Journal of InterDisciplinary Research Applied to Medicine
JDREAM. Journal of interDisciplinary REsearch Applied to Medicine
JDREAM (2019), v. 2 i. 2, 43-52
ISSN 2532-7518
DOI 10.1285/i25327518v2i2p43
http://siba-ese.unisalento.it, © 2018 Università del Salento

Intrapartum ultrasound during prolonged second stage of labor: a diagnostic tool suggested for operative delivery to reduce complications.

Andrea Tinelli[1,2], Yanyan Ma[3], Sarah Gustapane[4], Antonio Malvasi[2,5]

[1] Department of Obstetrics and Gynecology, Division of Experimental Endoscopic Surgery, Imaging, Technology and Minimally Invasive Therapy, Vito Fazzi Hospital, P.zza Muratore, Lecce, Italy
[2] Laboratory of Human Physiology, Phystech BioMed School, Faculty of Biological & Medical Physics, Moscow Institute of Physics and Technology (State University), Dolgoprudny, Moscow Region, Russia
[3] Department of Obstetrics & Gynecology, Second Hospital, Tsingua University, Beijing, China
[4] Department of Obstetrics & Gynecology, Salus Hospital, Brindisi, Italy
[5] Department of Obstetrics & Gynecology, Santa Maria Hospital, GVM Care & Research, Bari, Italy

Corrisponding author: Andrea Tinelli
andreatinelli@gmail.com

Abstract
Diagnosis and management of prolonged second stage of labor and its complications is difficult and often poses a dilemma to the treating obstetrician regarding timing and type of intervention. Nowadays, the diagnosis of dystocic prolonged second stage of labor is largely based on digital evaluation of cervical dilatation and fetal head station and position, resulting inaccurate and subjective. Moreover, the problem of timing of delivery for nulliparа during dystocic labor and labor analgesia is clinically unsolved, as well as questioned since many years. Thus, labor management is largely based upon clinical and not instrumental findings. Women in dystocic labor require, often, operative delivery, after many hours of pain during labor. Accurate assessment of fetal head position and station is crucial in clinical decision-making during the second stage of labor and the fetal station was misinterpreted as lower than it really was in 15–22% of cases. Misdiagnosis or failure to correctly identify the fetal head position and station is one of the causes of failed instrumental delivery and subsequently of higher rate of neonatal morbidity. Intrapartum ultrasound also distinguishes patients destined for spontaneous vaginal delivery from those to submit to operative delivery. The intrapartum US is an adjunctive tool for labor ward obstetricians in the management of prolonged second stage and dystocia. It is a more objective and reliable tool than digital examination, and may give the obstetrician a more accurate perspective before making crucial clinical decisions regarding the chances of a successful vaginal delivery, and may lower the rate of failed instrumental delivery and its associated morbidity.

Keywords: Intrapartum ultrasound, prolonged second stage of labor, operative delivery, obstructed labor, dystocia, vacuum extractor, cesarean section.

Introduction

The philosophy of labor is based on two important queries: when and how to deliver. The answer to these two questions seems apparently simple but, on the contrary, it is extremely complex and abstruse. On the one hand there is the pregnant, full of anxiety and uncertainty about what will happen, on the other there is the fetus that must pass through the uterus that pushes it, the birth canal. In between there are dozens and dozens of variables and risk factors, for a sudden and unexpected modification of labor, while staying cognizant of monitoring safety and preventing harm.

The second stage of labor begins, basing on FIGO guidelines, from full dilatation of the cervix up to the birth of the singleton baby or the last baby in a multiple pregnancy (FIGO Safe Motherhood and Newborn Health (SMNH) Committee 2012, 111–16). At the start of the second stage, the fetal presenting part may or may not be fully engaged (meaning that the widest diameter has passed through the pelvic brim), and the woman may or may not have the urge to push (FIGO Safe Motherhood and

Newborn Health (SMNH) Committee 2012, 111–16)

Second stage may get unduly prolonged because of cephalopelvic disproportion (CPD), abnormal fetal position, and poor expulsive efforts resulting from conduction analgesia, sedation or maternal exhaustion. Many clinical factors can influence the progress of the second stage of labor.

These factors include maternal characteristics, such as age, parity, the size and shape of the pelvis, height and weight, uterine contractile forces, soft tissue resistance, expulsion effort, as well as presence of medical/obstetric conditions, including hypertensive disorders or pregestational/gestational diabetes mellitus. Fetal characteristics include birth weight, fetal occiput position/degree of flexion, and station at complete cervical dilation (Cheng and Caughey 2017, 547–66)

Prolonged second stage of labor is generally associated with several maternal and perinatal complications, including: increased operative vaginal delivery (OVD), cesarean section (CS), third- and fourth-degree perineal tear, cervical injury (with increased risk of preterm delivery in the subsequent pregnancy), post-partum hemorrhage (PPH) and chorioamnionitis. Neonatal complications include low 5-minute APGAR score, admission to the Neonatal Intensive Care Unit, birth trauma and birth depression (Cheng and Caughey 2017, 547–66; FIGO Safe Motherhood and Newborn Health (SMNH) Committee 2012, 111–16)

In management of a second stage of labor, there is a large evidence that digital obstetric examination does not provide an accurate assessment of the descend and position of the fetal head during the first and the second stage of labor (Malvasi et al. 2014, 520–26).

