Vacuum-Assisted Vaginal Delivery: A Comprehensive Review

Khaled ElShamy[1], Taha Abdelfattah[1], Ahmed ElMaasarawy[1]& Hussein Abdeldayem[1]

[1]Department of Obstetrics and Gynecology, Faculty of Medicine, Zagazig University, Egypt.

Correspondence: Khmm3elshamy@gmail.com

ABSTRACT

Approximately 5% (1 in 20) of all deliveries are operative vaginal deliveries. The past 20 years have seen a progressive shift away from forceps in favor of the vacuum extractor as the instrument of choice. This article reviews in detail the indications, contraindications, choice of instrument, and Application and Technique for vacuum-assisted vaginal delivery. The use of vacuum extraction at the time of cesarean delivery will also be discussed. With vacuum extraction becoming increasingly popular, it is important that obstetric care providers are aware of the maternal and neonatal risks associated with such deliveries and of the options available to affect a safe and expedient delivery.

Keywords: Operative vaginal delivery • Vacuum-assisted vaginal delivery • Vacuum

1. Vacuum-Assisted Vaginal Delivery

Assisted vaginal birth (AVB) attempts to mimic spontaneous vaginal birth (SVB). Delivery by AVB may benefit both mothers and neonates by decreasing risks of serious morbidity associated with prolonged delays in delivery or a Caesarean delivery late in the second stage [1].

Various types of forceps or vacuum devices can be used to safely and successfully achieve vaginal delivery, provided the prerequisites for AVB are met. Care providers are expected to have the appropriate training, skill, and experience with any instrument used. The choice of device will depend on the clinical situation; however, this choice is primarily determined by the clinical skill and scope of practice of the care provider [2].

AVB should be undertaken when there is a reasonable chance of success, a high level of safety, and a suitable contingency plan in place. Informed consent is an essential component of AVB, as are documentation of the event and debriefing afterward with the care team, patient, and family. AVB has been widely studied and debated, with a range of outcomes and safety profiles reported. Consideration must be given to both the maternal and neonatal risks of using either vacuum or forceps to achieve delivery [3].

The observed variation in maternal and neonatal outcomes may be due to differences in underlying patient characteristics, multiple types of instruments being used under a variety of protocols, as well as the range of skill and experience of care providers.

Ideally, a risk assessment would consider the risk associated with any delay in delivery that may differ for AVB and Caesarean delivery. The balance of risk of Caesarean delivery versus AVB continuously changes as the second stage of labor progress and depends on the clinical scenario [1].

There may also be increased risks associated with Caesarean delivery performed in the second stage of labor compared to the first stage of labor or AVB. This would include subsequent cervical insufficiency, particularly if the fetus was at a low station[4].

2. Interventions that have been Shown to Promote Spontaneous Vaginal Birth:

A.*Dedicated maternal support person*. One-to-one support in labor has been shown to decrease the rate of AVB.

These results are consistent throughout a variety of obstetrical settings, hospital conditions, pregnancy risk factors, and differing levels of professional training in the persons who provided support. This practice should be encouraged in all maternity care sites [1].

B.*Use of intermittent auscultation for low-risk labor*. A 2017 Cochrane review suggests use of continuous electronic fetal monitoring in low-risk women in labor is associated with an increase in both Caesarean delivery and AVB when compared with intermittent auscultation [5].

C.*Delayed pushing with the epidural*. Epidural use is associated with an increased rate of AVB. The 2017 Cochrane review on this subject has shown that delaying pushing with an epidural when there is no urge to push reduces the total duration of pushing and increases the rates of a successful vaginal birth but may increase the incidence of low Apgar scores [6].

In nulliparous patients, a 2018 randomized clinical trial of 2404 patients demonstrated that immediately compared to delayed pushing was associated with similar rates of SVB, lower rates of chorioamnionitis, PPH, and neonatal academia [7].

There were, however, higher rates of OASIS in the immediate pushing group. Currently, the evidence is conflicting in this area.

E. *Increasing the time is pushing with the epidural.* Although there are geographic variations within centers across Canada, the contemporary obstetrical practice has generally defined a prolonged second stage as pushing in labor with an epidural as >3 hours for nulliparous women and >2 hours for parous women [8].

