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Intrapartum translabial ultrasound (ITU): sonographic landmarks and correlation with successful vacuum extraction

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KEYWORDS: infrapubic line; infrapubic plane; intrapartum ultrasound; operative vaginal delivery; translabial ultrasound

ABSTRACT

Objective *Having studied intrapartum translabial ultrasound (ITU) to define easily obtainable sonographic criteria during maternal pushing, we used it dynamically immediately before vacuum extraction to determine its use in predicting successful operative vaginal delivery.*

Methods *In a pilot study, maternal and fetal landmarks were determined sonographically during maternal pushing from a mid-sagittal translabial insonation using a curved array transducer in women delivering singleton fetuses in cephalic presentation spontaneously. With this transducer placed infrapubically ('infrapubic plane'), easily obtainable landmarks and signs were: (i) the 'infrapubic line', perpendicular to the long axis of the pubic joint and extending dorsally from its inferior margin in a mid-sagittal plane, (ii) the widest fetal head diameter and its movement with regard to the infrapubic line during pushing, and (iii) the 'head direction' with respect to the long axis of the symphysis. A three-dimensional reconstruction from a computed tomographic (CT) dataset of a normal female pelvis was then used to quantify accurately the spatial relationship between the infrapubic line and the anatomical landmarks. Finally, 20 pregnant women in spontaneous term labor with normal singleton fetuses in cephalic presentation and clinical indication for vacuum extraction were studied by ITU immediately before operative vaginal delivery.*

Results *CT reconstruction demonstrated the infrapubic line to be 3 cm cranial to the parallel interspinous plane. Eleven of the 20 vacuum deliveries with the 'head-up' sign (head pointing ventrally) and objective descent of the fetal head below the infrapubic line, both noted at the height of pushing, resulted in successful ('simple' or 'moderately difficult') operative delivery. Lack of descent or lack of passage below the infrapubic line and horizontal or downward head direction were poor prognostic signs.*

Conclusions *ITU provides objective information on the dynamics of the second stage of labor, head station and head direction. ITU may be used to assess the prognosis for operative vaginal delivery. Copyright © 2006 ISUOG. Published by John Wiley & Sons, Ltd.*

INTRODUCTION

Assessment of fetal head station with regard to the narrowest part of the maternal bony pelvis is of crucial importance if safe operative vaginal delivery is to be attempted. The incidence of intracranial hemorrhage depends on the mode of delivery, increasing from 1 in 1900 with spontaneous vaginal birth, to 1 in 860 with vacuum delivery and 1 in 333 with Cesarean section after failed operative vaginal delivery[1]. Digital vaginal examination for the assessment of fetal head position and station is subjective and depends on the examiner's obstetric experience. Fetal head position in labor has been assessed using transabdominal ultrasound and in comparison with digital vaginal examination, with the aim of detecting malposition (occiput posterior position). Translabial ultrasound has only recently been applied to measure objectively fetal head engagement, taking the pubic symphysis as a reference point[2]. Intrapartum translabial ultrasound (ITU), using a curved transducer placed in a mid-sagittal plane below the pubic symphysis, to visualize head station, descent and direction during the active phase of the second stage of labor, has not been described previously. We have established a simple method of performing and assessing ITU. Relating the

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position of the fetal skull to the symphysis in laboring women during pushing and immediately prior to vaginal vacuum extraction, we aimed to define easily obtainable sonographic criteria associated with successful operative vaginal delivery.

METHODS

Sonographic assessment of the female pelvis was performed in consecutive pregnant women with normal singleton term pregnancies in spontaneous labor and after rupture of membranes between December 2004 and January 2006. Informed consent was obtained from every woman, and the Institutional Review Board and local hospital ethics committee approved the study. The study was performed on deliveries at times when one of the authors (W.H.) was present and aware of the previous digital vaginal examination results, but was not managing these particular deliveries. This operator performed all ultrasound studies, and ITU was always done after the vaginal exam (by the managing obstetrician) that resulted in the decision for operative delivery.

The managing obstetricians were blinded to the results of ITU. Based on the clinical level of suspicion of fetal jeopardy, ITU was not performed in emergency situations. A pilot study was undertaken in order to describe the anatomical landmarks and signs of progressive head engagement during normal labor. Its results were used to design the main clinical study.

