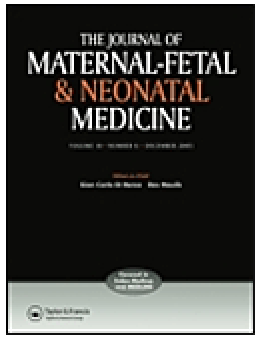

Automatic measurement of head-perineum distance during intrapartum ultrasound: description of the technique and preliminary results

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Keywords:	childbirth, intrapartum ultrasound, labor monitoring, head-perineum distance, transperineal ultrasound

Automatic measurement of head-perineum distance during intrapartum ultrasound: description of the technique and preliminary results

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Abstract

Objectives:

To evaluate the accuracy and reliability of a new ultrasound technique for the automatic assessment of the head-perineum distance (HPD) during childbirth.

Methods:

HPD was measured on a total of 40 acquisition sessions in 30 laboring women both automatically by an innovative algorithm and manually by trained sonographers, assumed as goldstandard.

Results:

A significant correlation was found between manual and authomatic measurements (Intra-CC = 0.994). High values of the coefficient of determination (r^2 = 0.98) and low residual errors: RMSE = 2.01 mm (4.9%) were found.

Conclusions:

The automatic algorithm for the assessment of the HPD represents a reliable technique.

Keywords: childbirth; intrapartum ultrasound; labor monitoring; medical decision support; head-perineum distance; ultrasonic imaging, transperineal ultrasound, automatic measurement

INTRODUCTION

Intrapartum ultrasound is increasingly performed in the routine practice, with the aim of supporting the clinical skills with a more objective and reproducible assessment tool [1-3]. The concept that fetal head position and station are more precisely identified by ultrasound than by clinical examinations is well established [4-7]. A better performance of the former approach for the prediction and the diagnosis of labor arrest is also acknowledged [8-9]. Moreover, it has been demonstrated that ultrasound imaging is valuable in predicting the outcome of instrumental vaginal delivery [10-14].

When using ultrasound in labor, the transperineal approach is commonly performed for the evaluation of the fetal head rotation and station[15]. The latter can be established by means of a series of quantitative parameters that have been proposed to define objectively the level of the presenting part within the birth canal [1-3,16-18]. Eggebø *et al.* [2] proposed the head-perineum distance (HPD), defined as the shortest distance from the outer bony limit of fetal skull to the perineum, while Barbera *et al.*[1] introduced the progression angle (PA), which is the angle between the long axis of the pubic symphysis and the line starting from the distal point of the symphysis and running tangentially to the leading part of the fetal skull.

A potential limitation to the use of labor ultrasound is represented by the lack of a simple method for the measurement of the sonographic parameters that seem relevant to refine the clinical management of labor. Actually, new approaches for the automatic measurement of PA during labor have been recently proposed[19-21], but, to the best of our knowledge, there are still no examples of similar systems dedicated to HPD assessment.

The aim of this feasibility study was to preliminarily assess the accuracy of a new algorithm for the automatic measurement of HPD during the second stage of labor.

METHODS

Patients

A non-consecutive series of pregnant women in the active second stage of labor were recruited for the study purpose. They were eligible if they carried a singleton pregnancy with fetuses in cephalic presentation, absence of documented fetal malformations and no history of previous Caesarean sections. The study was conducted at the Maternity Hospital of the Department of Medicine and Surgery of the University of Parma between February 2018 and February 2019. The enrolled women underwent the conventional labor management according to standard local procedures. The study protocol was approved by the local ethics committee of the University Hospital of Parma (270/2018/OSS/AOUPR) and a signed consent was obtained in all cases prior to enrolment.