Investigations showed that digital obstetric examination during labor and delivery frequently fails to identify the correct fetal position in a high proportion of cases and ultrasonography in labor may play an important role in labor and delivery management (Sherer et al. 2002, 258–63; Sherer et al. 2002, 264–68)

Recent studies using intrapartum ultrasound (IU) have described objective measures of progression of the fetal head during labor, with a reduced error in diagnosis of fetal head position and progression (Malvasi et al. 2016, 2408–13)

Prolonged second stage may be managed by oxytocin augmentation, instrumental delivery or caesarean section and the safe use of vacuum extractor (VE) and forceps during OVD assumed the use of IU for the correct determination of the fetal head position and appropriate application of the instrument (Gustapane, Malvasi and Tinelli 2018, 540–41).

The use of IU is of fundamental importance for a safe OVD and can help in the prediction of whether a vaginal delivery would be successful, since scientific evidences suggested that IU may play an important role in the prediction of the time of onset and the progress of labor (Chor, Poon and Leung 2019, 31–37; Barak et al. 2018, 9–14; Choi et al. 2016, 3988–92)

The modern obstetric management of second stage is an ongoing challenge to reduce rates of emergency cesarean deliveries and to avoid adverse maternal and neonatal outcomes, since spontaneous parts are reduced and maternal and fetal complications are increased.

Thus, we performed a literature analysis to assess the impact of IU on management of prolonged second stage of labor, to assess its utility for operative delivery and if it can reduce complications.

Literature analysis

The safe balance between maternal and neonatal benefits and risks during the prolonged second stage of labor has been hindered by a lack of high-quality, prospective studies. The length of the second stage of labor was primarily defined as the duration between complete cervical dilation and delivery of the fetus. According to American College of Obstetricians and Gynecologists (ACOG) Practice Bulletin No. 49 on Dystocia and Augmentation of Labor, a prolonged second stage was defined as more than 2 hours without epidural or 3 hours with epidural analgesia in nulliparous women, and 1 hour without, or 2 hours with epidural analgesia for multiparous women (American College of Obstetrics and Gynecology Committee on Practice Bulletins-Obstetrics 2003, 1445–54) The additional hour allotted for labor with epidural anesthesia appeared to be based on the mean effect of epidural (Albers 1999, 114–19; Albers, Schiff and Gorwoda 1996, 355–59)

Subsequently, there were other literature data about the duration of the second stage of labor; recent recommendations often include longer durations in some cases, that is, that management is individualized depending on progress of labor, epidural analgesia, fetal position and interventions (Cheng and Caughey 2017, 547–66)
An obstetric care consensus in 2014, on the safe prevention of primary CS, the ACOG and the Society for Maternal Fetal Medicine (SMFM) allow an additional 1 hour of extended pushing in the second stage of labor for nulliparous and multiparous women before diagnosing second-stage arrest (Caughey et al. 2014, 179–93)
The extended second-stage labor represents a promising approach for balancing maternal and fetal risks, while working to reduce the rate of primary CS; nevertheless, the literature data are not yet sufficient to demonstrate the benefit of reducing CSs compared to maternal and fetal complications that may arise after a prolonged second stage of labor.
We searched on PubMed/Medline, Scopus, Google Scholar, EMBASE, the Cochrane Database, and a previous review the following key words: prolonged second stage of labor, intrapartum ultrasound, dystocia, operative delivery, vacuum extractor, cesarean sections and complications, to identify relevant articles published from 2000 and 2019 and to find the conclusions to our queries.

Intrapartum ultrasound in labor

The literature analysis has amply demonstrated that, in the case of prolonged labor, the IU is much more reliable than the vaginal visit in the obstetric diagnosis of situation, position and fetal progression.
Studies largely demonstrated the major diagnostic accuracy of IU to diagnose, during labor, the fetal head position (Sherer et al. 2002, 258–63; Sherer et al. 2002, 264–68), station (Dupuis et al. 2005, 193–97) and internal rotation (Ghi et al. 2009, 331–36; Malvasi et al. 2016, 2408–13) in the maternal pelvis, in comparison of traditional digital vaginal examination.
Similarly, different trials report the superior diagnostic value of IU in the malpositions (Bellussi et al. 2017, 633–41) and malrotations, (Simkin 2010, 61–71) during dystocic labor and delivery, especially in Occiput Posterior Position (OPP) (Bellussi et al. 2017, 633–41) and asynclitism (Simkin 2010, 61–71).
Moreover, the use of US did not have any negative impact on neonatal morbidity and mortality, basing on literature data.