Pilot study

In the first part of the study anatomical landmarks were determined in 10 pregnant women in the second stage of labor by sonography via sagittal translabial insonation with a 3.5-MHz curved array transducer (Sonoline Adara, Siemens, Berlin, Germany). For ITU as well as for the digital exams, the laboring women were placed in a semi-recumbent position with their legs flexed at the hips and knees at 45° and 90° angles, respectively. Using this approach revealed the following anatomical structures that were later used for the main study (from ventral; Figure 1). (1) The pubic symphysis joint, as an easily recognizable, oblong, irregular echogenic structure. For standardization, the transducer was placed so that the symphysis was in a horizontal position. (2) The fetal skull, with anterior and posterior tabula clearly depicted, enabling measurement of the widest diameter in the imaging plane. (3) The dorsal part of the birth canal: soft tissue and sacrococcygeal bones. These structures could not be resolved individually. The plane encompassing these anatomical structures was referred to as the 'infrapubic plane'. In this plane, the line perpendicular to the long axis of the symphysis pubis, originating from the caudal end of the symphysis and extending to the dorsal part of the birth canal, was referred to as the 'infrapubic line'. Imaging of the head rotation was not attempted because the midline or other intracranial structures could not be visualized easily from this insonation. When the head position was not clear from digital vaginal examination, transabdominal ultrasound (using the same transducer placed in a low transverse section above the symphysis) was used.

During pushing, three parameters were assessed by ITU: (a) 'descent' (subjectively judged as 'yes' or 'no'); (b) 'whether the widest part was below the infrapubic line'; (c) 'head direction', defined as the direction of a line perpendicular to the widest diameter of the fetal head in the infrapubic plane, with respect to the infrapubic line. When this line pointed ventrally at an angle of 30° or more, it was considered 'head up' (e.g. see arrow in Figure 1). For lines below 0°, the direction was

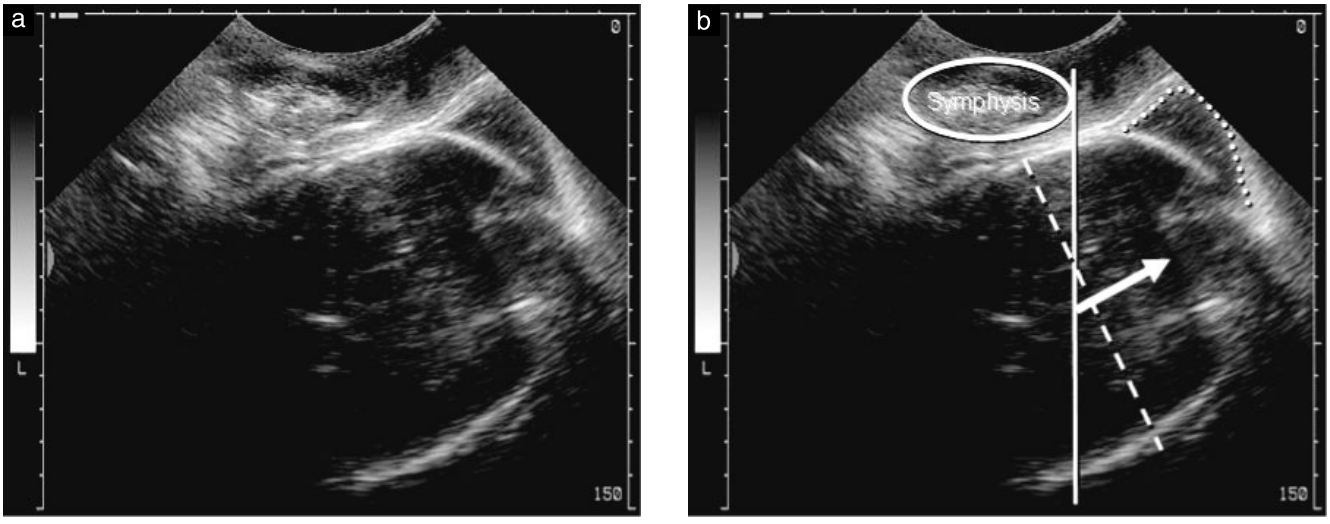

Figure 1 Anatomical structures in the infrapubic plane used in this study: original (a) and annotated (b) ultrasound images. The transducer is applied to show the pubic symphysis in a horizontal plane. The 'infrapubic line' (solid line) runs perpendicular to the symphysis and originates from its caudal end. The dashed line indicates the greatest diameter of the fetal head. The 'head direction' (arrow) indicates the orientation of the widest part of the fetal head with respect to the infrapubic line (in this example, towards the symphysis, i.e. 'head up'). Note the caput succedaneum (indicated by the dotted line) appearing at a lower station than the actual skull.