Ultrasound assessment

Ultrasound acquisitions were performed using the SensUS Touch system (Amolab Srl, Lecce, Italy; www.amolab.it), an ultrasound portable system consisting of a tablet PC equipped with a 3.5-MHz convex transducer. Each acquisition was performed with the woman in a semirecumbent position, with legs flexed at the hips and knees at 45° and 90°, respectively [15]. The probe was transversally placed over the posterior fourchette, with the operator exerting a firm pressure but without creating discomfort to the patient. The transducer was angled until the skull contour appeared as clear as possible, indicating that the ultrasound beam was perpendicular to the fetal skull. All acquisitions were performed after the uterine contraction, within 1 minute after the peak intensity. When two different sonographic acquisitions were performed on the same patient, the corresponding time interval was variable and always established by the clinical staff.

Once the operator correctly identified the anatomical landmarks, a 5-second acquisition was started: 80 B-mode images were acquired (frame rate ~16 fps) and stored for the subsequent off-line analysis, in which each frame was automatically analysed by the algorithm. The algorithm automatically processed the images in order to calculate the HPD. These results were compared with those manually obtained by two experienced sonographers (AD and NV) who were blinded to the algorithm outcomes and who performed the measurements off-line on the same images analysed by the algorithm. Manual results obtained by the two different trained sonographers were assumed as the gold standard reference for the automated measurements.

The images collected during the first acquisition were processed through the automatic segmentation algorithm and a pattern tracking algorithm was used to analyse the images associated to the possible subsequent sessions acquired on the same patient.

Automatic HPD calculation

The algorithm computed the HPD value as the distance between the horizontal line tangent to the outer bony limit of fetal skull and the horizontal line drawn at the midpoint of the probe-tissue interface, corresponding to the maternal perineum (Figure 1).

To optimize the reliability of the automatic measurement and calculation procedure, the operators who performed the image acquisitions were asked to orientate the probe in a way such to display the fetal head in the central part of the field of view of ultrasound.

A schematic illustration of the algorithm is reported in Figure 2.

Each acquired image was analysed through the steps described below:

(1) *Image validation*, based on grey level and geometrical feature analysis. The aim of this phase was to verify the image suitability for the subsequent processing steps and to discard the images of insufficient quality;

(2) *Search for raw bone structures,* based only on pixel cluster positions and their grey level intensities (the clusters of pixels identified in this step may include artefacts due to noise);

(3) *Fetal head detection*, which occurred in two different ways, depending on the fact that the considered image belonged to the first acquisition session or to a subsequent acquisition session. In the former case, fetal head detection was accomplished through morphological image filters aimed at the automatic identification of the landmark bone structure, whereas in the latter case a pattern tracking approach was employed;

(4) Detection of the perineal interface central point, based on the geometrical features of the probe;

(5) *Co-registration of coordinates for fetal head and perineal interface,* aimed at the knowledge of the mutual position of the identified references;

(6) *HPD calculation,* as the distance between the central point identified on the semi-arc of the perineal maternal interface, and the horizontal axis passing from the leading edge of fetal skull. It represents the part of the birth canal yet to be passed by the fetus.

This process was applied to all the acquisition sessions and the obtained results were used to select a reference image as representative of the whole session. Actually, for each image belonging to the considered acquisition session, the algorithm calculated the values of HPD and the coordinates of the fetal head (centre, radius). The reference image was chosen as the one having the values of these parameters closest to the corresponding average values.

Data analyses was performed on a laptop equipped with an Intel i7 Core™ i7-3610QM processor at 2.3 GHz (8 GB of RAM, 64 bits). Using the approach validated in a previous paper [19], the pattern tracking algorithm demonstrated again to be a faster approach.

Statistical analysis

The correlation between the manual and the automatic measurements of the HPD was assessed through the calculation of the Intraclass Correlation Coefficient (Intra-CC), the coefficient of determination (r^2) and the RMSE (root mean square error). Furthermore, the agreement between the two methods was also assessed by calculating the paired difference for each measurement and by estimating the bias and 95% limits of agreement relative to the average measurement of both methods.