One randomized trial in 2016 showed that for nulliparous women if the duration of active pushing is extended by 1 hour beyond this convention that there is a reduced risk of Caesarean delivery without increases in adverse maternal or perinatal outcomes. Regardless of definitions and limits applied, a pragmatic approach to prolonged second stage and management is advised [9].

F. *Manual rotation.* Manual rotation from an OT or OP position to a more optimal position has been correlated with decreased use of vacuum or forceps in the second stage and maybe up to 90% effective in achieving rotation to OA.In most cases, manual rotation is attempted after reaching full dilation; however, in certain clinical scenarios, it may be required prior to full dilation to facilitate the progress of labor. Manual rotation to optimize the fetal head position may also aid subsequent AVB if required [10].

3. Historical Perspective

The first instrumental deliveries were performed to extract fetuses from women at high risk of dying due to prolonged or obstructed labor. In these cases, saving the mother's life took precedence over possible harm to the fetus. With the development of safer techniques for vaginal extraction, however, the focus of these procedures has changed dramatically. The major indications for operative vaginal delivery in modern obstetric practice are to safeguard the wellbeing of the fetus. Vacuum extraction was first described in 1705 by Dr. James Yonge, an English surgeon, several decades before the invention of the obstetric forceps. However, it did not gain widespread use until the 1950s, when it was popularized in a series of studies by the Swedish obstetrician Dr. Tage Malmström [11].

By the 1970s, the vacuum extractor had almost completely replaced forceps for assisted vaginal deliveries in most northern European countries, but its popularity in many English-speaking countries, including the United States and the United Kingdom, was limited. By 1992, however, the number of vacuum-assisted deliveries surpassed the number of forceps deliveries in the United States, and by the year 2000, approximately 66% of operative vaginal deliveries were by vacuum [12].

AVB rates in Canada have declined from 2002-2003 (15.7%), 2005-2006 (14.3%), and 2011-2012 (rural areas 8.6%, urban areas 10.6%). This downward trend was observed for both vacuum and forceps deliveries, and data available from 2010-2011 suggest the rate of vacuum-assisted deliveries was threetimes the rate of forceps-assisted deliveries (9.6% vs. 3.2%).13 Concurrently, the rates of primary Caesarean delivery have been climbing, and many authorities have raised concerns over these trends. International data would suggest that these changes are being seen on a global scale [13].

As one approach, in order to ameliorate increasing rates of Caesarean delivery, the American College of Obstetricians and Gynecologists and the Society for Maternal-Fetal Medicine have recently begun advocating for the increased use of AVB to achieve delivery [14].

Strategies and evaluations of approaches to achieve this end goal are underway,16,17, and the current primary challenge of AVB hinges on opportunities to promote adequate skills and training. It is now widely accepted that obstetrical trainees should receive appropriate comprehensive training in AVB and be deemed competent prior to independent practice [15].

This not only maintains a high standard of patient care and improves outcomes, it also serves to maintain the highly skilled Art of Obstetrics in the next generation of care providers.According to the World Health Organization (2015), at the population level, CS rates higher than 10 percent are not associated with reductions in maternal and newborn mortality rates. In Egypt, the past decade has witnessed a sharp increase in the prevalence of CS, with the most recent Egypt Demographic and Health Survey (EDHS) documenting a CS rate of 52 percent [1].

4. Indications

An operative vaginal delivery should only be performed if there is an appropriate indication. In 2000, The American College of Obstetricians and Gynecologists

(ACOG) published guidelines on the use of operative vaginal delivery (both forceps and vacuum), which included a list of accepted indications for such procedures. These are summarized in Table 1. It should be made clear that none of these indications are absolute because the option of cesarean delivery is always available (American College of Obstetricians and Gynecologists2000) [16].

Table 1. Indications for Vacuum-Assisted Vaginal Delivery

Indication	Definition
The prolonged second stage of labor	In nulliparous women, this is defined as lack of progress for 3 hours with regional anesthesia or 2 hours without anesthesia. In multiparous women, it refers to lack of progress for 2 hours with regional anesthesia or 1 hour without anesthesia.
Nonreasoningfetal testing	Suspicion of immediate or potential fetal compromise (nonreasoning fetal heart rate pattern, abruption) is an indication for operative vaginal delivery when an expeditious delivery can be readily accomplished.
Elective shortening of the second stage of labor	Vacuum can be used to electively shorten the second stage of labor if pushing is contraindicated because of maternal cardiovascular or neurologic disease.
Maternal exhaustion	Largely subjective and not well defined.

