Review Article

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Association between vacuum extraction and subgaleal haemorrhage: can intrapartum ultrasound reduce the risks?

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Vacuum extraction is a common procedure in the labour ward. Subgaleal haemorrhage is a rare neonatal complication that can be life threatening. We examine the risk factors associated with subgaleal haemorrhage after vacuum extraction, including fetal head malposition and inappropriate cup placement, and the role of intrapartum ultrasound in reducing perinatal complications. Although there is an increasing trend for using intrapartum ultrasound for more precise diagnosis of fetal head position, there is no evidence that this practice reduces failed vacuum delivery rates or perinatal morbidity.

Keywords: Hemorrhage; Ultrasonography; Vacuum extraction, obstetrical

Vacuum extraction and subgaleal haemorrhage

Vacuum extraction (VE) is widely performed to expediate delivery in the second stage of labour for various maternal and fetal indications. Compared with forceps delivery, VE is more commonly used because of its ease of application and low incidence of maternal trauma. Forceps delivery is more likely to achieve vaginal birth with decreased fetal trauma but has a greater risk of perineal trauma and higher pain relief requirement[1]. In Hong Kong, one study reported that the decreasing instrumental delivery rates were associated with an increase in second-stage caesarean section and a higher failed instrumental delivery rate[2].

The failure rate of VE is 4% to 6%[3-5]. VE is the most common factor associated with neonatal subaponeurotic or subgaleal haemorrhage (SGH)[6-8]. SGH is a life-threatening condition caused by bleeding into the space between the galea aponeurosis and pericranium of the scalp (Figure 1). The loose areolar tissue that lies in this potential space can accommodate a large volume of blood; newborns with SGH can lose more than half of total blood volume and result in hypovolaemic shock, coagulopathy, anaemia, hyperbilirubinaemia, and death[6,9]. The incidence of SGH is estimated to be 0.4 per 1000 spontaneous vaginal deliveries and 5.9 per 1000 VE deliveries[10], whereas 60% to 89% of SGH occur as a result of VE[7]. Perinatal mortality secondary to SGH can be as high as 25%, but prompt recognition greatly decreases mortality[8]. A study demonstrated that a mean time to diagnosis of 1 hour was achievable with a formal surveillance for all babies born following VE, and that the mortality rate can be as low as 2.8% with prompt recognition and active management[11].

Mild SGH with no clinical sequelae is often not detected, which results in an over-estimation of the overall morbidity and mortality from SGH based on moderate or severe cases. In a retrospective review of SGH cases in 10 years, 19% were mild, 48% were moderate, and 33% were severe[12]. Hypovolemic shock occurred in 48% of cases, encephalopathy in 62%, coagulopathy in 24%, and neonatal death in 14%. Nonetheless, long-term outcomes were good in surviving infants.

According to the Royal Australian and New Zealand College of Obstetricians and Gynaecologists guidelines, risk factors for SGH include VE or attempted VE, particularly with inappropriate placement of vacuum cup, prolonged vacuum application over >20 minutes, ≥3 tractions during contractions, detachment of vacuum cup, VE at <36 weeks gestation (relatively contra-indicated at <36 weeks and contraindicated at <34 weeks), nulliparity, and fetal coagulation defects such as congenital haemophilia[8]. However, most babies delivered by VE with these risk factors do not have SGH. When VE fails, sequential instrumental (usually forceps) delivery or second-stage caesarean section is associated with increased risks