Intrapartum ultrasound in prolonged second stage of labor

Abnormal descent pattern leads to prolongation of the second stage of labor. This abnormal descent is of two types: protracted descent and arrest of descent. Protracted descent is defined as descent of presenting part by less than 2cm per hour for multiparous women, and less than 1cm per hour for primiparous women. The arrest of descent is defined as no descent of the presenting part for more than one hour. Both may be an indicator of obstructed labor that needs an accurate IU diagnosis and a prompt intervention by OVD or CS. Nevertheless, prolonged attempts at VE are associated with neonatal morbidity and maternal trauma, especially so if the procedure is unsuccessful and an urgent CS is performed.
Moreover, important potential complications arising in the prolonged second stage of labor are fetal hypoxia and acidemia leading to "birth asphyxia," failure of the presenting part to rotate or descend appropriately leading to obstructed labor, and worsening or new manifestations of maternal hypertension leading to eclampsia (Sandström et al. 2017, 236–42).
Maternal complications after a prolonged second stage of labor are: infections, urinary retention, hematomas or ruptured sutures, especially in the early postpartum period; pregnants with pre-existing cardiac disease or severe anemia may be at risk of heart failure during the prolonged second stage, owing to the additional circulatory demands of active pushing (Stephansson et al. 2016, 608–16)
When patients have a delay or prolongation of the second stage, a prompt and thorough clinical assessment by IU should be recommended, to rule out full bladder, malposition or/and malpresentation of the fetal head, apart the inadequate uterine activity, poor pushing effort, all signs of obstructed labor.

Thus, the IU can accurately determine fetal head position, station and progression in delivery canal, during the second stage of labor, and it can be of great help in the management of prolonged second stage of labor.
An urgent CS during prolonged second stage of labor, "especially for a deeply engaged head" can be a nightmare for all obstetricians, since it can lead complications including: bladder injury while opening up of abdomen, difficulty in delivery of head, lateral extension of the angle causing broad ligament hematoma, tear of lower uterine segment (LUS) & downward extension of scar that may involve bladder, difficulty in tracing retracted LUS after surgery for which one may take a stay suture earlier, accidental incision over vagina, PPH, puerperal infection and later fistula formation and pelvic organ prolapse (POP).
Delivery of a deeply impacted head may pose a problem even during caesarean section.

Intrapartum ultrasound and operative delivery

Generally, misdiagnosis or failure to correctly identify the fetal head position and station is one of the causes of failed instrumental delivery and subsequently of higher rate of neonatal morbidity (Ben-Haroush et al. 2007, 308.e1-308.e5; Murphy et al. 2001, 1203–7; Hiraizumi et al. 2012, 280–83).
The VE and forceps are useful tools for conduction of vaginal delivery in prolonged second stage, to shorten and reduce the effects of the second stage of labor on maternal/fetal conditions. Literature data report a failure rate of 4%–8% for instrumental delivery, especially among women with risk factors such as obesity, fetal occipital-posterior position, and mid-cavity delivery (Bhide et al. 2007, 541–45; Aiken et al. 2014, 796–803; Murphy et al. 2001, 1203–7)
The US has been suggested as a more objective and reliable tool than digital vaginal examination for assessing fetal head position and station as well as in predicting the success of labor (Ghi et al. 2018, 128–39)
Barak et al (Barak et al. 2018, 9–14) evaluated the impact of IU on VE attempts. They demonstrated that among women who also had an intrapartum US as part of the clinical decision-making process, during the second stage of labor, there was a trend toward a lower rate of failed VE (although not reaching a statistical significance), with lower rate of CS, higher rate of vaginal deliveries, and without significant differences in neonatal outcome. Authors reported also that in the "+US" group, the CS rate was lower than in the "no-US" group.
In addition, Duckelmann et (Dückelmann et al. 2012, 484–88) evaluated the impact of IU on decision making for VE application, in a cohort of women with a prolonged second stage of labor; authors showed that by using intrapartum US, they were able to lower the CS rate without increasing maternal and neonatal morbidity. This study concluded that the use of intrapartum US can also lower the rate of failed VE attempts.
Sainz et al (Sainz et al. 2016, 1348–52) evaluated the predictive capacity of intrapartum transperineal ultrasound (ITU) in prolonged second stage of labor, to predict cases of failure in fetal extraction in operative deliveries by VE. They evaluated the following IU parameters: Angle of Progression (AoP), Progression Distance (PD) and head direction (HD). In the transverse plane, midline angle (MLA) and head-perineum distance (HPD) were assessed. The VEs were classified as easy (three or less vacuum pulls), difficult (more than three vacuum pulls) or impossible (delivery completed by cesarean section or CS). In the results, authors observed that the presence of an AoP with pushing <105°, a PD <25 mm, a "head-down" direction and a >45° MLA are very unfavorable ITU parameters which can be used to identify cases of high risk of fetal extraction failure in vacuum-assisted deliveries. Thus, ITU can help differentiate easy (3 pulls or less), hard (more than 3 pulls), or impossible (CS was needed) VE trials and that it is possible to identify high risk cases for failed VE by using some TPUS parameters.
Chan et al (Chan et al. 2019, 192–98) evaluated patients in prolonged second stage of labor, measuring the AoP by ITU before, indicating an instrumental delivery or CS. Authors concluded that AoP predicted approximately 80% of successful OVD performed for prolonged second stage of labor. This study' observation was not surprising given that the AoP is known to widen as the fetal head descends along the birth canal, suggesting that a lowered fetal head