Data from The American College of Obstetricians and Gynecologists [11].
Earlier data suggested that fetal morbidity was higher when the second stage of labor exceeded 2 hours, irrespective of fetal testing. As such, obstetric care providers were encouraged to expedite delivery once the second stage of labor was noted to be prolonged (American College of Obstetricians and Gynecologists2000) [16].
More recent data collected after routine use of epidural analgesia, however, have disputed this assertion and have shown that continued expectant management of women with the prolonged second stage of labor is a safe and reasonable option if fetal testing is reassuring. As such, prolonged second stage of labor—although still an indication—should no longer be regarded as an absolute indication for operative delivery. The risks to the mother of a prolonged second stage of labor include severe perineal injury and postpartum hemorrhage and appear to be associated more strongly with obstetric instrumentation rather than the length of the second stage of labor [17]
Suspected fetal compromise in the form of a nonreassuring fetal heart rate tracing is perhaps the most common and widely accepted indication for operative vaginal delivery, although the interpretation of fetal heart rate tracings is subjective and highly variable [18].

Women with contraindications to Valsalva maneuver may benefit from elective operative vaginal delivery. This includes women with select cardiac or neurologic diseases, such as some women with New York Heart Association (NYHA) class III/IV cardiac disease and uncorrected intracerebral vascular malformations. Operative vaginal delivery may also be required if there is inadequate maternal expulsive efforts, such as women with spinal cord injuries or neuromuscular diseases. Maternal exhaustion is another commonly used indicator for operative vaginal delivery but is not well defined and is highly subjective [19].

5. Contraindications

Several clinical situations exist in which operative vaginal delivery should not be attempted because of the potential risks to the fetus (Table 2) (American College of Obstetricians and Gynecologists2000) [16].

For example, an underlying fetal condition such as a documented bleeding diathesis or demineralizing bone disease will predispose the fetus to a major injury, including intraventricular hemorrhage and skull fracture, and, as such, should be regarded as an absolute contraindication to operative vaginal delivery. Such deliveries should also not be attempted if the fetal vertex is not engaged in the maternal pelvis, if the cervix is incompletely dilated, if the fetal membranes are not ruptured, if the fetal position is not known, if there is suspected cephalopelvic disproportion, or if there is fetal malpresentation (such as breech, brow, or face presentation)[20].

Vacuum-assisted vaginal delivery should not be performed prior to 34 weeks of gestation because of the risk of fetal intraventricular hemorrhage.Prior scalp sampling or multiple attempts at fetal scalp electrode placement are also relative contraindications to vacuum extraction because these procedures may increase the risk of cephalohematoma or external bleeding from the scalp wound [21].

There is no consensus regarding minimum and maximum estimated fetal weights that preclude operative vaginal delivery. Performance of operative vaginal delivery in a fetus with suspected macrosomia is supported by ACOG but should be performed with caution given the possible increased risk of fetal injury and of shoulder dystocia, especially when the second stage of labor is prolonged. Because of the risk of intraventricular hemorrhage, vacuum extraction is not recommended in fetuses with an estimated weight of less than 2500 g (which corresponds to < 34 weeks of gestation) [22].

Table 2. Contraindications for Vacuum-Assisted Vaginal Delivery

Absolute Contraindications
• **Underlying fetal disorder**
– Fetal bleeding disorders (e.g., hemophilia, alloimmune thrombocytopenia)

–	Fetal demineralizing diseases (e.g., osteogenesis imperfecta)
•	**Failure to fulfill all the requirements for operative vaginal delivery**
–	Incomplete dilatation of the cervix
–	Intact fetal membranes
–	Unengaged vertex
•	**Abnormalities of labor**
–	Fetal malpresentation (e.g., breech, transverse lie, brow, face)
–	Suspected cephalopelvic disproportion
•	**Estimated gestational age < 34 weeks or estimated fetal weight < 2500 g**
•	**Failure to obtain informed consent from the patient**
Relative Contraindications	
•	**Suspected fetal macrosomia (defined as an estimated fetal weight of ≥ 4500 g)**
•	**Uncertainty about fetal position**
•	**Inadequate anesthesia**
•	**Prior scalp sampling or multiple attempts at fetal scalp electrode placement**

Data from The American College of Obstetricians and Gynecologists (**Ali &Norwitz 2009).**

6. Selection of Instrument

The selection of the appropriate instrument depends on both the clinical situation and the operator's level of comfort and experience with the specific instrument. Factors that need to be considered include the availability of the instrument in question, the degree of maternal analgesia, and an appreciation of the risks and benefits of each of the individual instruments [11].