RESULTS

A cohort of 30 laboring women at the beginning of the active phase of the second stage of labor was recruited. The median gestational age at the recruitment was 40 weeks (range 35-41). Most of the women were nulliparous (24/30 or 80%), median BMI was 25 (16-40) and the median maternal age was 35 years (27-45). Overall, 23 women (77%) achieved spontaneous vaginal delivery, while instrumental vaginal delivery or Cesarean delivery were performed in 5 (16%) and in 2 cases (7%) respectively. A total of 40 transperineal sonographic acquisitions were carried out on the study population. The number of ultrasound acquisitions for each patient varied from 1 to 4: the majority of patients (24/30) were submitted to a single acquisition, 2 acquisitions or more were performed in the remaining six women. Transperineal measurement of the HPD was well tolerated by all the patients also thanks to the short duration of sonographic acquisitions. Indeed, the single sonographic acquisition lasted 5 seconds, with the probe in a fixed transversal transperineal position, and was followed by 20 seconds of fully automatic image processing.

A statistically significant correlation was found between the HPD measurements performed by the algorithm and those obtained by the expert manual segmentation. The results of the Inter-method agreement analysis are shown in Table 1 in which we can observe the optimal Intra-CC value of 0.994 and the bias and 95% limits of agreement relative to the average measurement of both methods (0.18 ± 3.16 mm), whose actual meaning is graphically illustrated in the measurement agreement plot (Figure 3). Finally the high values of the coefficient of determination ($r^2 = 0.98$) and the low residual error, RMSE = 2.01 mm (4.9%), confirmed the good accuracy provided by the automatic method.

DISCUSSION

Intrapartum ultrasound has been introduced in the last decade to evaluate the fetal head descent during labor [8-9,16-17.22-23]. Different sonographic parameters have proved to be more reproducible and reliable than digital examination is assessing the fetal station[4-7,24,] . Among them, the HPD and the AoP have been demonstrated to be more valuable than clinical skills in predicting the labor outcome and the failure of operative vaginal delivery [-10-13,24-29] . Based on the available literature, the routine measurement of the HPD has been recommended by the ISUOG guidelines on labor ultrasound before considering or performing an instrumental vaginal delivery[15]. However, the use of intrapartum transperineal ultrasound in clinical routine is still limited, mainly because of the lack of expertise in obtaining the proper images and in measuring the sonographic parameters. More recently, newly developed automated devices available in research settings have offered the opportunity to measure the fetal head progression in labor[19-21]. Such tools are operator-independent and in some instances may optimize the acquisition of the sonographic parameters of interest. With some devices more than one parameter can be obtained and calculated at once on the same scanning plane, so that the results of the ultrasound study can be more easily integrated and interpreted for clinical purposes.

The present study introduced a new methodology for the automatic measurement of the HPD during labor, according to the scanning technique originally proposed by Eggebø *et al.*[2] The algorithm for HPD calculation was constructed in accordance with a previously established approach which had been used for automatic assessment of the AoP and had been validated in a previous study [19].

More specifically, automatic segmentation and tracking algorithms were used to identify the reference anatomical landmarks which allow the automatic measurement of the HPD. This technique was applied to 40 transperineal axial ultrasound acquisitions and the corresponding results were compared with those obtained through the manual tracking of the same anatomic landmarks performed by an experienced operator. A strong and statistically significant correlation was found between the two methods.

In principle, we cannot exclude that during the image acquisition a small systematic error in the HPD measurement could be introduced by the variable degree of external compression of the soft tissues. However, considering that a firm pressure during the acquisition was applied, we can assume a good reproducibility of the measures.

During the implementation of the algorithm, in fact, a major simplification has been intentionally made. The fetal skull was approximated to a circumference, which is not strictly correct, but in order to calculate the HPD value, only the leading edge of the fetal skull has to be considered, and therefore we can assume this as a reasonable approximation. Furthermore, the same assumption had been made in the previous study in which the accuracy and reliability of a new ultrasound technique for automatic calculation of the progression angle during labor monitoring was demonstrated[19].

The fact that the fetal head was not always exactly in the center of the ultrasound image is not likely to have affected the HPD measurement, since the lines drawn by the software guaranteed that the distance from the leading edge of fetal skull and the central point of the maternal perineal interface was always correctly measured (Figure 1b).

