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Research Article

The Sonopartogram: UltrasoundAssessment of the First Stage of Labor versus Vaginal Examination – A Prospective Comparative Study

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Abstract:

Background: Vaginal examination (VE) is the referencemethod for monitoring labor, but itis subjective, operator-dependent, uncomfortable, and carries an infectiousrisk. Transperinealultrasound (TPU) offers a non-invasive alternative. The aim of thisstudywas to describeultrasound aspects of laborparameters, compare themwithclinicalexamination, and propose a "sonopartogram".

Methods: This prospective, double-blind, comparative studywasconducted over 5 months (February–June 2025) at Nabeul regional Hospital, Tunisia. Weincluded 85 womenwith singleton pregnancy, cephalicpresentation, term ≥37 weeks, and earlylabor. Beforeeach routine VE, a TPU wasperformed to measure cervical length (CL), cervical dilatation (CD), head-perineum distance (HPD), posterior cervical angle (PCA), and fetalhead position. Agreement wasanalysed by Bland-Altman, correlation by Pearson's R, and qualitative concordance by Cohen's kappa.

Results: Among the 85 women, ultrasound images wereobtainablein 100% of cases for CL, CD, and HPD. For CL, good agreement wasfound (bias –0.05 cm; R=0.7). For CD during the active phase, the anteroposteriordiametershowed excellent correlation (R=0.93; bias 0.07 cm). For HPD, concordance wassatisfactory, especiallyduring the active phase. Fetalhead position waspoorlydetermined by VE (failure rate 86%, error 36%), whiletransabdominalultrasoundwas the best method. A two-phase sonopartogram (latent and active) wasdeveloped.

Conclusion: Transperinealultrasoundis reliable, reproducible, and non-invasive for monitoring the first stage of labor. The proposedsonopartogramcouldbecome a valuabletool in Tunisianmaternityunits.

Keywords: ultrasound, sonopartogram, labor, vaginal examination, cervical dilatation

Introduction

For decades, vaginal examination (VE) has been the onlymeans of monitoring laborprogress. It remains the referenceexamination for assessing cervical effacement, position, dilatation, as well as fetalheaddescent and rotation. The results are recordedprospectively on a partograminitiallyproposed by Friedman EA in 1954 [1-3]. In Africanhospitals, the partogramwasadapted as recommended by Philpott RH et al. in 1972 [4]. It is a simple, low-cost toolwith a good cost-effectiveness ratio, and it has reduced the frequency of prolongedlabor, postpartum hemorrhage, uterine rupture, puerperal infection, and maternal-perinatalmorbidity and mortality.

However, clinicalexamination has limitations. Severalstudies have reportedits subjective, operator-dependent nature withsignificant inter-examiner variability. This uncertainty can increase patient stress and lead to lack of confidence in the examiner [5]. Moreover, VE can beuncomfortable, especially if repeated, in the absence of analgesia, or in cases of a history of psychological trauma . VE alsoincreases the risk of chorioamnionitis and shortens the latency phase in pretermpremature rupture of membranes [6].

The World Health Organization (WHO) has recommendedlimiting the number of VEs duringlabor and starting the partogram at 3 cm, reservingexamination in the latent phase for particular situations (induction, artificial rupture of membranes, or epiduralanalgesia) [7]. However, these "particular" situations are far fromexceptional; the current induction rate in developed countries isestimated at 13-20% .

To overcome the limitations of clinicalexamination, the ultrasoundapproach for labor monitoring has emerged. Differenttools (2D and 3D ultrasound), different routes (transabdominal, transvaginal, transperineal), and variousalgorithms have been evaluated, but no consensus has been reached. The 3D approach has the main disadvantage of beingill-adapted to the delivery room, complex, and poorlyreproducible [8].

Primary objective:

To describe the ultrasoundfeatures of the most important parametersduring the first stage of labor.

Secondary objectives:

- To perform a comparative analysisbetweenultrasoundparameters and the referenceclinicalexamination.
- To develop an ultrasoundpartogram or "sonopartogram" adapted to ourmaternityunits.

Methods

2.1. Study Design

A prospective, double-blind, comparative study.

2.2. Setting

Department of Obstetrics and Gynecology, Nabeul regionalhospital, Tunisia (level 2B maternity unit, 3300 deliveries/year). The studyperiodwasfromFebruary 1 to June 1, 2025.

2.3. Participants

Eighty-five consecutiveparturientswereincludedaccording to the followingcriteria: singleton pregnancy, gestationalagebetween 37 and 42 weeks, cephalicpresentation, clinically normal pelvis, and earlylabordefined by regularpainfuluterine contractions associatedwith cervical changes [9].

Non-inclusion criteria: twinpregnancy, pathological pelvis, gestationalage<37 weeks, non-cephalicpresentation, contraindication to vaginal delivery.

Exclusion criteria: refusal to participate, unavailability of the ultrasoundoperator.

2.4. Variables

The primaryoutcomewas agreement between TPU and VE for measuring cervical dilatation. Secondaryoutcomesincluded cervical length, headdescent (head-perineum distance), posterior cervical angle, fetalhead position, and feasibility of the sonopartogram.