position in the pelvis might have favored vaginal delivery. The study also found that median AoP during contraction with pushing was 20°–30° wider than median AoP at rest, which implied the presence of fetal head descent with maternal pushing.
Several studies have suggested that an AoP of 120° was associated with successful vaginal delivery (Sainz et al. 2016, 1348–52; Chan et al. 2019, 192–98; Barbera et al. 2009, 313–19; Kalache et al. 2009, 326–30; Sainz et al. 2015, 2041–47) but other studies suggested that AoP cutoff values of 105°–145.5° were associated with difficult or failed instrumental delivery (Ghi et al. 2013, 430–35; Cuerva et al. 2014, 687–92; Bultez et al. 2016, 86–91)

Gilboa et al (Gilboa et al. 2015, 399–404) evaluated, in a prospective study, different sonographic methods for the prediction of the difficulty and the success of OVD in pregnants with prolonged second stage of delivery with cephalic presentation. The investigated parameters were the following: head station, passage of the biparietal diameter (BPD) of the infrapubic line (IPL), percentage of head after the IPL, head circumference after IPL were all correlated with the difficulty of OVD. When the distance between the widest diameter of the head and the IPL is <1.2cm, there is a 90% probability of success of OVD. When that distance is >3.3cm, there is 90% probability of cesarean section. When the percentage of head beyond the IPL was >54%, there was 90% probability of successful OVD.
Authors concluded that ITU was useful in the prediction of the difficulty and the success of OVD. The higher the extent of head that passed the IPL, the less difficult the OVD and the greater the success rate of the OVD.
Kahrs et al (Kahrs et al. 2017, 69.e1-69.e10) evaluated, in a prospective cohort investigation on 222 pregnants, if ultrasound measurements of fetal position and station can predict duration of VE, mode of delivery, and fetal outcome in nulliparous women with prolonged second stage of labor.
The duration of VE was shorter in women with HPD ≤ 25 mm (log rank test <0.01). The estimated median duration in women with HPD ≤ 25 mm was 6.0 (95% confidence interval, 5.2-6.8) minutes vs 8.0 (95% confidence interval, 7.1-8.9) minutes in women with HPD >25 mm. The HPD was associated with spontaneous delivery with area under the curve 83% (95% confidence interval, 77-89%) and associated with CS with area under the curve 83% (95% confidence interval, 74-92%). In women with HPD ≤35 mm, 7/181 (3.9%) were delivered by CS vs 9/41 (22.0%) in women with HPD >35 mm (P <.01). Ultrasound-assessed position was occiput anterior in 73%. Only 3/138 (2.2%) fetuses in occiput anterior position and HPD ≤35 mm vs 6/17 (35.3%) with non-occiput anterior position and HPD >35 mm was delivered by CS. Umbilical cord arterial pH <7.10 occurred in 2/144 (1.4%) women with head-perineum distance ≤35 mm compared to 8/40 (20.0%) with HPD >35 mm (P < .01). They concluded that IU has the potential to predict labor outcome in women with prolonged second stage of labor.
Zipori et al (Zipori et al. 2019, 191.e1-191.e7) recently changed their approach to labor dystocia, as recommended by ACOG/SMFM (Caughey et al. 2014, 179–93), extending the length of prolonged second stage of labor; they significantly decreased the primary CS rate, in both nulliparous and multiparous women. However, this practice of extending the second stage of labor was associated with a small rise in OVD among nulliparous women, as well as with increases in other immediate maternal complications, specifically, higher rates of PPH and of third- or fourth-degree perineal lacerations. In assessing the neonatal complications, they noticed a higher rate of low umbilical artery cord pH in period II, but the early neurological outcome did not change. Authors concluded that in a prolonged second stage of labor, a CS can be done in all cases of doubt in order to prevent failed OVD, but a reduced rate of failed VE/forceps will be accompanied by an increased emergent CS rate. Thus, the benefits of safe prevention of primary CS, by extending the duration allowed for the second stage of labor, must be weighed against the potential adverse maternal and neonatal outcomes.
Muraca et al (Muraca et al. 2017, E764–72) investigated the effect OVD at mid-pelvis to reduce the CS rate, trying to quantify severe perinatal and maternal morbidity and mortality associated with attempted mid-pelvic OVD on more of 180000 pregnants. Among women with dystocia and prolonged second stage of

labor, mid-pelvic OVD was associated with higher rates of severe perinatal morbidity and mortality compared with CSs, especially with higher rates of severe birth trauma. Rates of severe maternal morbidity and mortality were not significantly different after OVD, although rates of obstetric trauma were higher.
Authors concluded that mid-pelvic OVD was associated with higher rates of severe birth trauma and obstetric trauma, whereas overall rates of severe perinatal and maternal morbidity and mortality vary by indication and operative instruments.