In conclusion, our work has shown that the automated measurement of the HPD during labor is feasible and shows good correlation with gold standard manual measurement performed by senior experts. This newly developed algorithm has the potential to support clinicians in performing intrapartum ultrasound, which has been recently suggested to improve the the management of labor.

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Angeli Laura[1], collecting data, analysing data**,** writing the manuscript

Conversano Francesco[2], analysing data, statistical analysis, writing the manuscript

Dall'Asta Andrea[1]; collecting data, analysing data, statistical analysis, writing the manuscript

Eggebø Torbjørn[3], analysing data, writing the manuscript

Volpe Nicola[1], collecting data,

Simone Marta[4]; collecting data, analysing data

Pisani Paola[2]; collecting data**,** analysing data

Di Paola Marco[2]; collecting data

Sergio Casciaro[2] , analysing data, collecting data

Frusca Tiziana[1]; analysing data

Ghi Tullio[1] analysing data, writing the manuscript, devising the study project

Statement of Ethics

The research was conducted ethically in accordance with the **World Medical Association Declaration of Helsinki**.

Disclosure Statement

CONFLICTS OF INTEREST

F. Conversano, M. Di Paola, and S. Casciaro are shareholders of Amolab S.r.l., a National Research Council Spin-off company that may or may not benefit from the results of this study

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Tables

Table 1: Analysis of the differences in HPD measurements between expert manual segmentation and automatic algorithm (*n*=40)

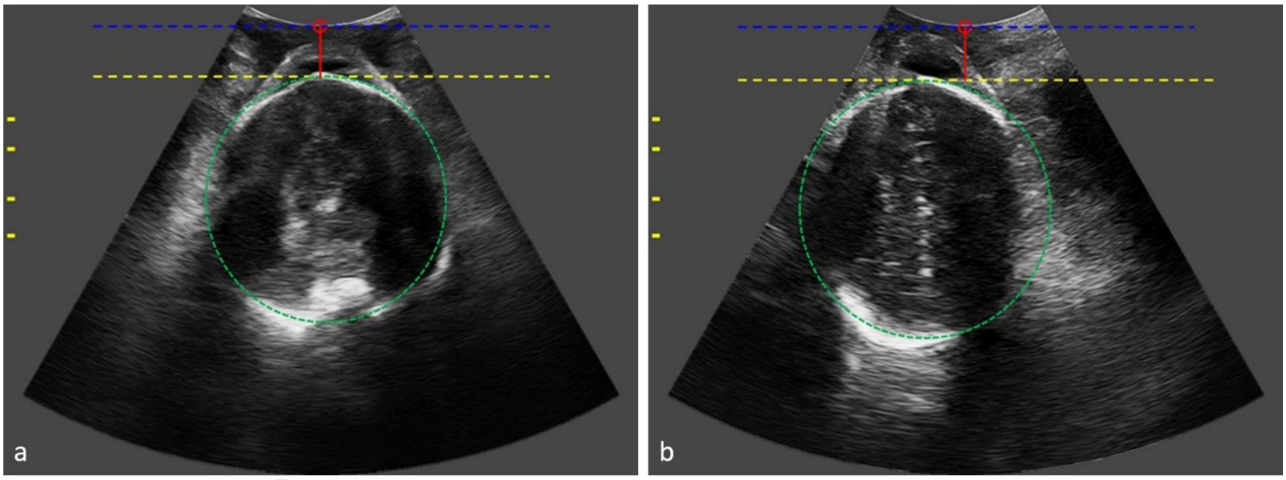
Difference between the two methods (mm)								
ICC	*Mean*	*95% CI of mean*	*1.96 SD*	*Lower limit*	*Upper limit*	*95% CI of lower limit*	*95% CI of upper limit*	*Range*
0.994	0.18	-0.33 to 0.67	3.16	-2.98	3.34	-3.86 to -2.09	2.45 to 4.22	-3.65 to 2.72

Figures legends:

Fig. 1. a) Automatic segmentation of a typical ultrasound image acquired transperineally on the axial plane: the HPD value is identified by the length of the vertical segment between the dotted lines; b) Example of automatic image segmentation when the fetal head was not in the center of the ultrasound image

Fig. 2. Schematic representation of the adopted algorithm for HPD calculation.