Published data suggest that forceps deliveries are associated with more maternal morbidity, whereas vacuum devices cause more neonatal injury. For example, a meta-

analysis of 10 clinical trials concluded that vacuum-assisted deliveries were associated with significantly less maternal trauma than forceps, including a lower rate of severe perineal injury (odds ratio [OR], 0.41; 95% confidence interval [CI], 0.33–0.50) [23].

7. Selection of Instrument: Which Vacuum Cup?

Having decided to perform a vacuum extraction, the operator must decide which cup to use. The original vacuum device developed in the 1950s by the Swedish obstetrician Dr. Tage Malmström was a disc-shaped stainless steel cup attached to a metal chain for traction [24].

Due to technical problems and lack of experience with this instrument, vacuum devices did not gain popularity in the United States until the introduction of disposable cups in the 1980s. There are two main types of disposable cups, which can be made of plastic, polyethylene, or silicone. The *soft cup* is a pliable funnel- or bell-shaped cup, which is the most common type used in the United States. The *rigid cup* is a firm mushroom-shaped cup (M cup) similar to the original metal disc-shaped cup and is available in 3 sizes (40, 50, and 60) [25].

Figure1.   Malmström ventouse. The original vacuum extractor developed in the 1950s by the Swedish obstetrician Dr. Tage Malmström is shown, including the metal mushroom cup (M cup), traction bar, and suction device [11].

**Figure 2.** Types of vacuum cups[11].

8. Application and Technique

A successful vacuum-assisted vaginal delivery is dependent on several factors, including patient selection and several technical considerations. The goal is the correct placement of the vacuum cup on the fetal scalp, application of a vacuum of up to 0.8 kg/cm^2 to suck part of the scalp into the cup and create an artificial caput succedaneum (known as a chignon), and then application of a traction force to the fetus in concert with uterine contractions to expedite delivery. The bladder should be emptied immediately prior to the procedure, and adequate analgesia should be provided [26].

The maternal and fetal status should be assessed continuously throughout the delivery. Most importantly, the obstetric provider should be willing to abandon the procedure if there is no descent of the vertex or in the event of complications, and access to emergent cesarean delivery should be immediately available at all times. Correct placement of the suction cup on the fetal scalp is critical to the success of the procedure. The suction cup should be placed symmetrically astride the sagittal suture at the median flexion point (also known as the pivot point), which is 2-cm anterior to the posterior fontanelle or 6-cm posterior to the anterior fontanelle**[27].**

Extreme care should be taken to avoid placement directly over the fontanelle. Correct placement will facilitate flexion, descent, and rotation of the vertex when traction is applied and will minimize injury to both the fetus and soft tissues of the birth canal. After the cup is applied, the circumference of the cup should be swept to ensure that no vaginal or cervical tissues have been inadvertently trapped within the vacuum cup [28].