Conclusions

During a prolonged second stage of labor, assessments of the balance of risks and benefits between mid-pelvic OVD and CS have tended to favor the latter option in recent decades to reduce maternal neonatal complications (Sandström et al. 2017, 236–42; Shmueli et al. 2017, 886–89; Altman et al. 2015, 1209–15; Salman et al. 2017, 1145–50; Stephansson et al. 2016, 608–16) and this has contributed to a rising rate of CS worldwide (Zizza et al. 2011, 161–73; Boerma et al. 2018, 1341–48)
Diagnosing and managing of a prolonged second stage of labor is challenging, and prolonged second stage diagnoses will affect 10% to 14% of nulliparous and 3% to 3.5% of multiparous women (Cheng and Caughey 2015, 227–40)
Currently, the decision to perform OVD is traditionally based on subjective assessment by digital vaginal examination and clinical expertise and there is currently no method of objectively quantifying the likelihood of successful delivery.
The routine uses of IU or ITU should be encouraged during labor and in delivery room since there is large scientific evidence that digital obstetric examination either for the determination of fetal head position during labor or in the descent of the head in the birth canal is not accurate and IU is effective and feasible for a correct diagnosis (Tinelli, Di Renzo and Malvasi 2015, 310–11; Malvasi et al. 2015, 1890–94; Gustapane, Malvasi and Tinelli 2018, 540–41)
Moreover, for the successful and safe use of OVD, the correct determination of the fetal head position and appropriate application of the instrument by IU or ITU can reduce also the medical legal liability for VE failure or maternal and neonatal complications (Malvasi et al. 2018, 1108–9; Eggermont 2015, 87–95)
In fact, the IU demonstrated, also in such case, its great utility and precision in indicate, indirectly, the correct placement of the vacuum cup on the flexing point and placement of the forceps blades parallel to the sagittal suture.
Both features are associated with high success rate and reduction in maternal and fetal morbidity, since OVD is an integral part of obstetric care and is indicated for prolonged second stage of labor or fetal compromise or to shorten the second stage of labor for maternal indications.

References

- Aiken, Catherine E., Abigail R. Aiken, Jeremy C. Brockelsby and James G. Scott. (2014). Factors Influencing the Likelihood of Instrumental Delivery Success. Obstetrics & Gynecology 123, no 4, 796–803. doi:10.1097/AOG.0000000000000188.
- Albers, L L. (1999). The Duration of Labor in Healthy Women. Journal of Perinatology : Official Journal of the California Perinatal Association 19, no 2, 114–19.
- Albers, L L, M Schiff and J G Gorwoda. (1996). The Length of Active Labor in Normal Pregnancies. Obstetrics and Gynecology 87, no 3, 355–59.
- Altman, Maria, Anna Sandström, Gunnar Petersson, Thomas Frisell, Sven Cnattingius and Olof Stephansson. (2015). Prolonged Second Stage of Labor Is Associated with Low Apgar Score. European Journal of Epidemiology 30, no 11, 1209–15. doi:10.1007/s10654-015-0043-4.
- American College of Obstetrics and Gynecology Committee on Practice Bulletins-Obstetrics. (2003). ACOG Practice Bulletin Number 49, December 2003: Dystocia and Augmentation of Labor. Obstetrics and Gynecology 102, no 6, 1445–54.
- Barak, Oren, Roni Levy, Orna Flidel, Svetlana Zaks, Moshe Gillor, Zion Hagay and Edi Vaisbuch. (2018). The Rou-

tine Use of Intrapartum Ultrasound in Clinical Decision-Making during the Second Stage of Labor - Does It Have Any Impact on Delivery Outcomes? Gynecologic and Obstetric Investigation 83, no 1, 9–14. doi:10.1159/000455847.