Fig. 3. Measurement agreement plot for the comparison of manually- and automatically-measured HPD values (dotted lines identify the 95% limits of agreement).



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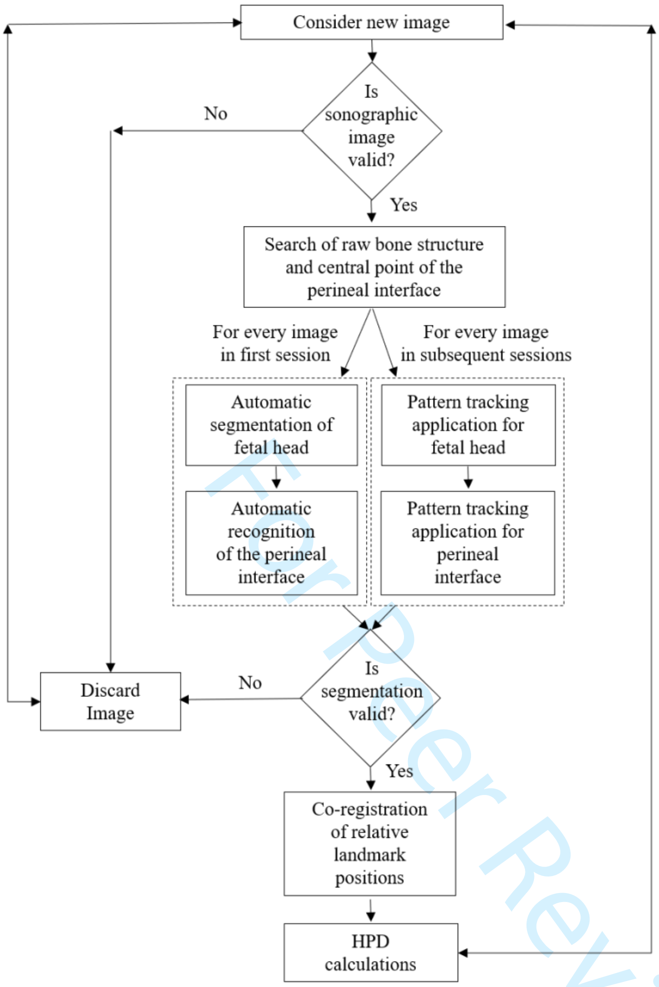

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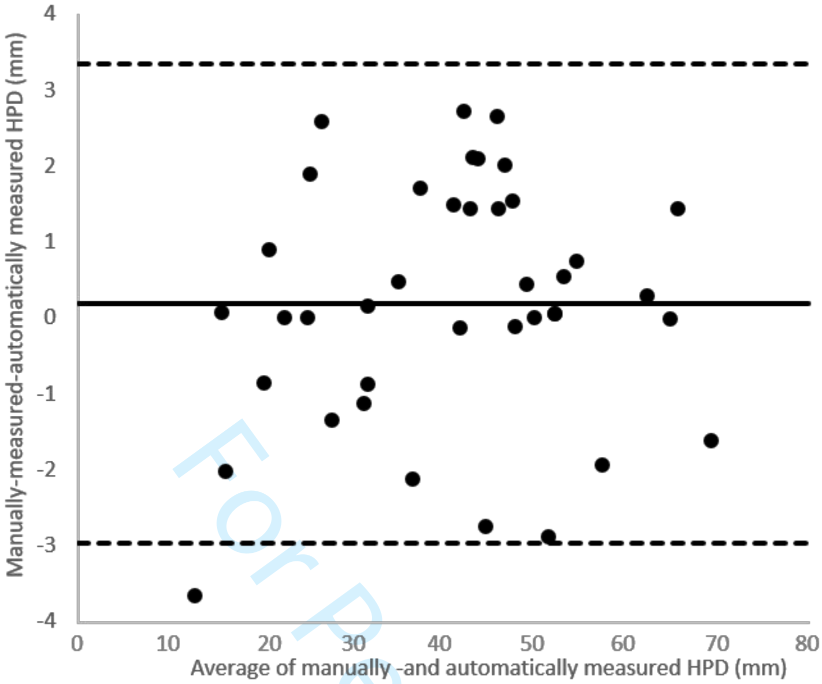

