combined with very preterm gestations, determination of fetal position without the use of ultrasound may be impossible. The use of ultrasound in this scenario may be crucial in deciding the route of delivery. In the presence of a cephalic presentation, the position of the occiput can be accurately determined by abdominal ultrasound using as a guide the fetal orbits. This information is very useful in laboring patients prior to the use of forceps, especially when there is significant caput formation.

In the presence of a breech presentation, ultrasound can be used to diagnose the type of breech presentation (frank, complete or footling), as well as conditions that contraindicate vaginal delivery including hyper-extended fetal head, large EFW, hydrocephalus, nuchal arm, nuchal umbilical cord or funic presentation.

Biophysical profile-amniotic fluid assessment

Other than term uncomplicated patients in labor, the biophysical profile, including amniotic fluid assessment, can provide useful information in several scenarios.

In women admitted to labor and delivery to rule out labor, a normal biophysical profile is reassuring, whereas an abnormal biophysical profile could be the result of (a) impending or active labor; (b) intra-amniotic infection; or (c) fetal acidemia. Patients in early labor with biophysical score of $<6/10$ have higher cesarean delivery rate as compared to those with biophysical score of $>8/10$ (37% versus 7%, respectively) [21].

Oligohydramnios on admission to Labor and Delivery Suite has been associated with: (a) increased rates of non-reassuring fetal heart rate (FHR) patterns in the first stage of labor, (b) operative delivery, (c) thick meconium (especially in postdate pregnancies) and (d) intra-amniotic infection (especially in women with preterm PROM) [22]. Oligohydramnios could be subjective or it can be defined as largest vertical pocket less than 2 cm or amniotic fluid index less than 5 cm.

In the presence of severe variable FHR decelerations, especially in women who are not in very active labor, an ultrasound exam can rule out some of the known causes for having variable decelerations in the absence of labor such as: (1) oligohydramnios, (2) funic presentation, (3) vasa previa, (4) tight cord around the fetal neck and (5) other umbilical cord abnormalities.

Fetal anomalies

With the current widespread use of prenatal ultrasound, most fetal anomalies are known before admission to labor and delivery. Intrapartum management should be conservative by avoiding cesarean delivery in the presence of fetal conditions incompatible with life or meaningful life (anencephaly, renal agenesis, alobar holoprosencephaly, thanatophoric skeletal dysplasia, trisomy 18, 13, etc.).

Vaginal bleeding

In patients admitted with vaginal bleeding the ultrasound exam should be targeted to rule out the following: (1) low-lying placenta or placenta previa, (2) placenta accreta/percreta, if there is a placenta previa and a history of one or more cesarean deliveries), (3) abruptio placenta and (4) vasa previa. If the bleeding occurs in the immediate postpartum period, the ultrasound exam should be targeted to rule out retained placental fragments.

The diagnosis of a low-lying placenta or placenta previa should be always verified by a transvaginal ultrasound exam. The clinical significance of a low-lying placenta can be determined by measuring the internal cervical os-to-placental edge distance. If this distance is less than 1 cm, almost all patients (95%) will require cesarean delivery for vaginal bleeding; if it is 1–1.9 cm, approximately half (50%) will require cesarean delivery due to hemorrhage; if it is 2 cm or greater, only 5% will require cesarean delivery. [23,24].

Placenta accreta/percreta should be always ruled out in the presence of placenta previa in patients with a history of one or more previous cesarean deliveries. The bleeding from placenta accreta/percreta can be catastrophic with devastating sequelae, if the diagnosis is not made before birth. The earlier ultrasound sign of placenta accreta/percreta may be in the first trimester, if implantation in the cesarean scar is seen by transvaginal ultrasound [25]. In later gestations, in addition to the finding of placenta previa, the following ultrasound signs are typical for accreta/percreta: (1) prominent intraplacental vascular lesions/lacunae close to the basal plate (this is the most consistent and reliable sign), (2) absence of the hypoechoic area between myometrium and placenta and (3) blood vessels (on color Doppler) crossing from the myometrium to the posterior bladder wall.

The diagnosis of abruptio placenta should be suspected when there is vaginal bleeding in the absence of placenta previa and vasa previa. In most cases, the direct ultrasound recognition of a retroplacental clot is not possible because such clots may have passed through the vagina prior to the ultrasound exam or because retroplacental clots frequently may have the "same" appearance as the placenta. However, a meticulous, targeted ultrasound exam for any of the following signs has been shown to have a detection rate of abruptio placenta over 80% [26]. These signs include the following: (1) retroplacental hematoma (which can be hyperechoic, isoechoic or hypoechoic), (2) preplacental hematoma (which can create a jello-like appearance with movement by the fetus or transducer), (3) increased placental thickness and echogenicity, (4) subchorionic collection and (5) marginal collection. The presence of a blood clot behind the internal os, especially when it is emanating from a low-lying placenta, can lead to a false diagnosis of placenta previa. However, a high or fundal location of the bulk of the placenta should be the clue for the correct diagnosis of abruptio placenta.