termed 'head down', and all other angles were considered 'horizontal'. During normal descent of the fetal head, the relation between the landmarks (the infrapubic line and the greatest head diameter in the infrapubic plane) and the head direction change in an easily recognizable way (Figure 2): during the descent of the fetal head towards the pelvic floor its widest diameter seen in the infrapubic plane turns 'upward' (ventrally). The landmarks and 'signs' of ITU could be seen in every patient. The duration of the ITU scan was less than 2 min in all cases.

Computed tomographic (CT) comparison

To correlate the normal anatomy of the female pelvis with ITU-derived landmarks, we used a three-dimensional reconstruction (GE Advantage workstation, Volume Viewer software package version 4.2) from a CT volume dataset (16 Multidetector-Row-CT, Lightspeed Pro 16, helical acquisition with a 1.25-mm slice thickness, GE Medical Systems Milwaukee, WI, USA) of a healthy non-pregnant volunteer's bony pelvis (43 years old; gravida 2 para 2; history of two uncomplicated vaginal deliveries of normal-sized infants). Standard pelvimetric measurements were also taken from these reconstructed CT images.

Main study

We investigated 20 pregnant women in spontaneous term labor with ruptured membranes and with normal singleton fetuses in cephalic presentation. All women presented clinical indications for vacuum delivery, i.e. a failure to progress or suspicious or pathological fetal heart rate tracings as determined by external cardiotocography. Additionally, operative vaginal delivery was deemed