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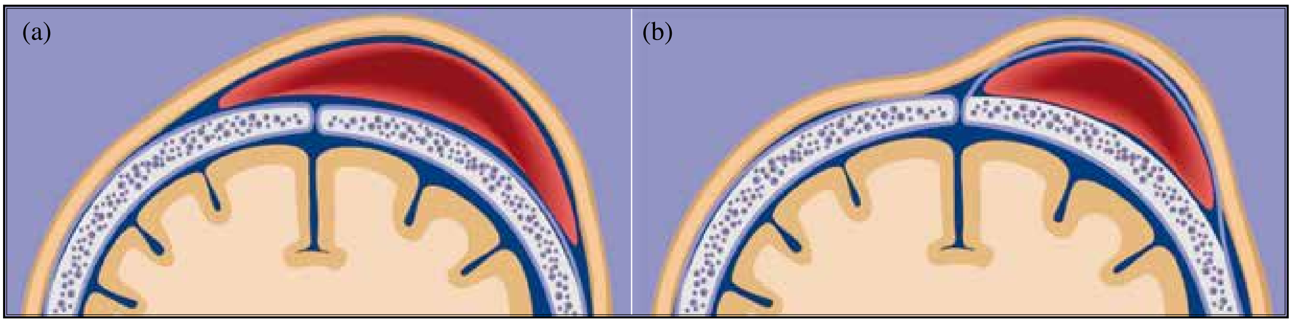

Figure 1. (a) Subgaleal haematoma crossing the suture line, (b) cephalohaematoma does not cross the suture line (reproduced from ALSO course materials 2020 with permission from ALSO (HK) Advisory Board)

of maternal and fetal complications including postpartum haemorrhage, neonatal intracranial haemorrhage, cranial facture, other birth trauma, and neonatal asphyxia[4,13-15].

Comparing babies with or without SGH after attempted VE, six independent risk factors have been identified: second-stage duration (for each 30-minute increase: adjusted odds ratio (aOR)=1.13, p=0.006), presence of meconium-stained amniotic fluid (aOR=2.61, p=0.001), presence of caput succedaneum (aOR=1.79, p=0.01), duration of VE (for each 3-minute increase: aOR=2.04, p<0.001), number of dislodgments (aOR=2.38, p<0.001), and fetal head station (aOR=3.57, p=0.006). VE duration of ≥15 minutes has 96.7% sensitivity and 75.0% specificity in predicting SGH, with the area under the receiver operating characteristic curve being 0.849[9]. Various factors that contribute to a difficult VE are associated with increased risks of SGH.

Malposition of fetal head

Occipital-posterior positioning of the fetal head is associated with the need for rotational delivery and failed VE. Malposition of fetal head complicates 2% to 13% of births at delivery, leading to increased obstetric interventions and adverse fetal and maternal outcomes[16]. In a cohort of 17 533 women in Hong Kong in 2000, the overall incidence of malposition was 14%, and the operative delivery rate of this group was 82.5%, which was higher than the 20.7% in the occipital-anterior position (control) group[17]. After excluding cases of operative delivery for non-mechanical indications such as fetal distress, the malposition group had higher odds of all assisted deliveries (aOR=9.8) and caesarean sections (aOR=30.2). In addition, the malposition group had longer duration of second stage, higher birth weight, higher incidence of low Apgar scores (0.52% vs 0.29%), and more birth trauma (2.15% vs 0.95%). Compared with infants born after a successful VE, those with failed VE had higher risks of SGH (OR=7.3), convulsions (OR=1.9), and low Apgar score (OR=2.6)[18]. Of 12 063 women with singleton pregnancies, 9.2% underwent VE, of whom 77.9 % were in the occipital-anterior position group and 22.1% were in the occipital-posterior position group[19]. The latter had a higher rate of single detachment of vacuum cup (11.3% vs 6.7 %, p=0.02) and higher risks for SGH (aOR=4.36, p=0.03) and low 5-min Apgar score (aOR=4.63, p=0.02). Independent factors associated with vaginal delivery failure include ethnicity, arrest or maternal exhaustion as an indication, occipital-posterior position, and a low (vs outlet) pelvic application[20]. Malposition of fetal head is a consistent risk factor for failed VE, and occipital-posterior position is an independent risk factor for SGH.