2.5. Data sources / measurement

Data werecollectedprospectively. Eachparturientunderwent TPU (low-frequency probe 3-5 MHz, Toshiba SSA-510 A and Logic 3 Expert) immediatelybeforeeach routine VE performed by the midwife. The time between the twoexaminationswaslessthan 5 minutes. Ultrasoundparameterswere:

- Head-perineum distance (descent) according to Dimassi et al. [10] . Figure 1A illustrates the methodologyadopted for the placement of the ultrasound probe. Figure 1B and Figure 1C show an example of the [P-P] distance measuredduringourwork and a demonstrative image of the obtained section, respectively.
- On the same image used to measure the [P-P] distance, the operatornoted the presence or absence of a chignon (caputsuccedaneum) as well as possible overlapping of the skullbones, as shown in Figure 2A and Figure 2B. Thesesignscouldalsobevisualised on another section, for example on a sagittal section (Figure 2C).
- Here, the probe wasplaced in the sagittal plane between the labia majora as shown in Figure 3A; vertical and lateralmovementstogetherwith fine angulations wereperformeduntil a satisfactory image of the cervix (internal os, external os and cervical canal) wasobtained. On the same section, the pubicsymphysis, the fetalhead and the lower part of the loweruterine segment wereobserved (Figure 3B, 3C)
- Posterior cervical angle (PCA) according to Rane et al. [11]. Using the samemethodology as for the measurement of cervical length and on the same image, weused the methodpreviouslydescribed by Rane SM et al. to measure the posterior cervical angle (PCA). This represents the angle formed by the posteriorlip of the cervix.Wethereforedeveloped a score according to the measured angle: for an angle <90°, the score was 0; for an angle between 90° and 120°, the score was 1; and for an angle >120°, the score was 2.
- Cervical dilatation (CD): during the latent phase, measurement of anteroposteriordiameter (APD), transverse diameter (TD), and theirmean; during the active phase, measurement of APD according to Hassan et al. [12]
- Fetalhead position by TPU thentransabdominalultrasound [13]

Clinicalexaminationfollowed WHO recommendations [7] and data wererecorded on a standard partogram [14].

2.6. Bias

The studywas double-blind (the ultrasoundinternwasunaware of the VE result, and the midwifewasunaware of the ultrasoundmeasurements). The very short intervalbetweenexaminationslimitedbias due to laborprogress. The ultrasoundoperatorwas a non-specialistintern to reflect real-life practice.

2.7. Study size

Among the 85 includedwomen, 183 pairs of examinations (clinical + ultrasound) wereanalysed, averaging 2-3 pairs per patient.

2.8. Continuous variables

Quantitative variables (CL, CD, HPD) wereexpressed as means ± standard deviation. Qualitative variables (cervical position, fetalhead position) wereexpressed as frequencies and percentages.

2.9. Statisticalmethods

Analysiswasperformedusing XLSTAT 2026. Agreement between the twomethodswasstudiedusing Bland-Altman analysis [15] and

correlationusingPearson's R [16]. For qualitative variables, Cohen's kappa coefficient wascalculated [17]. A p-value < 0.05 wasconsideredsignificant.

Results

Participants

A total of 85 womenwhocompleted follow-up wereincluded in the final analysis. Theirbaselinesociodemographic and obstetriccharacteristics are presented in Table 1.

Table 1. Characteristics of parturients (N=85)

Variable	Value
Age (years), mean ± SD	29.4 ± 5.2
Nulliparous, n (%)	45 (53%)
Multiparous, n (%)	40 (47%)
Gestationalage at delivery (weeks), mean ± SD	39.1 ± 1.3
Vaginal delivery, n (%)	67 (78.8%)
Caesarean section, n (%)	18 (21.1%)
Total number of VEs, mean (min-max)	18 (10-33)

Descriptive Data

Ultrasoundenabled a consistent and detailedassessment of cervical changes and fetalhead progression duringlabor.

The mean cervical lengthwas 1.04 cm (range: 0.15–2.69 cm). In womenwith intact membranes, the cervix showed a progressive morphologicalevolution, changingfrom a T shape to a Y shape, then to a V shape, and finally to a U shape. After membrane rupture, a characteristic "double superimposed V" pattern wasfrequentlyobserved.

Cervical dilatation wassuccessfullyassessed in all patients. During the latent phase, cervical openingwasinitiallyvisualized at the internal os and progressivelyextendedtoward the external os.

The progression distance of the fetalheadwasmeasurable in all cases, withcontinuousvisualizationthroughoutlabor progression.

Outcome Data

Agreement betweentransperinealultrasound (TPU) and vaginal examination (VE) wasevaluated for the main laborparameters.

Regarding cervical length, good agreement wasobservedbetween the twomethods, with a slightsystematicbias of –0.05 cm and limits of agreement rangingfrom –0.86 to 0.76. Correlationwasmoderate ($R = 0.70$; $p < 0.0001$).