Vasa previa is one of the very few fetal life-saving prenatal diagnoses. Its prenatal diagnosis is associated with survival rate of 97% (with elective delivery at a mean gestational age of 35 weeks), whereas the fetal loss rate is more than 50%, if the diagnosis is not made prenatally [27]. The diagnosis of vasa previa should be made by documenting (by transvaginal ultrasound and color Doppler) the presence of umbilical blood vessels behind the internal cervical os. Situations that should increase the suspicion of vasa previa and trigger a targeted transvaginal ultrasound exam with color Doppler to exclude this condition include the following: (1) inability to visualize a normal (central) umbilical cord insertion on the placental end, (2) accessory placental lobe, (3) low-lying placenta in a previous second trimester ultrasound exam, (4) twins and (5) IVF-conceived pregnancies [28].

Twin gestation

In the presence of a twin gestation, ultrasound is extremely useful if a vaginal delivery is contemplated. In vertex/vertex presentations, after delivery of twin A, twin B should be monitored with ultrasound to rule out the following: (1) possible conversion to a nonvertex presentation, (2) funic presentation or (3) bradycardia. In vertex/nonvertex presentations, in addition to the aforementioned monitoring for twin B, ultrasound can be used to (1) estimate the weight of twin B to make sure that it is not considerably larger than twin A and (2) guide the maneuvers of external or internal podalic version, if such maneuvers are contemplated.

Preterm PROM

In women complaining of fluid leakage, the use ultrasound is absolutely necessary for complete evaluation. First, the diagnosis of PROM can be verified by the presence of oligohydramnios (subjective or by amniotic fluid pocket measurements). In contrast, the presence of normal amniotic fluid on admission, and on repeat ultrasound exam 4–6 h later, virtually rules out PROM. If the diagnosis of PROM is confirmed, then EFW, fetal presentation and position and biophysical profile evaluation should be performed. In the presence of reduced fetal biophysical activities or severe oligohydramnios (largest pocket less than 1 cm), there is a strong likelihood for subclinical intra-amniotic infection [29].

Threatened preterm labor

In women with threatened preterm labor, ultrasound can assist in (1) differentiating true from false labor and (2) evaluating for possible cause(s) in true preterm labor cases.

Transvaginal cervical length (CL) measurement is very helpful to differentiate between false from true preterm labor in women who present with regular contractions, intact membranes and digital cervical dilatation less than 3 cm. In such cases, if the CL is greater than 3 cm, true labor is highly unlikely. This CL cut-off has the highest sensitivity for true labor (100%) and therefore, it can be reliably used to exclude the diagnosis of true labor. The shorter the CL, the higher is the risk for true preterm labor. A CL less than 1.5 cm has a positive predictive value of approximately 50% for delivering within 1 week [30]. CL's between 1.5 and 3.0 cm are not very predictive.

If true preterm labor is diagnosed, ultrasound can be used to rule out possible cause(s) including (1) intra-amniotic infection/inflammation, which should be suspected in the presence of amniotic fluid 'sludge' behind the internal cervical os [31] or reduced fetal biophysical activities [29]; (2) ischemic placental disease (presence of IUGR with or without ultrasound signs of concealed abruptio placenta); (3) uterine factors (i.e. large fibroids, uterine anomalies); (4) uterine overdistention (polyhydramnios, multiple gestations); (5) surgical emergences that may mimic or cause preterm labor (adnexal torsion or appendicitis).

Induction of labor

Ultrasound can be used, in addition to parity and Bishop score, in the prediction of successful induction of labor. The two most important pieces of information that can be obtained by ultrasound are CL and determination of the occiput position. In nulliparas, CL 20 mm or less predicts vaginal delivery within 24 h in 80% of the cases, whereas CL greater than 30 mm predicts vaginal delivery in only 10% of the cases. CL's between 21 and 30 mm are not very predictive. The overwhelming majority of multiparas will deliver vaginally within 24 h; however, if the CL is greater than 30 mm, vaginal delivery within 24 h is expected to occur in only 40% of the cases [32]. Lastly, fetal occiput anterior or occiput transverse position at the onset of the induction will increase the chances for vaginal delivery, as compared to occiput posterior positions [33].

Postdates pregnancy

In women admitted to labor and delivery with postdate pregnancies, ultrasound can assist in the identification of fetal macrosomia or fetal dysmaturity. The presence of oligohydramnios in this group of patients should be 'equated' with thick meconium. Thus, continuous electronic FHR monitoring is indicated and amnioinfusion should be considered, especially in the presence of persistent moderate-to-severe FHR variable decelerations.