The placement of the cup on the scalp should be again confirmed. Suction can then be applied. Vacuum pressures should be raised initially to 100 to 150 mm Hg to maintain the cup's position before being increased further to facilitate traction **[29].**
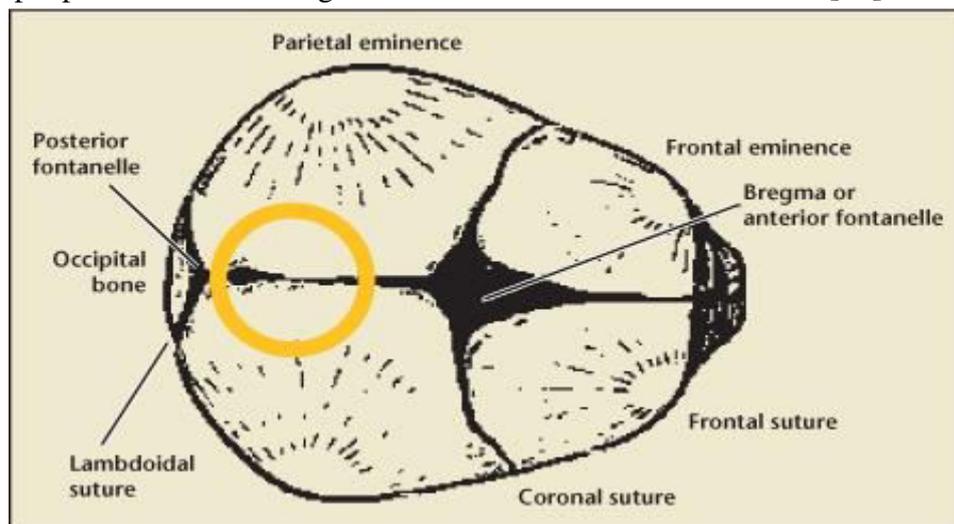
Figure 3. Placement of the obstetric vacuum (**Ali &Norwitz 2009**).

Correct placement of the suction cup on the fetal scalp is shown. The suction cup should be placed symmetrically astride the sagittal suture at the median flexion point (also known as the pivot point), which is 2 cm anterior to the posterior fontanelle or 6 cm posterior to the anterior fontanelle **[28].**

In the past, a slow incremental increase in vacuum pressure was recommended before applying traction, starting at a negative pressure and increasing gradually at 0.2 kg/cm^2 every 2 minutes to achieve a pressure of approximately 0.8 kg/cm^2 (alternatively expressed as 500–600 mm Hg, 500–600 torr, 23.6 in Hg, or 11.6 lbs/in^2) within 8–10 minutes. The explanation given was that this slow incremental approach would allow for a more firm attachment of the vacuum cup to the fetal head and, thereby, a lower failure rate. However, there is no evidence that such an approach is associated with an improved rate of successful vaginal delivery. In fact, a randomized control trial of 94 women comparing stepwise versus rapid pressure application demonstrated that the rapid technique was associated with a significant reduction in the duration of vacuum extraction by an average of 6 minutes without adversely impacting fetal and maternal outcomes[11].

A vacuum pressure of 0.6 to 0.8 kg/cm^2 (500–600 mm Hg) and an artificial caput succedaneum can be achieved in a linear, rapid fashion in less than 2 minutes [30].

9. Reasons for Failed Vacuum Extraction

Vacuum-assisted vaginal deliveries may fail because of poor patient selection (such as attempting vacuum extraction in pregnancies complicated by cephalopelvic disproportion) or errors in application or technique. For example, selection of the incorrect cup size, accidental inclusion of maternal soft tissues within the cup, and/or incorrect placement of the vacuum cup, resulting in worsening asynclitism (lateral traction) or de-flexion (extension) of the fetal head, may all contribute to failed vacuum attempts. Failure to apply traction in concert with maternal pushing efforts or traction along the incorrect plane may also result in failed vacuum extraction [31].

To avoid fetal injury, the obstetric care provider should not be overly committed to achieving a vaginal delivery and should be willing to abandon the procedure if it is not progressing well. Delay may increase the risk of neonatal or maternal morbidity. The ability to perform an emergency cesarean delivery should always be at hand[32].

The FDA was concerned that some health care professionals who were using vacuum devices for delivery might not be fully aware of the possibility of life-threatening neonatal complications such as subgaleal hematoma or intracranial hemorrhage [33].

10. Conclusions

Approximately 5% (1 in 20) of all deliveries are operative vaginal deliveries. There is an increasing trend toward the use of vacuum devices rather than forceps for suchprocedures due, at least in part, to mounting data suggestingthat vacuum extraction is associated with less maternal morbidity. Tosafely perform a vacuum delivery, it isimportant that the operator understandthe indications and contraindicationsfor this procedure. As a generalrule, the soft (bell-shaped) cupsshould be used for uncomplicatedocciput-anterior deliveries, whereasthe rigid M cups should be reservedfor more complicated deliveries such as those involving larger infants, significantcaput succedaneum, occiputposteriorposition, or asynclitism.Informed patient consent must beobtained. With appropriate trainingand careful patient selection, vacuum-assistedvaginal delivery can be avaluable tool in the armamentariumof the practicing obstetric careprovider to effect delivery of an at-

riskfetus. In all instances, the potentialrisks and benefits of a vacuum-assisteddelivery must be weighedagainst the availablealternative,including continued expectant management,oxytocin augmentation, andcesarean delivery.