- Barbera, A. F., X. Pombar, G. Perugino, D. C. Lezotte and J. C. Hobbins. (2009). A New Method to Assess Fetal Head Descent in Labor with Transperineal Ultrasound. Ultrasound in Obstetrics and Gynecology 33, no 3, 313–19. doi:10.1002/uog.6329.
- Bellussi, Federica, Tullio Ghi, Aly Youssef, Ginevra Salsi, Francesca Giorgetta, Dila Parma, Giuliana Simonazzi and Gianluigi Pilu. (2017). The Use of Intrapartum Ultrasound to Diagnose Malpositions and Cephalic Malpresentations. American Journal of Obstetrics and Gynecology 217, no 6, 633–41. doi:10.1016/j.ajog.2017.07.025.
- Ben-Haroush, Avi, Nir Melamed, Boris Kaplan and Yariv Yogev. (2007). Predictors of Failed Operative Vaginal Delivery: A Single-Center Experience. American Journal of Obstetrics and Gynecology 197, no 3, 308.e1-308.e5. doi:10.1016/j.ajog.2007.06.051.
- Bhide, Amarnath, Melih Guven, Federico Prefumo, Padma Vankalayapati and Baskaran Thilaganathan. (2007). Maternal and Neonatal Outcome after Failed Ventouse Delivery: Comparison of Forceps versus Cesarean Section. The Journal of Maternal-Fetal & Neonatal Medicine 20, no 7, 541–45. doi:10.1080/14767050701412297.
- Boerma, Ties, Carine Ronsmans, Dessalegn Y Melesse, Aluisio J D Barros, Fernando C Barros, Liang Juan, Ann-Beth Moller et al. (2018). Global Epidemiology of Use of and Disparities in Caesarean Sections. The Lancet 392, no 10155, 1341–48. doi:10.1016/S0140-6736(18)31928-7.
- Bultez, T., T. Quibel, P. Bouhanna, T. Popowski, M. Resche-Rigon and P. Rozenberg. (2016). Angle of Fetal Head Progression Measured Using Transperineal Ultrasound as a Predictive Factor of Vacuum Extraction Failure. Ultrasound in Obstetrics & Gynecology 48, no 1, 86–91. doi:10.1002/uog.14951.
- Caughey, Aaron B., Alison G. Cahill, Jeanne-Marie Guise, Dwight J. Rouse, Jeanne-Marie Guise and Dwight J Rouse. (2014). Safe Prevention of the Primary Cesarean Delivery. American Journal of Obstetrics and Gynecology 210, no 3, 179–93. doi:10.1016/j.ajog.2014.01.026.
- Chan, Viola Y.T., Wai-lam Lau, Mike K.P. So and Wing-cheong Leung. (2019). Measuring Angle of Progression by Transperineal Ultrasonography to Predict Successful Instrumental and Cesarean Deliveries during Prolonged Second Stage of Labor. International Journal of Gynecology & Obstetrics 144, no 2, 192–98. doi:10.1002/ijgo.12712.
- Cheng, Yvonne W. and Aaron B. Caughey. (2017). Defining and Managing Normal and Abnormal Second Stage of Labor. Obstetrics and Gynecology Clinics of North America 44, no 4, 547–66. doi:10.1016/j.ogc.2017.08.009.
- Cheng, Yvonne W and Aaron B Caughey. (2015). Second Stage of Labor. Clinical Obstetrics and Gynecology 58, no 2, 227–40. doi:10.1097/GRF.0000000000000113.
- Choi, Sae Kyung, Yong Gyu Park, Da Hye Lee, Hyun Sun Ko, In Yang Park and Jong Chul Shin. (2016). Sonographic Assessment of Fetal Occiput Position during Labor for the Prediction of Labor Dystocia and Perinatal Outcomes. The Journal of Maternal-Fetal & Neonatal Medicine 29, no 24, 3988–92. doi:10.3109/14767058.2016.1152250.
- Chor, Chung Ming, Liona Chiu Yee Poon and Tak Yeung Leung. (2019). Prediction of Labor Outcome Using Serial Transperineal Ultrasound in the First Stage of Labor. The Journal of Maternal-Fetal & Neonatal Medicine 32, no 1, 31–37. doi:10.1080/14767058.2017.1369946.