Dystocia in late labor

Abnormalities in the progress of labor, especially dystocia in late labor, should raise suspicion of malposition of the occiput (i.e. occiput posterior, brow presentation). Ultrasound could be used to verify the position of the occiput, especially when forceps use is contemplated and there is uncertainty regarding the occiput position because of caput formation. There are several reports suggesting that ultrasound is more accurate than digital vaginal examination in determining fetal head (occiput) position and station during the active phase of labor or during the second stage of labor [34–40]. Ultrasound evaluation can provide an objective assessment of labor progress and dystocia. Recently, the degree of descent of the fetal head during the second stage of labor have been objectively monitored by using ultrasound to measure 'head progression distance', 'head direction' or 'angle of progression' [41–43]. In measuring head progression, the reference line is through the inferior edge of the pubis symphysis perpendicular to its long axis. The minimal distance between this reference line and the leading edge of the presenting vertex represents the 'head progression distance' [41]. In measuring head direction, the angle between the aforementioned reference line and a line perpendicular to the widest diameter of the fetal skull is measured. On the basis of this angle, the head direction is characterized as 'head up' (angle 30° or greater), 'head down' (angle less than 0°) or 'head horizontal' (all other angles) [42]. A simpler method is to measure the angle of progression, which is the angle formed by a horizontal line through the midline of the pubis symphysis and another line that connects tangentially the inferior edge of the symphysis with the fetal skull [43]. An angle of 120° or greater is associated with vaginal delivery in the overwhelming majority of the cases [43,44]. In summary, ultrasound can be used in the second stage of labor to assess fetal station and objectively monitor labor progress [45].

Uterine rupture

Uterine ruptures most commonly occur during labor and they can have catastrophic consequences. Ultrasound can help in prevention and also in early diagnosis of uterine rupture.

The most frequent scenario, where there is concern for uterine rupture, involves women who attempt a vaginal birth after a previous cesarean delivery. This risk can be individualized based on anterior uterine wall thickness measured under the bladder flap (on a sagittal scan). The thinnest measurement should be used. Measurements greater than 3.5 mm are reassuring, whereas measurements of 3 mm or less are associated with extremely thin anterior lower uterine segment and a significant risk (10–15%) for existing uterine defects. Caution should be exercised when the measurement is between 3.1 and 3.5 mm [46].

Other candidates for uterine rupture are grant multiparas, especially those receiving oxytocin, and after blunt abdominal trauma. The ultrasound findings in uterine rupture cases may include (1) abnormal fetal lie due to extrusion of parts of the fetus and/or placenta in the intraperitoneal cavity; (2) fetal parts in the bladder; (3) signs on intraperitoneal bleeding (free fluid in the abdomen). The ultrasound demonstration of free abdominal fluid in pregnant women after blunt abdominal trauma is very accurate (sensitivity, specificity, positive and negative predictive values are 80, 100, 100 and 99%, respectively) [47].

Preoperative assessment

Ultrasound can be used in the preoperative assessment and incision planning prior to cesarean delivery. This preoperative 'mapping' can be done by determining the fetal presentation and position, placental location and exact location of umbilical cord vessels (in cases of vasa previa). Such mapping is necessary for choosing the most appropriate placement of the incision and uterine entry, so that excessive blood loss is avoided. Since 10% of the patients are expected to have low anterior placenta, it is a good policy to perform a quick preoperative assessment by ultrasound prior to all cesarean deliveries. In certain instances, preoperative ultrasound mapping for incision planning is absolutely necessary to avoid excessive blood loss and traumatic deliveries. These conditions include (1) very preterm gestation, (2) fetal malpresentation, (3) large uterine fibroids, (4) anterior low-lying placenta or placenta previa and (5) vasa previa.

Postpartum period

In the postpartum period, ultrasound can assist in the diagnosis and management of complications such as bleeding, pain or fever.

If there is postpartum bleeding, a quick ultrasound can determine the need for curettage/evacuation. An unnecessary uterine curettage/evacuation procedure can be avoided by the demonstration of an 'empty' uterus (presence of clean uterine stripe in the uterine cavity). In contrast, retained placenta fragments are diagnosed with certainty in the presence of viable intrauterine tissue, as demonstrated by positive color Doppler blood flow. This feature may differentiate between retained placental fragments and blood clots. If uterine curettage/evacuation is needed, this can be done under continuous ultrasound guidance to minimize the risk of uterine perforation.

In the presence of post-cesarean fever or unusual pain, ultrasound can be helpful in the diagnosis of bladder flap, pelvic, subfascial or wound hematomas. In such instances, if drainage is required, it can be done quickly and safely under continuous ultrasound guidance.

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