References

1. **Hobson, S., Cassell, K., Windrim, R., & Cargill, Y. (2019).** No. 381-assisted vaginal birth. Journal of Obstetrics and Gynaecology Canada, 41(6), 870-882.

2. **AJohnston, T. (2016).** Instrumental vaginal delivery. Obstetrics &Gynaecology: An Evidence-based Text for MRCOG, 437.

3. **Muraca, G. M., Sabr, Y., Lisonkova, S., Skoll, A., Brant, R., Cundiff, G. W., & Joseph, K. S. (2019).** Morbidity and mortality associated with forceps and vacuum delivery at outlet, low, and midpelvic station. Journal of Obstetrics and Gynaecology Canada, 41(3), 327-337.

4. **Lemos, A., Amorim, M. M., de Andrade, A. D., de Souza, A. I., Cabral Filho, J. E., & Correia, J. B. (2017).** Pushing/bearing down methods for the second stage of labour. Cochrane Database of Systematic Reviews, (3).

5. **Alfirevic, Z., Gyte, G. M., Cuthbert, A., &Devane, D. (2017).** Continuous cardiotocography (CTG) as a form of electronic fetal monitoring (EFM) for fetal assessment during labour. Cochrane database of systematic reviews, (2).

6. **Fraser, W. D., Marcoux, S., Krauss, I., Douglas, J., Goulet, C., Boulvain, M., &**PEOPLE (Pushing Early or Pushing Late with Epidural) Study Group. (2000). Multicenter, randomized, controlled trial of delayed pushing for nulliparous women in the second stage of labor with continuous epidural analgesia. American journal of obstetrics and gynecology, 182(5), 1165-1172.

7. **Cahill, A. G., Srinivas, S. K., Tita, A. T., Caughey, A. B., Richter, H. E., Gregory, W. T., ... &Macones, G. A. (2018).** Effect of immediate vs delayed pushing on rates of spontaneous vaginal delivery among nulliparous women receiving neuraxial analgesia: a randomized clinical trial. Jama, 320(14), 1444-1454.

8. **Zhang, J., Landy, H. J., Branch, D. W., Burkman, R., Haberman, S., Gregory, K. D., ... & Hibbard, J. U. (2010)**. Contemporary patterns of spontaneous labor with normal neonatal outcomes. Obstetrics and gynecology, 116(6), 1281.

9. **Gimovsky, A. C., &Berghella, V. (2016).** Randomized controlled trial of prolonged second stage: extending the time limit vs usual guidelines. American journal of obstetrics and gynecology, 214(3), 361-e1.

10. **Broberg, J., Rees, S., Jacob, S., Drewes, P., Wolsey, B., Dayton, L., ... &Caughey, A. B. (2016).** 90: a randomized controlled trial of prophylactic early manual rotation of the occiput posterior fetal head at the beginning of the second stage of labor vs. expectant management in nulliparas. American Journal of Obstetrics & Gynecology, 214(1), S63.

11. **Ali, U. A., &Norwitz, E. R. (2009).** Vacuum-assisted vaginal delivery. Reviews in Obstetrics and Gynecology, 2(1), 5.

12. **Jauniaux, E., & Thorp, J. (2017).** Instrumental delivery: complex paternity and a fading art. BJOG: An International Journal of Obstetrics &Gynaecology, 124(9), 1373.

13. **Betrán, A. P., Ye, J., Moller, A. B., Zhang, J., Gülmezoglu, A. M., &Torloni, M. R. (2016).** The increasing trend in caesarean section rates: global, regional and national estimates: 1990-2014. PloS one, 11(2), e0148343.

14. **Caughey, A. B., Cahill, A. G., Guise, J. M., Rouse, D. J., & American College of Obstetricians and Gynecologists. (2014).** Safe prevention of the primary cesarean delivery. American journal of obstetrics and gynecology, 210(3), 179-193.

15. **Skinner, S., Davies-Tuck, M., Wallace, E., & Hodges, R. (2017).** Perinatal and maternal outcomes after training residents in forceps before vacuum instrumental birth. Obstetrics & Gynecology, 130(1), 151-158.