Vacuum cup placement

Suboptimal placement of the vacuum cup as a risk factor for SGH was controversial. In a study measuring both midline and anterior-posterior line deviations from the ideal cup placement, the mean deviation from the mid anterior-posterior line was 3.72±1.46 cm, and the mean midline-lateral deviation was 1.92±1.33 cm[21]. Cup placement deviations were similar between residents and consultants as well as between successful and failed procedures, despite a high failure rate of 8.6%. The authors asked for scientific proof that accurate placement of the vacuum cup would improve outcome; if this was clinically important, the deviation from ideal placement location ought to become a universal quality measure[21].

Of 338 (3.4%) of 10 066 babies delivered by VE, 71 (21.0%) had SGH[11]. The exceedingly high incidence of SGH was based on the clinical detection of a tender fluctuant scalp swelling across the skull suture lines rather than on radiological imaging. Risk factors for SGH were maternal nulliparity (aOR=4.0), failed VE (aOR=16.4), Apgar score of <8 at 5 minutes (aOR=5.0), marks of vacuum cup over the sagittal suture (aOR=4.4), and marks of leading edge of vacuum cup at <3 cm away from the anterior fontanel of infant head (aOR=6.0). Conventional teaching, including acute life support in obstetrics training, dictates that the vacuum cup should be placed over the flexing median position[22,23], with the leading edge of the cup at least 3 cm away from the anterior fontanelle (Figure 2). Therefore, placement of the vacuum cup at a distance too near the anterior fontanelles is a risk factor for SGH and may lead to deflection of the fetal head during delivery and hence difficulty in delivery[22,23]. When downward traction is applied with the cup placed in such a position, the traction force has slanting or shearing effects on the scalp, as the direction of traction is not perpendicular to the scalp, resulting in lacerations or tears of the transosseous emissary veins and hence SGH[11]. Paradoxically, when the vacuum cup is placed to one side of the sagittal suture, particularly at a distance of ≥3.0 cm away from the anterior fontanelle, the resultant deflection of the head decreases the risk of SGH[11]. This is contradictory to conventional teaching, as by the nature of the deflection that is apparently protective against SGH produces asynclitism that makes delivery more difficult[24]. These findings imply that even when the vacuum cup is optimally placed on the flexion point in the midline, SGH may still occur when the direction of traction is not perpendicular to the scalp. However, suboptimal placement with lateral deviation to one side of the sagittal suture may spare the central emissary veins as long as delivery of the fetal head is achieved. Therefore, although cup placement on the flexion point should be the most desirable mechanically to effect delivery, such optimal cup placement does not guarantee prevention of SGH.

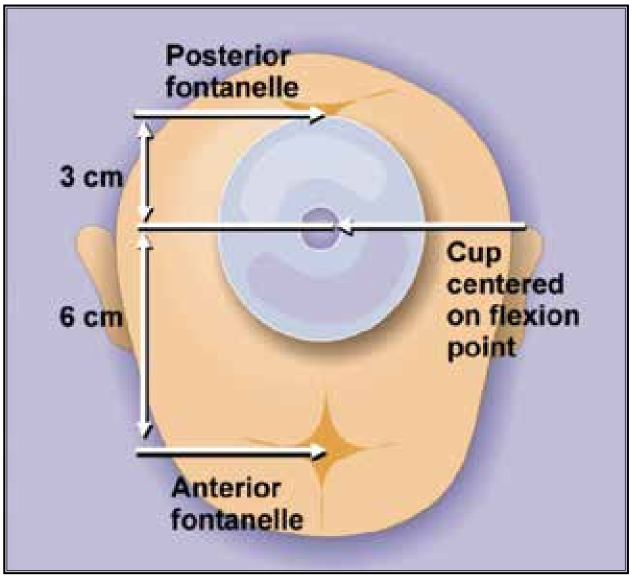

Figure 2. Proper vacuum cup position at the flexion point (reproduced from ALSO course materials 2020 with permission from ALSO (HK) Advisory Board)