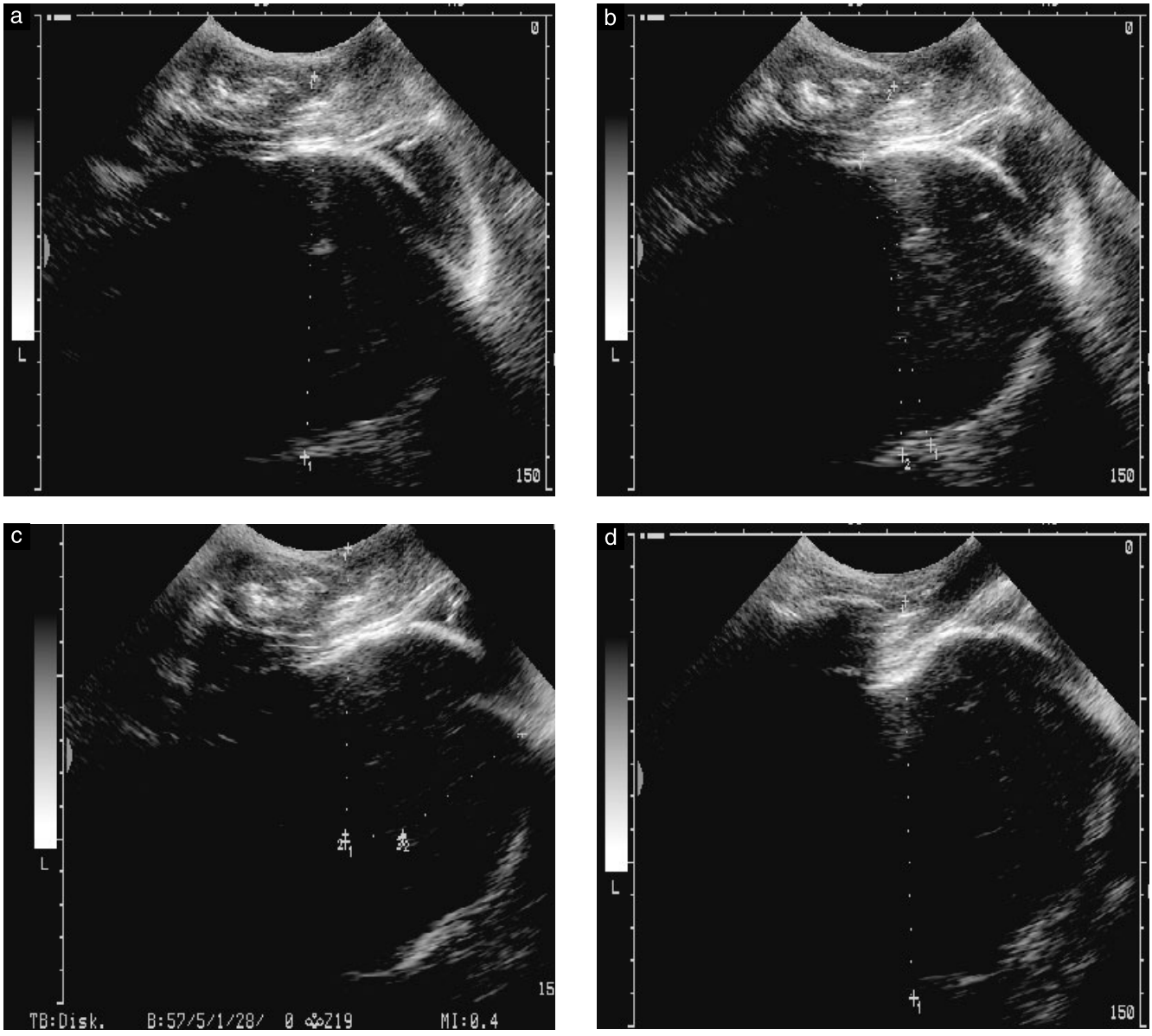

Figure 2 Descent of the fetal head as seen on infrapubic intrapartum ultrasound: (a) without contraction, (b) during contraction, (c) with pushing during contraction, and (d) after a further contraction and immediately prior to a complication-free vacuum extraction (two tractions; Case 19).

possible by an experienced obstetrician, following a digital vaginal examination. The women were examined sonographically by ITU at least once; in all cases one exam was performed immediately before vacuum extraction.

Clinical and ITU parameters, vacuum extraction characteristics and newborn data including umbilical cord arterial pH measurements were recorded in a standard manner immediately after each delivery. Vacuum extractions were rated, based on the number of tractions and on overall subjective impression, as 'simple', 'moderately difficult', 'difficult' or 'failed' by the operator who also performed the scans. Images were recorded before pushing, during pushing and immediately before vacuum extraction. The ITU criteria were taken at the height of pushing without additional fundal pressure. If multiple ITU assessments were made during the course of a delivery, only the last set of parameters, recorded immediately prior to vacuum extraction, was used. All data were evaluated and analyzed post-hoc by two of the authors in a non-blinded fashion.

RESULTS

Correlation with three-dimensional CT reconstruction

Using a three-dimensional CT reconstruction, standard pelvimetric measurements of a normal female pelvis were taken. In this pelvis's inlet plane, the obstetric conjugate was 12.0 cm (normal > 10 cm). In the mid-pelvis (the narrowest pelvic dimension) the interspinous diameter (normal ≥ 10 cm) was 11.5 cm (images not shown). Using this reconstructed pelvis with normal measurements, CT correlation with ITU confirmed that a line parallel to the infrapubic line and 3 cm caudal to it indicates the level of the ischial spines (mid-pelvis), i.e. the narrowest bony part of the female pelvis (Figure 3).

ITU immediately before vacuum extraction

The clinical characteristics, vaginal examination results, ITU findings and clinical course of the vacuum extractions in the 20 women examined by ITU immediately before operative vaginal delivery are shown in Table 1.

There were four cases with difficult and one with a failed vacuum extraction. Typical ITU images of a fetus just before complicated and failed vacuum extractions are shown in Figures 4 and 5, respectively. Corresponding images before successful vacuum extraction are shown in Figure 2. In the case of the failed vacuum extraction, which led to a subsequent Cesarean delivery (Table 1, Case 9), vaginal palpation examination parameters (station 0, no descent palpable during pushing) as well as all ITU parameters were unfavorable.

It appeared that the head-up sign was a predictor for successful vacuum extraction in protracted labor. Seventeen of the 20 fetuses had an occiput anterior position. Eleven of these had a head-up sign, all of which had either simple (5/11) or only moderately difficult (6/11) vacuum extractions. In contrast, among the six occiput anterior fetuses with head horizontal or down, there was only one simple vacuum extraction. In one fetus with head down sign, in which two other ITU parameters were also unfavourable (no descent during pushing and widest head diameter not below the infrapubic line), vacuum extraction was attempted, based on clinical judgment, but failed (Case 9).