16. **American College of Obstetricians and Gynecologists. (2000).** Operative vaginal delivery. ACOG practice bulletin.

17. **Simic, M., Cnattingius, S., Petersson, G., Sandström, A., &Stephansson, O. (2017).** Duration of second stage of labor and instrumental delivery as risk factors for severe perineal lacerations: population-based study. BMC pregnancy and childbirth, 17(1), 72.

18. **Macones, G. A., & Moore, T. (2008).** and Human Development Workshop Report on Electronic Fetal Monitoring Update on Definitions, Interpretation, and Research Guidelines.

19. **Fisher?Hubbard, A. O., Kesha, K., Diaz, F., Njiwaji, C., Chi, P., & Schmidt, C. J. (2016).** Commode Cardia-Death by Valsalva Maneuver: A Case Series. Journal of forensic sciences, 61(6), 1541-1545.

20. **Wegner, E. K., & Bernstein, I. M. (2014).** Operative vaginal delivery. Berghelia V, Barss VA, eds. UpToDate.[Internet]. Waltham (MA): UpToDate Inc, 2019. Available from: https://www. uptodate. com/contents/operativevaginal-delivery/print.

21. **Suwannachat, B., Laopaiboon, M., Tonmat, S., Siriwachirachai, T., Teerapong, S., Winiyakul, N., ... &Lumbiganon, P. (2011).** Rapid versus stepwise application of negative pressure in vacuum extraction?assisted vaginal delivery: a multicentrerandomised controlled non?inferiority trial. BJOG: An International Journal of Obstetrics &Gynaecology, 118(10), 1247-1252.

22. **Rosen, H., Hodges, R., Malvasi, A., Tinelli, A., Farine, D., & Marinelli, E. (2017).** Operative Vaginal Delivery. In Management and Therapy of Late Pregnancy Complications (pp. 145-166). Springer, Cham.

23. **Kripke, C. (2011).** Instruments for Assisted Vaginal Delivery. American family physician, 84(1), 26.

24. **Georgsson, E. (2018).** "At least three Vacuum Extractionsare possible every day!": A questionnaire study in two hospitals inTanzania. By: Elsa.

25. **Greenberg, J. (2009).** Procedure for vacuum assisted operative vaginal delivery. UpToDate. Waltham, MA.

26. **Pettersson, K. A., Westgren, M., Blennow, M., &Ajne, G. (2020).** Association of traction force and adverse neonatal outcome in vacuum?assisted vaginal delivery: A prospective cohort study. Acta Obstetricia et GynecologicaScandinavica, 99(12), 1710-1716.

27. **Han, B. R., Park, K. H., Lee, S. Y., Jung, E. Y., & Park, J. W. (2016).** Prediction of the risk of cesarean delivery after labor induction in twin gestations based on clinical and ultrasound parameters. Journal of Obstetrics and Gynaecology Research, 42(9), 1125-1131.

28. **Oduola, O., Garry, N., & Murphy, D. J. (2020).** Operative vaginal birth. Obstetrics, Gynaecology& Reproductive Medicine, 30(1), 19-25.

29. **Shehu, C. E., &Omembelede, J. C. (2016).** Instrumental Vaginal Delivery-an assessment of use in a tertiary care centre. Orient J Med, 28, 1-2.

30. **Suwannachat, B., Lumbiganon, P., &Laopaiboon, M. (2012).** Rapid versus stepwise negative pressure application for vacuum extraction assisted vaginal delivery. Cochrane Database of Systematic Reviews, (8).

31. **Verhoeven, C. J., Nuij, C., Janssen-Rolf, C. R., Schuit, E., Bais, J. M., Oei, S. G., & Mol, B. W. J. (2016).** Predictors for failure of vacuum-assisted vaginal delivery: a case-control study. European Journal of Obstetrics & Gynecology and Reproductive Biology, 200, 29-34.

32. **Lacker, C. (2012).** Preventing maternal and neonatal harm during vacuum-assisted vaginal delivery. AJN The American Journal of Nursing, 112(2), 65-69.

33. **Danforth, D. N. (2008).** Danforth's obstetrics and gynecology. Ed. Ronald S. Gibbs.