- Cuerva, M. J., C. Bamberg, P. Tobias, M. M. Gil, M. De La Calle and J. L. Bartha. (2014). Use of Intrapartum Ultrasound in the Prediction of Complicated Operative Forceps Delivery of Fetuses in Non-Occiput Posterior Position. Ultrasound in Obstetrics & Gynecology 43, no 6, 687–92. doi:10.1002/uog.13256.
- Dückelmann, A M, S A M Michaelis, C Bamberg, J W Dudenhausen and K D Kalache. (2012). Impact of Intrapartal Ultrasound to Assess Fetal Head Position and Station on the Type of Obstetrical Interventions at Full Cervical Dilatation. The Journal of Maternal-Fetal & Neonatal Medicine : The Official Journal of the European Association of Perinatal Medicine, the Federation of Asia and Oceania Perinatal Societies, the International Society of Perinatal Obstetricians 25, no 5, 484–88. doi:10.3109/14767058.2011.587057.
- Dupuis, Olivier, Silveira Ruimark, Dupont Corinne, Thevenet Simone, Dittmar André and Rudigoz René-Charles. (2005). Fetal Head Position during the Second Stage of Labor: Comparison of Digital Vaginal Examination and Transabdominal Ultrasonographic Examination. European Journal of Obstetrics, Gynecology, and Reproductive Biology 123, no 2, 193–97. doi:10.1016/j.ejogrb.2005.04.009.
- Eggermont, Marlies. (2015). Intrapartum Care and Substandard Care: Juridical Recommendations to Reduce the Risk of Liability. Archives of Gynecology and Obstetrics 292, no 1, 87–95. doi:10.1007/s00404-014-3612-y.
- FIGO Safe Motherhood and Newborn Health (SMNH) Committee. (2012). Management of the Second Stage of Labor. International Journal of Gynaecology and Obstetrics: The Official Organ of the International Federation of Gynaecology and Obstetrics 119, no 2, 111–16. doi:10.1016/j.ijgo.2012.08.002.
- Ghi, T., T. Eggebø, C. Lees, K. Kalache, P. Rozenberg, A. Youssef, L. J. Salomon and B. Tutschek. (2018). ISUOG Practice Guidelines: Intrapartum Ultrasound. Ultrasound in Obstetrics & Gynecology 52, no 1, 128–39. doi:10.1002/uog.19072.
- Ghi, T., A. Farina, A. Pedrazzi, N. Rizzo, G. Pelusi and G. Pilu. (2009). Diagnosis of Station and Rotation of the Fetal Head in the Second Stage of Labor with Intrapartum Translabial Ultrasound. Ultrasound in Obstetrics and Gynecology 33, no 3, 331–36. doi:10.1002/uog.6313.
- Ghi, T., A. Youssef, E. Maroni, T. Arcangeli, F. De Musso, F. Bellussi, M. Nanni et al. (2013). Intrapartum Transperineal Ultrasound Assessment of Fetal Head Progression in Active Second Stage of Labor and Mode of Delivery. Ultrasound in Obstetrics & Gynecology 41, no 4, 430–35. doi:10.1002/uog.12379.
- Gilboa, Y., O. Moran, Z. Kivilevitch, S. Kees, T. Borkowsky, R. Achiron and A. Weissmann-Brenner. (2015). Can Ultrasound Performed in Prolonged Second Stage of Labor Predict the Difficulty and Success Rates of Operative Vaginal Delivery? Ultraschall in Der Medizin - European Journal of Ultrasound 37, no 04, 399–404. doi:10.1055/s-0034-1398831.
- Gustapane, Sarah, Antonio Malvasi and Andrea Tinelli. (2018). The Use of Intrapartum Ultrasound to Diagnose Malpositions and Cephalic Malpresentations. American Journal of Obstetrics and Gynecology 218, no 5, 540–41. doi:10.1016/j.ajog.2018.01.028.
- Hiraizumi, Yoshie, Atsushi Miura, Hidehiko Miyake and Shunji Suzuki. (2012). Perinatal Outcomes of Failed Vacuum Extraction. Journal of Nippon Medical School = Nippon Ika Daigaku Zasshi 79, no 4, 280–83.
- Kahrs, Birgitte H, Sana Usman, Tullio Ghi, Aly Youssef, Erik A Torkildsen, Elsa Lindtjørn, Tilde B Østborg et al. (2017). Sonographic Prediction of Outcome of Vacuum Deliveries: A Multicenter, Prospective Cohort Study.

American Journal of Obstetrics and Gynecology 217, no 1, 69.e1-69.e10. doi:10.1016/j.ajog.2017.03.009.

- Kalache, K D, A M Dückelmann, S A M Michaelis, J Lange, G Cichon and J W Dudenhausen. (2009). Transperineal Ultrasound Imaging in Prolonged Second Stage of Labor with Occipitoanterior Presenting Fetuses: How Well Does the "angle of Progression" Predict the Mode of Delivery? Ultrasound in Obstetrics & Gynecology : The Official Journal of the International Society of Ultrasound in Obstetrics and Gynecology 33, no 3, 326–30. doi:10.1002/uog.6294.
- Malvasi, A., A. Tinelli, A. Barbera, T.M. Eggebø, O.A. Mynbaev, M. Bochicchio, E. Pacella and G.C. Di Renzo. (2014). Occiput Posterior Position Diagnosis: Vaginal Examination or Intrapartum Sonography? A Clinical Review. The Journal of Maternal-Fetal & Neonatal Medicine 27, no 5, 520–26. doi:10.3109/14767058.2013.825598.
- Malvasi, A, A Barbera, G Di Vagno, A Gimovsky, V Berghella, T Ghi, GC Di Renzo and A Tinelli. (2015). Asynclitism: A Literature Review of an Often Forgotten Clinical Condition. The Journal of Maternal-Fetal & Neonatal Medicine 28, no 16, 1890–94. doi:10.3109/14767058.2014.972925.
- Malvasi, A, Francesco Giacci, Sarah Gustapane, Radmila Sparic, Antonio Barbera and Andrea Tinelli. (2016). Intrapartum Sonographic Signs: New Diagnostic Tools in Malposition and Malrotation. The Journal of Maternal-Fetal & Neonatal Medicine : The Official Journal of the European Association of Perinatal Medicine, the Federation of Asia and Oceania Perinatal Societies, the International Society of Perinatal Obstetricians 29, no 15, 2408–13. doi:10.3109/14767058.2015.1092137.
- Malvasi, A, G Montanari Vergallo, A Tinelli and E Marinelli. (2018). "Can the Intrapartum Ultrasonography Reduce the Legal Liability in Distocic Labor and Delivery?" The Journal of Maternal-Fetal & Neonatal Medicine 31, no 8, 1108–9. doi:10.1080/14767058.2017.1306514.
- Muraca, Giulia M., Yasser Sabr, Sarka Lisonkova, Amanda Skoll, Rollin Brant, Geoffrey W. Cundiff and K.S. Joseph. (2017). Perinatal and Maternal Morbidity and Mortality after Attempted Operative Vaginal Delivery at Midpelvic Station. Canadian Medical Association Journal 189, no 22, E764–72. doi:10.1503/cmaj.161156.
- Murphy, D J, R E Liebling, L Verity, R Swingler and R Patel. (2001). Early Maternal and Neonatal Morbidity Associated with Operative Delivery in Second Stage of Labour: A Cohort Study. Lancet (London, England) 358, no 9289, 1203–7. doi:10.1016/S0140-6736(01)06341-3.
- Sainz, JA, C Borrero, A Aquise, R Serrano, L Gutiérrez and A Fernández-Palacín. (2016). Utility of Intrapartum Transperineal Ultrasound to Predict Cases of Failure in Vacuum Extraction Attempt and Need of Cesarean Section to Complete Delivery. The Journal of Maternal-Fetal & Neonatal Medicine 29, no 8, 1348–52. doi:10.3109/14767058.2015.1048680.
- Sainz, JA, C Borrero, A Fernández-Palacín, A Aquise, P Valdivieso, L Pastor and R Garrido. (2015). Intrapartum Transperineal Ultrasound as a Predictor of Instrumentation Difficulty with Vacuum-Assisted Delivery in Primiparous Women. The Journal of Maternal-Fetal & Neonatal Medicine 28, no 17, 2041–47. doi:10.3109/14767058.2014.976547.
- Salman, Lina, Amir Aviram, Eyal Krispin, Arnon Wiznitzer, Rony Chen and Rinat Gabbay-Benziv. (2017). Adverse Neonatal and Maternal Outcome Following Vacuum-Assisted Vaginal Delivery: Does Indication Matter? Archives of Gynecology and Obstetrics 295, no 5, 1145–50. doi:10.1007/s00404-017-4339-3.
- Sandström, A, M Altman, S Cnattingius, S Johansson, M Ahlberg and O Stephansson. (2017). Durations of Sec-