Intrapartum ultrasound

Intrapartum ultrasound has been advocated in the recent two decades, challenging the conventional practice in the labour ward of assessing the progress of labour and position of the fetal head based solely on clinical vaginal examination. Intrapartum ultrasound provides a more objective assessment of fetal head position than digital vaginal examination. Correct identification of fetal head position is particularly useful before instrumental delivery, although fetal head position in the first stage of labour should not be used to predict successful vaginal delivery[25]. Early studies showed that transabdominal ultrasound is more accurate than clinical examination,

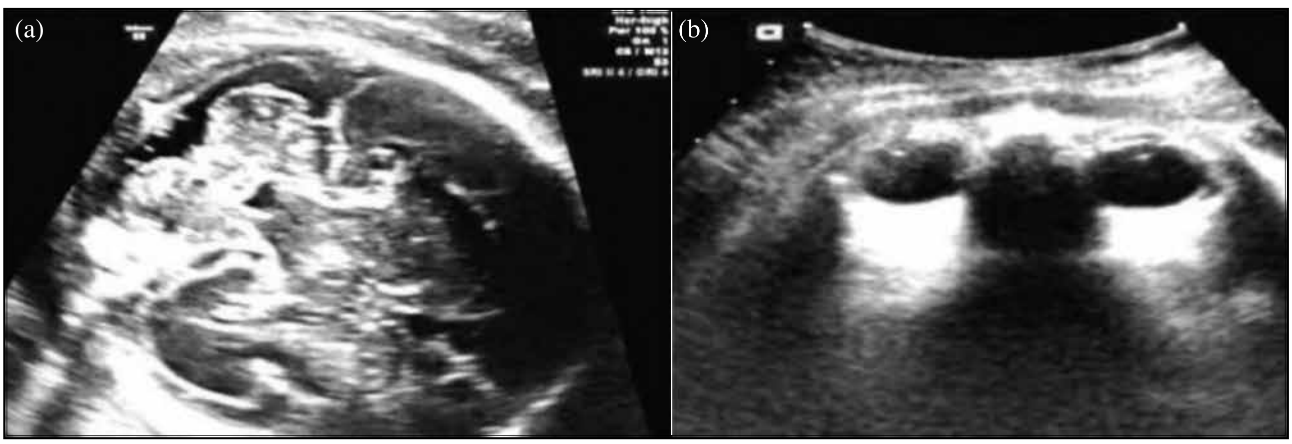

Figure 3. Intrapartum transabdominal ultrasound showing the fetal head position: (a) occiput and cerebellum shown anteriorly in occipital anterior position, and (b) anterior pointing orbits in occipital posterior position (reproduced from ALSO course materials 2020 with permission from ALSO (HK) Advisory Board)

while transperineal ultrasound was later introduced to measure the head perineal distance to demonstrate the fetal head station and to visualise the descent of the fetal head during the second stage of labour[25-28] (Figure 3).

In a prospective study among Hong Kong women with prolonged second stage of labour, transabdominal ultrasound assessment of the fetal head position improves the accuracy of vacuum cup placement during VE[29]. The mean distance between the centre of the chignon and the flexion point was shorter in those with both digital examination and ultrasound assessment than in those with digital examination alone (2.1±1.3 cm vs 2.8±1.0 cm, p=0.039). However, the study was underpowered to determine pregnancy outcomes.

In 478 nulliparous term women, instrument placement was suboptimal in 28.8% of deliveries[30]. Factors associated with suboptimal instrument placement included fetal malposition (OR=2.44), mid-cavity station (OR=1.68), and forceps as the primary instrument (OR=2.01). Compared with optimal instrument placement, suboptimal placement was associated with prolonged hospital stay (aOR=2.28), neonatal trauma (aOR=4.25), and more frequent use of sequential instruments (aOR=3.99) and caesarean section (aOR=3.81) for failed instrumental delivery. The mean decision-to-delivery interval was 4 minutes longer in the suboptimal placement group. Suboptimal instrument placement was associated with increased maternal and neonatal morbidity and procedural complications.