In the three occiput posterior cases, the head direction on ITU was horizontal; two of these had difficult vacuum extractions, despite the fact that the widest diameter of the fetal head had been below the infrapubic line on ITU. The third extraction was moderately difficult.

On digital vaginal examination, an elongated (configured) head with caput succedaneum may appear falsely to be further down than it actually is in the birth canal. This situation was clearly demonstrated by ITU (Figure 5).

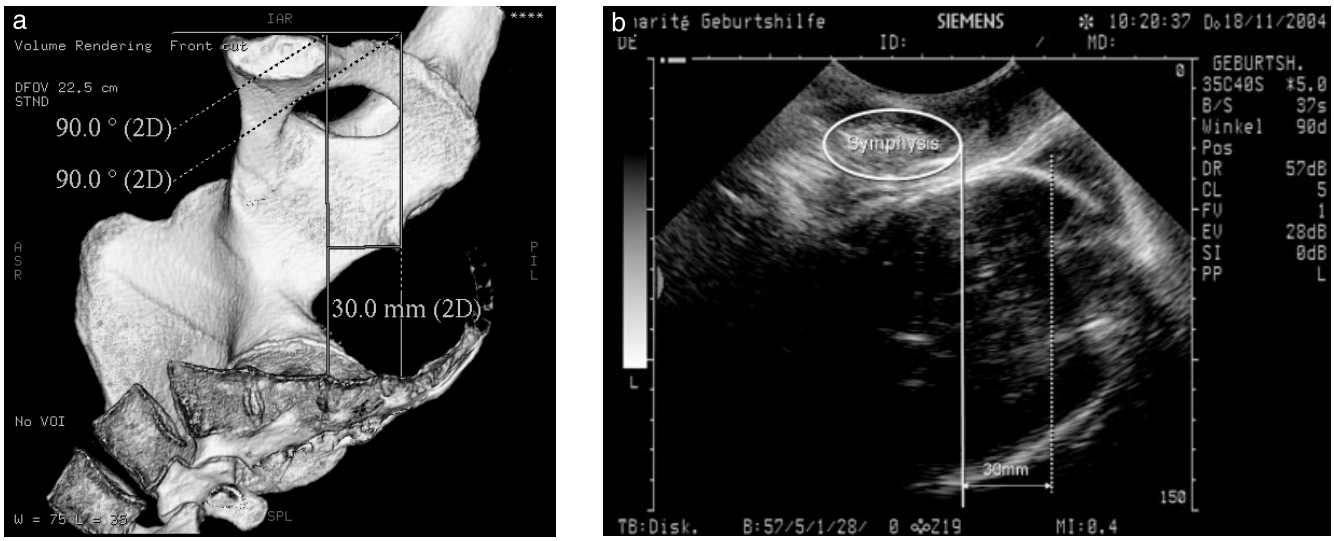

Figure 3 Correlation of intrapartum translabial ultrasound with computed tomographic (CT) reconstruction. (a) CT reconstruction of a normal female bony pelvis with the infrapubic line and the parallel line at the level of the ischial spines 3 cm in the caudal direction. (b) The parallel line running through the projected level of the ischial spines (dotted line) lies 3 cm caudal to the infrapubic line.

Table 1 Clinical characteristics, digital vaginal examinations, intrapartum translabial ultrasound (ITU) parameters and outcome of vacuum extractions in the study group ($n = 20$)