ond Stage of Labor and Pushing and Adverse Neonatal Outcomes: A Population-Based Cohort Study. Journal of Perinatology 37, no 3, 236–42. doi:10.1038/jp.2016.214.

- Sherer, DM, M. Miodovnik, K. S. Bradley and O. Langer. (2002). Intrapartum Fetal Head Position II: Comparison between Transvaginal Digital Examination and Transabdominal Ultrasound Assessment during the Second Stage of Labor. Ultrasound in Obstetrics and Gynecology 19, no 3, 264–68. doi:10.1046/j.1469-0705.2002.00656.x.
- Sherer, DM, M Miodovnik, KS Bradley and O Langer. (2002). Intrapartum Fetal Head Position I: Comparison between Transvaginal Digital Examination and Transabdominal Ultrasound Assessment during the Active Stage of Labor. Ultrasound in Obstetrics and Gynecology 19, no 3, 258–63. doi:10.1046/j.1469-0705.2002.00641.x.
- Shmueli, Anat, Lina Salman, Eran Ashwal, Liran Hiersch, Rinat Gabbay-Benziv, Yariv Yogev and Amir Aviram. (2017). Perinatal Outcomes of Vacuum Assisted versus Cesarean Deliveries for Prolonged Second Stage of Delivery at Term. The Journal of Maternal-Fetal & Neonatal Medicine 30, no 8, 886–89. doi:10.1080/14767058.2016.1191066.
- Simkin, Penny. (2010). The Fetal Occiput Posterior Position: State of the Science and a New Perspective. Birth 37, no 1, 61–71. doi:10.1111/j.1523-536X.2009.00380.x.
- Stephansson, O, A Sandström, G Petersson, A-K Wikström and S Cnattingius. (2016). Prolonged Second Stage of Labour, Maternal Infectious Disease, Urinary Retention and Other Complications in the Early Postpartum Period. BJOG: An International Journal of Obstetrics & Gynaecology 123, no 4, 608–16. doi:10.1111/1471-0528.13287.
- Tinelli, A, GC Di Renzo and A Malvasi. (2015). The Intrapartum Ultrasonographic Detection of the Bandl Ring as a Marker of Dystocia. International Journal of Gynecology & Obstetrics 131, no 3, 310–11. doi:10.1016/j.ijgo.2015.06.030.
- Zipori, Yaniv, Oren Grunwald, Yuval Ginsberg, Ron Beloosesky and Zeev Weiner. (2019). The Impact of Extending the Second Stage of Labor to Prevent Primary Cesarean Delivery on Maternal and Neonatal Outcomes. American Journal of Obstetrics and Gynecology 220, no 2, 191.e1-191.e7. doi:10.1016/j.ajog.2018.10.028.
- Zizza, A, A Tinelli, A Malvasi, E Barbone, M Stark, A De Donno and M Guido. (2011). Caesarean Section in the World: A New Ecological Approach. Journal of Preventive Medicine and Hygiene 52, no 4, 161–73.