To reduce the incidence of suboptimal placement and subsequent morbidity, 514 nulliparous women at term with singleton cephalic pregnancies were randomised to receive clinical assessment with or without ultrasound assessment[13]. The incidence of incorrect diagnosis was lower in those with both clinical and ultrasound assessments (1.6% vs 20.2%, OR=0.06, p<0.001). However, the two groups were comparable in terms of the decision-to-delivery interval and the rates of maternal and neonatal complications, failed instrumental delivery, and caesarean section. Ultrasound assessment prior to instrumental delivery reduced the incidence of incorrect diagnosis of the fetal head position without delaying delivery but did not reduce morbidity.

In a study to evaluate the effect of ultrasound determination of fetal head position on the mode of delivery, women with a singleton term pregnancy in vertex presentation, cervical dilation of ≥8 cm, and epidural anaesthesia were randomly assigned to receive digital vaginal and ultrasound examinations (n=944) or digital vaginal examination alone (n =959). Those with both examinations had higher overall rate of operative delivery (33.7% vs 27.1%, p=0.002), rate of caesarean delivery (7.8% vs 4.9%, p=0.01), and rate of instrumental vaginal delivery (25.8% vs 22.2%, p=0.07)[31]. Neonatal outcomes were similar between the two groups. Addition of ultrasound examination did not improve management of labour and increased the rate of operative delivery without decreasing maternal and neonatal morbidity.

In the RISPOSTA (Randomised Italian Sonography for occiput position trial ante vacuum) trial to assess whether sonographic assessment of fetal head position before VE can reduce the risk of failure and perinatal complications in singleton, term cephalic presenting fetuses, 653 women per group was initially planned based on the hypothesis that the risk of failed VE would be 5% when vaginal examination alone was used and decrease to 2% when ultrasound assessment was used[32]. The study was terminated for futility after an interim analysis of 222 women. The two groups were comparable with respect to the incidence of emergency caesarean section owing to failed VE and other maternal outcomes. Women assessed by both vaginal and ultrasound examinations had a higher incidence of non-occipital anterior position of the fetal head and a lower incidence of incorrect diagnosis of the fetal head position. Recruitment was slow, as many women were excluded because ultrasound examination was a routine before instrumental delivery. Although ultrasound examination enables more accurate knowledge of fetal head position, the authors projected that the study was unlikely to demonstrate any clinical benefits or improved delivery outcomes.

In a similar trial, women at term, with full cervical dilatation, singleton fetus in cephalic presentation, and an established indication for instrumental vaginal delivery were randomised to undergo no ultrasound assessment (n=109) or both transabdominal ultrasound (to determine the fetal head position) and transperineal ultrasound (to evaluate the angle of progression) before instrumental vaginal delivery (n=113)[33]. The two groups were comparable in terms of composite measures of maternal morbidity (23.9% vs 22.9%, OR=1.055) and neonatal morbidity (9.7% vs 6.4%, OR=1.57). The trial was stopped for futility before reaching the required sample size.

In a meta-analysis of 1463 women, compared with standard care, ultrasound assessment prior to instrumental vaginal delivery did not affect the caesarean section rate (p=0.805), the composite adverse maternal outcome (p=0.428), perineal lacerations (p=0.800), postpartum haemorrhage (p=0.303), shoulder dystocia (p=0.862), prolonged stay in hospital (p=0.059), and composite adverse neonatal outcome (p=0.400)[34]. There was no increased risk of abnormal Apgar score (p=0.882), umbilical artery pH of <7.2 (p=0.713), base excess of >-12 (p=0.742), admission to neonatal intensive care unit (p=0.879), or birth trauma (p=0.968). The risk of incorrect diagnosis of fetal head position was lower when ultrasonography was performed before instrumental delivery, with a relative risk of 0.16 (p<0.001). Although ultrasound examination was associated with a lower rate of incorrect diagnosis of fetal head position and station, it failed to translate to improvement of maternal or neonatal outcomes[34].