				Digital vaginal examination		*ITU*				
Case	*Age (years)*	G/P	*Indication for vacuum extraction*	*Station*	*Descent during pushing? (none/slight/ pronounced)*	*Descent during pushing?*	*Widest part below infrapubic line?*	*Head direction (up/horizontal/ down)*	*Vacuum extraction (simple/moderate/difficult)*	*Neonatal data: weight, head circumference, Apgar*, UA pH*
1	35	1/1	Path. CTG, failure to progress, o.p.	+1	Slight	Yes	Yes	Horizontal	Moderate (two tractions)	2900 g, 33 cm, 9-9-9, 7.27
2	22	1/1	Path. CTG, failure to progress	+2	Pronounced	Yes	Yes	Up	Moderate (two tractions)	2670 g, 33 cm, 6-8-9, 7.17
3	37	2/2	Failure to progress, o.p.	+1	None	No	No	Horizontal	Difficult (four tractions)	3890 g, 37 cm, 8-9-10, 7.21
4	36	1/1	Path. CTG, failure to progress	+2	Slight	Yes	Yes	Up	Moderate (two tractions)	3630 g, 36 cm, 9-10-10, 7.24
5	18	1/1	Failure to progress	+1	Slight	Yes	Yes	Horizontal	Difficult (four tractions)	2830 g, 33.5 cm, 9-9-10, 7.19
6	20	1/1	Path. CTG, meconium stained AF	+2	Pronounced	Yes	Yes	Up	Simple (two tractions)	3550 g, 35 cm, 4-7-8, 7.23
7	31	1/1	Path. CTG	+1	Pronounced	Yes	Yes	Horizontal	Moderate (two tractions)	2530 g, 33 cm, 8-9-10, 7.19
8	30	1/1	Failure to progress	+2	Slight	Yes	Yes	Up	Moderate (three tractions)	3300 g, 35.5 cm, 9-10-10, 7.28
9	26	1/1	Failure to progress	0	None	No	No	Down	Failure (three tractions), Cesarean	2675 g, 34.5 cm, 7-8-10, 7.17 (6 days in neonatal care unit)
10	27	1/1	Path. CTG	+4	Slight	Yes	No	Up	Simple (one traction)	3820 g, 36 cm, 8-10-10, 7.23
11	23	1/1	Path. CTG	+1	Slight	Yes	No	Up	Moderate (two tractions)	3120 g, 35.5 cm, 8-9-10, 7.17
12	34	1/1	Path. CTG, o.p.	+1	Slight	Yes	Yes	Horizontal	Difficult (four tractions)	3620 g, 33 cm, 9-10-10, 7.18
13	33	1/1	Path. CTG, failure to progress	+2	Pronounced	Yes	Yes	Up	Moderate (two tractions)	3360 g, 35 cm, 9-10-10, 7.27
14	29	1/1	Path. CTG, failure to progress	+1	Slight	Yes	Intermediate	Horizontal	Moderate (three tractions)	3410 g, 34.5 cm, 9-10-10, 7.24
15	32	1/1	Path. CTG	+2	Pronounced	Yes	Yes	Up	Moderate (three tractions)	3700 g, 35.5 cm, 7-8-9, 7.10
16	24	2/1	Path. CTG, failure to progress	+2	Slight	Yes	Yes	Up	Simple (two tractions)	3990 g, 37 cm, 9-10-10, 7.31
17	27	1/1	Path. CTG	+2	Pronounced	Yes	Yes	Horizontal	Simple (two tractions)	3750 g, 38 cm, 9-10-10, 7.28
18	28	1/1	Failure to progress	+2	None	No	No	Horizontal	Difficult (four tractions)	3710 g, 37 cm, 8-8-9, 7.25 (6 days in neonatal care unit)
19	23	1/1	Path. CTG	+2	Slight	Yes	Yes	Up	Simple (two tractions)	3500 g, 35 cm, 7-9-10, 7.24
20	32	1/1	Path. CTG, failure to progress	+3	Pronounced	Yes	Yes	Up	Simple (one traction)	2790 g, 33 cm, 9-10-10, 7.21

ITU parameters were noted at the height of pushing. *Apgar scores at 1, 5 and 10 min. Path. CTG, deep variable decelerations, terminal bradycardia or persistent tachycardia; G/P, gravidity/parity; o.p., occiput posterior; UA, umbilical artery.