For cervical dilatation, agreement variedaccording to the stage of labor. During the active phase, biaswas minimal (0.07 cm), withlimits of agreement rangingfrom –1.26 to 1.40 and a strongcorrelation ($R = 0.93$; $p < 0.0001$). During the latent phase, ultrasound-measureddiameters (anteroposterior, transverse, and meandiameters) showed good agreement with vaginal examination. Overall, cervical dilatation demonstrated excellent correlationbetween the twomethods ($R = 0.96$; $p < 0.0001$).

Assessment of fetalheaddescentshowedsatisfactory agreement between the two techniques, withgreateraccuracyduring the active phase and narrowerlimits of agreement.

The agreement betweentransperinealultrasound and vaginal examination for the main laborparametersissummarized in Table 2.

Table 2. Agreement betweentransperinealultrasound and vaginal examination

Parameter	Bias (95% CI)	Limits of agreement	Pearson's R	P
Cervical length (cm)	–0.05 (–0.13; 0.03)	]–0.86; 0.76[	0.70	<0.0001
Cervical dilatation – active phase (APD, cm)	0.07 (–0.08; 0.22)	]–1.26; 1.4[	0.93	<0.0001
Cervical dilatation – overall (cm)	0.23 (0.15; 0.31)	]–1.26; 1.4[	0.96	<0.0001
Head-perineum distance – active phase (cm)	–0.12 (–0.31; 0.07)	]–1.50; 1.26[	0.88	<0.0001

Main Findings

Ultrasoundassessment of cervical position (PCA) showedpoor agreement with vaginal examination (kappa = 0.24), suggestinglimitedreliability of clinicalassessment for thisparameter.

Regardingfetalhead position, vaginal examinationshowed a high failure rate (86%) and a diagnostic error rate of 36%. In comparison, transperinealultrasounddemonstrated high reliability, with no diagnostic errors. Transabdominalultrasoundappeared to be the most reliable method, with a verylowfailure rate and the highest diagnostic consistency.

The performance of the differentmethods for determiningfetalhead position ispresented in Table 3.

Table 3. Performance of methods for determiningfetalhead position

Method	Failure rate (%)	Error rate (%)
Vaginal examination (overall)	86%	36%
Transperinealultrasound	41%	0%
Transabdominalultrasound	3.5%	0%

Additional Analyses

Based on the combination of morphological and quantitative ultrasoundparameters, twosonopartogrammodelsweredeveloped, one for the latent phase and the other for the active phase of labor. Thesemodelsintegrate cervical morphology, cervical dilatation, fetalheaddescent, and fetalhead position. The proposedsonopartograms are presented in Figures 4–7 of the manuscript.

Discussion

Key results

In this prospective study, wedemonstratedthat TPU is reliable for measuring cervical length, cervical dilatation, and fetalheaddescent, with excellent correlationcompared to VE, particularlyduring the active phase of labor. Fetalhead position remainsdifficult to determine by the transperineal route, but transabdominalultrasoundis an excellent alternative.

Results in the context of existingliterature

Our results are consistent withthose of Hassan et al. (2013), whoshowedthatultrasound APD is reliable for measuring CD. The superiority of TPU over transabdominalultrasound for measuring CL wasreported by Dimassi et al. (2016) [18]. Assessment of descentusing HPD has been validated by severalauthors. The poor agreement for cervical position (PCA) is consistent with the work of Rane et al. [11] and Eggebø et al. [19]. Finally, the inability of VE to correctlydeterminefetalhead position has already been highlighted .

Strengths and limitations

Strengths: prospective double-blind study, use of standard equipment (accessible in Tunisia), non-specialistoperator (reflecting real-life practice), very short intervalbetweenexaminations.

Limitations: modestsample size (85 patients), single-centre, limitednumber of ultrasoundexaminations per patient (2-3), lack of multiple operators (no inter-observer variabilitystudy). Generalisabilityislimited to level 2B maternityunits.

Interpretation

Our findings support the use of TPU as an objective, non-invasive tool for monitoring labor. The proposedsonopartogramcouldadvantageously replace the classicalpartogram, pending validation by multicentre randomisedstudiesincluding more patients and operators.

Conclusion

This prospective studyconfirmsthattransperinealultrasoundis a simple, reproducible, non-invasive, and reliable method for monitoring the first stage of labor, with excellent agreement withclinicalexamination for cervical length, cervical dilatation, and fetalheaddescent. Fetalhead position is best determined by transabdominalultrasound. The proposed “sonopartogram” is a practical prototype adapted to Tunisianmaternityunits. Large-scalerandomised multicentre studies are neededbeforewidespreadimplementation.

Declarations

Ethicsapproval and consent to participate

This prospective studywasapproved by the local institutionalethicscommittee. Writteninformed consent wasobtainedfrom all participants prior to inclusion in the study.

Consent for publication

Not applicable.

Competinginterests

The authorsdeclarethatthey have no competinginterests.

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Availability of data and materials

The datasetsused and/or analyzedduring the currentstudy are availablefrom the correspondingauthor on reasonablerequest.

Authors’ contributions

HS contributed to data collection and manuscript drafting. MT contributed to study design, data analysis, and manuscriptrevision. All authorsread and approved the final manuscript.

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