Controversy of inclusion of intrapartum ultrasound in guidelines

One explanation for the failure of intrapartum ultrasound to improve delivery outcomes is the complexity of instrumental delivery. In addition to fetal head position and cup placement, other factors such as engagement, station of the presenting part, fetal size, and maternal pelvic dimensions should be taken into account[34]. The enhanced diagnosis of fetal head malposition by intrapartum ultrasound may not have enhanced the ability of the accoucheur to deal with the malposition. The inherent difficulty for the accoucheur to place the cup on the optimal flexion point in the presence of malposition is well recognised, and the use of occipital-posterior cups has not been shown to improve success rates. In addition, even when cup placement can be improved, this benefit has not been sufficient to reduce the failure rate of such procedures. Although the misdiagnosis rate for fetal head position without ultrasound assessment is >20%, the failure rate for instrumental delivery is consistently around 5%, and the success rate for VE in misdiagnosed cases is still around 70% to 80%. Although maternal and neonatal complication rates from these cases are higher, major complications including severe SGH remain low. Indeed, severe neonatal complications in those without intrapartum ultrasound are low. Given that accuracy of the fetal head position has little impact on the management decision in most scenarios apart from improvement in cup placement, it is not surprising that the morbidity rates are similar in those with or without intrapartum ultrasound.

According to the updated guidelines of the Royal College of Obstetricians and Gynaecologists in 2020[5], ultrasound assessment of the fetal head position prior to assisted vaginal birth is recommended where uncertainty exists following clinical examination. Although ultrasound assessment is more reliable than clinical examination, there is insufficient evidence to recommend the routine use of abdominal or perineal ultrasound to assess the station, flexion, and descent of the fetal head in the second stage of labour[5]. In practice, most misdiagnoses of fetal head position are made by accoucheurs who are certain they are correct. The more experienced the accoucheurs, the more likely they are confident with their perception and the less likely they resort to ultrasonography for verification. No significant alterations in clinical management are expected in such situations.

The International Society of Ultrasound in Obstetrics and Gynaecology published the first international guideline to endorse the use of intrapartum ultrasound before operative vaginal delivery[35], stating that the sonographic demonstration of fetal head position before considering or performing vaginal delivery is strongly recommended. The recommendation is based on Aristotelian logic, with the syllogism: if ultrasonography before placement of vacuum cup or forceps (A) enables a more precise determination of fetal position (B), and if the exact knowledge of position (B) makes safer the traction manoeuvre (C) owing to more accurate placement of the instrument (A), then ultrasonography may improve the safety and effectiveness of the operative vaginal delivery (A=B, B=C, so A=C)[36]. However, clinical data do not support this argument. The assumption that B=C is too optimistic, as the inherent difficulties with malpositions render this assumption only partially valid. Nevertheless, theoretically, knowing the precise fetal position is better than not knowing, and more routine use of intrapartum ultrasound as part of standard labour ward protocols is the trend. One may foresee the use of intrapartum ultrasound to trace the paths of electronic fetal heart monitoring in labour, where despite the lack of irrefutable evidence that it may improve perinatal outcome, would insidiously become part and partial of our everyday labour ward practice. It is anticipated that with the more and more routine use of intrapartum ultrasound, further attempts in conducting randomised trials on its use would be even more difficult and futile. The potential harm of the increasing rate of second stage caesarean section associated with the routine use of intrapartum ultrasound is a concern. It is unknown whether the overall incidence of clinically significant SGH secondary to VE decreases with the increase in the rate of second stage caesarean section.

Contributors

All authors designed and drafted the manuscript, and

critically revised the manuscript for important intellectual content. All authors had full access to the data, contributed to the study, approved the final version for publication, and take responsibility for its accuracy and integrity.

Conflicts of interest

As editors of the journal, CW Kong and W WK To were not involved in the peer review process of this article. All authors have disclosed no conflicts of interest.

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Data availability

All data generated or analysed during the present study are available from the corresponding author on reasonable request.

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