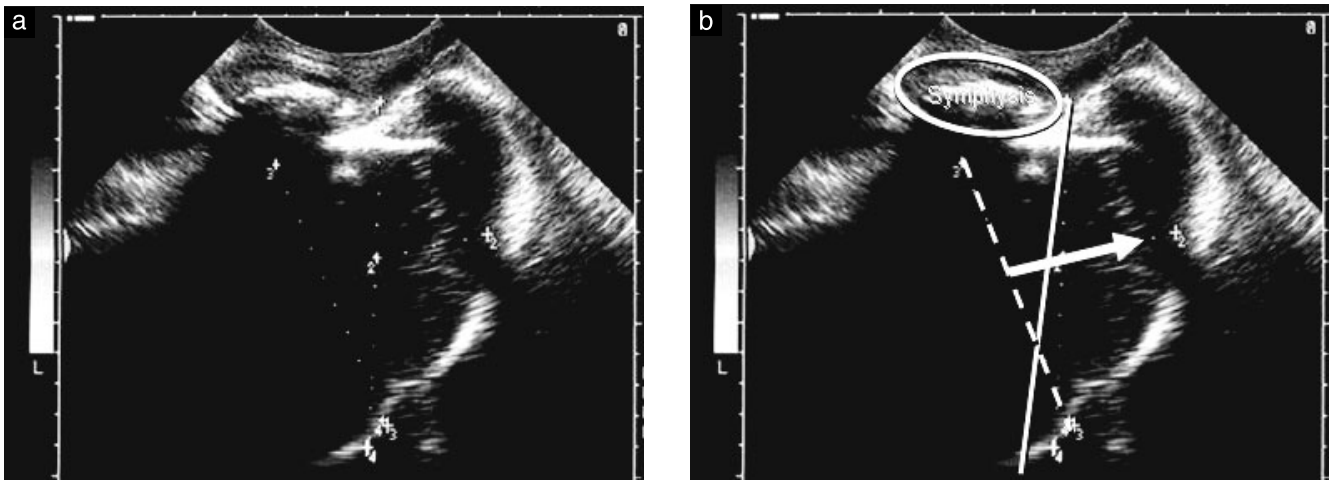

Figure 4 Intrapartum translabial ultrasound before difficult vacuum extraction (Case 18). Excessive configuration and large caput succedaneum suggested falsely a low head station (+2), while the largest diameter was above the infrapubic line. Head direction (arrow) was classified as horizontal. Solid line, infrapubic line; dashed line, greatest diameter of the fetal head.

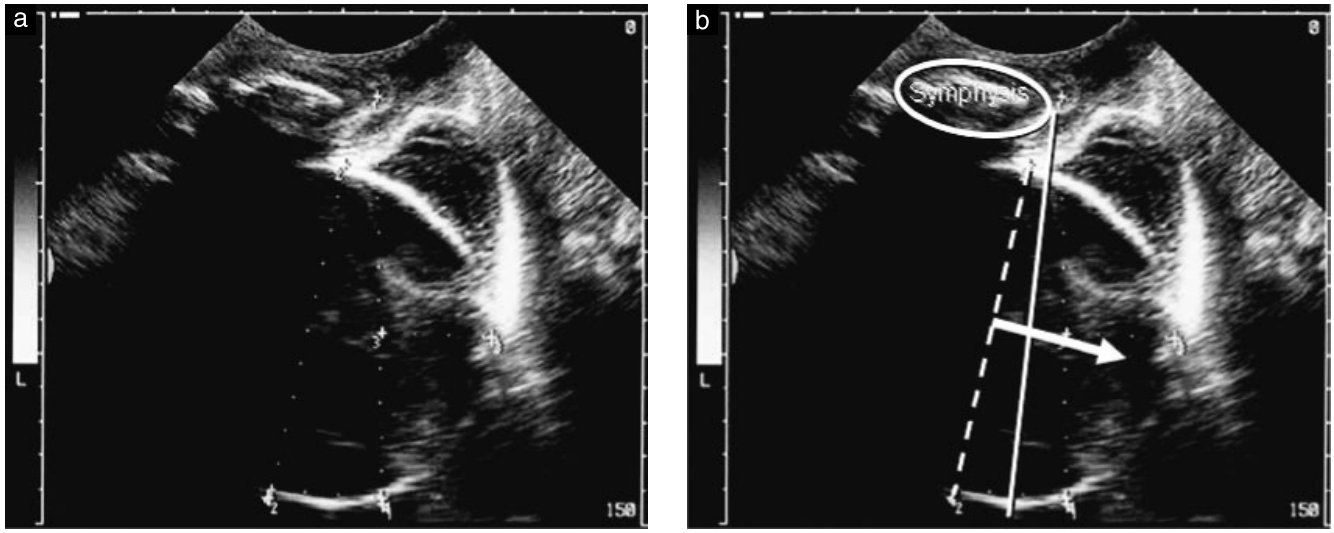

Figure 5 Intrapartum translabial ultrasound before failed vacuum extraction followed by Cesarean delivery (Case 9). Note the prominent caput succedaneum. Solid line, infrapubic line; dashed line, greatest diameter of the fetal head (here well above infrapubic line); arrow, direction of the fetal head (head down).

Excessive configuration and a large caput succedaneum suggested falsely a low head station (+2 by vaginal exam) while the largest diameter was still above the infrapubic line and, therefore, far above the mid-pelvis.

DISCUSSION

Clinically, engagement of the fetal head can be used as an 'internal pelvimeter' to determine whether the bony birth canal is sufficiently wide for an individual fetus[3]. We have developed a method with which to determine objectively, using ultrasound, fetal head engagement and direction in labor, aiding the assessment of birth progress at the level of the mid-pelvis. ITU can demonstrate dynamically and objectively fetal head engagement.

We used an intrapartum obstetric ultrasound reference plane, the mid-sagittal infrapubic plane[4,5], which has been used recently to assess fetal head station. Fetal head station as determined by translabial ultrasound before labor seems to be a robust measurement[2] and may even be used in combination with other clinical parameters near term to predict the risk for operative delivery[6]. We correlated the infrapubic line with a three-dimensional CT reconstruction of a normal female pelvis; this easily recognizable and accessible line on ITU lies 3 cm cranial to the level of the ischial spines.

The dynamic nature of ITU demonstrates objective descent, passage of the widest diameter of the fetal head below the infrapubic line and the fetal head direction. When there was no objective descent on ITU during pushing, vacuum extraction was either difficult (Cases 3 and 18) or failed altogether (Case 9). In these cases the digital vaginal examination had failed to demonstrate descent. However, based on the overall clinical impression, successful vacuum delivery had appeared possible.

There were only two cases in which there was descent on ITU, but the widest part of the fetal head was above the infrapubic line even at the height of pushing. Both resulted in successful vacuum deliveries. In three cases there was concordance of the poor prognostic variable 'no descent during pushing' between the vaginal exam and ITU. On clinical grounds, vacuum was still performed, but was difficult in two and unsuccessful in one case. ITU may have a role in supporting the certainty of the diagnosis of poor descent of the fetal head if vacuum delivery is contemplated.

Especially in protracted labor, the diagnosis of occiput posterior position by palpation can be difficult or impossible. Intrapartum ultrasound from an abdominal approach has been shown to be superior to vaginal palpation in the detection of occiput posterior position[7] and should be used if vaginal palpation is equivocal. In such cases, additional objective information from ITU might also be helpful, for example to demonstrate caput succedaneum. In our study there were only three occiput posterior cases, and ITU would not have contributed to the information available from palpation alone. It should be noted, however, that head direction was horizontal in all three of these cases.

Ultrasound has recently been used to improve the diagnosis of fetal head position. Several groups have reported that digital vaginal examinations for fetal head position are less accurate than is transabdominal ultrasound[8–13]. In the second stage of labor when the head is deeply engaged, transvaginal ultrasound has also proved accurate for determination of fetal head position, requiring the least time when compared with digital vaginal exam and transabdominal ultrasound[14]. One study has also used transperineal ultrasound[15]. Transabdominal ultrasound for fetal head position immediately before instrumental delivery showed its diagnostic superiority over digital vaginal exam[7]. Ultrasound has also been used to study the natural course of occiput posterior deliveries[12]. Transabdominal ultrasound is very reproducible between operators[16]. However, these studies have addressed head position. With regard to head engagement, there is good agreement between transabdominal ultrasound and vaginal palpation and less dependence on operator experience[10].

It is only very recently that ultrasound from a translabial approach has been studied to assess engagement objectively[2,6]. We used a very similar insonation, but performed the study in labor and observed the dynamic motion at the height of maternal pushing. We observed that when the widest diameter of the fetal head crosses the infrapubic line, and therefore, approaches or crosses the interspinous plane, and especially if the head direction is up, a favorable course of instrumental delivery is likely.

Our study was designed to avoid delay or bias of the clinically indicated obstetric management. This approach was confirmed by the umbilical artery pH values, all of which were found to be in the normal range for clinically indicated successful operative deliveries. Theoretically, there is room for bias in our analysis, as the operator performing ITU also performed the vaginal examinations and scored vacuum extractions carried out by the managing obstetrician. In a further ITU study, all digital vaginal study exams could be performed by an operator blinded to the results of ITU. It remains to be determined how ITU could be used to assess spontaneous deliveries.

Ultrasound now has an established role in the assessment of labor and delivery[17]. We present a simple approach to assess objectively and dynamically the fetal head position with respect to the birth canal in the context of instrumental delivery. We describe parameters of engagement and head position that were associated with successful operative vaginal delivery in cases of protracted labor. Additional prospective studies to further analyze the value of ITU, in both spontaneous and assisted deliveries, and to correlate ITU with clinical parameters, are needed.

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