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Automatic HPD calculation

The algorithm computed the HPD value as the distance between the horizontal line tangent to the outer bony limit of fetal skull and the horizontal line drawn at the midpoint of the probe-tissue interface, corresponding to the maternal perineum (Figure 1).

To optimize the reliability of the automatic measurement and calculation procedure, the operators who performed the image acquisitions were asked to orientate the probe in a way such to display the fetal head in the central part of the field of view of ultrasound.

A schematic illustration of the algorithm is reported in Figure 2.

Each acquired image was analysed through the steps described below:

(1) *Image validation*, based on grey level and geometrical feature analysis. The aim of this phase was to verify the image suitability for the subsequent processing steps and to discard the images of insufficient quality;

(2) *Search for raw bone structures,* based only on pixel cluster positions and their grey level intensities (the clusters of pixels identified in this step may include artefacts due to noise);

(3) *Fetal head detection*, which occurred in two different ways, depending on the fact that the considered image belonged to the first acquisition session or to a subsequent acquisition session. In the former case, fetal head detection was accomplished through morphological image filters aimed at the automatic identification of the landmark bone structure, whereas in the latter case a pattern tracking approach was employed;

(4) Detection of the perineal interface central point, based on the geometrical features of the probe;

(5) *Co-registration of coordinates for fetal head and perineal interface,* aimed at the knowledge of the mutual position of the identified references;

(6) *HPD calculation,* as the distance between the central point identified on the semi-arc of the perineal maternal interface, and the horizontal axis passing from the leading edge of fetal skull. It represents the part of the birth canal yet to be passed by the fetus.

This process was applied to all the acquisition sessions and the obtained results were used to select a reference image as representative of the whole session. Actually, for each image belonging to the considered acquisition session, the algorithm calculated the values of HPD and the coordinates of the fetal head (centre, radius). The reference image was chosen as the one having the values of these parameters closest to the corresponding average values. ~~Additional details are provided in the supplementary material of this article.~~

Data analyses was performed on a laptop equipped with an Intel i7 Core™ i7-3610QM processor at 2.3 GHz (8 GB of RAM, 64 bits). Using the approach validated in a previous paper [~~19~~22], the pattern tracking algorithm demonstrated again to be a faster approach.

Statistical analysis

The correlation between the manual and the automatic measurements of the HPD was assessed through the calculation of the Intraclass Correlation Coefficient (Intra-CC), the coefficient of determination (r^2) and the RMSE (root mean square error). Furthermore, the agreement between the two methods was also assessed by calculating the paired difference for each measurement and by estimating the bias and 95% limits of agreement relative to the average measurement of both methods.

RESULTS

A cohort of 30 laboring women at the beginning of the active phase of the second stage of labor was recruited. ~~The features of the population chosen for this study are reported in table 1.~~ The median gestational age at the recruitment was 40 weeks (range 35-41). Most of the women were nulliparous (24/30 or 80%), median BMI was 25 (16-40) and the median maternal age was 35 years (27-45). Overall, 23 women (77%) achieved spontaneous vaginal delivery, while instrumental vaginal delivery or Cesarean delivery were performed in 5 (16%) and in 2 cases (7%) respectively.

A total of 40 transperineal sonographic acquisitions were carried out on the study population. The number of ultrasound acquisitions for each patient varied from 1 to 4: the majority of patients (24/30) were submitted to a single acquisition, 2 acquisitions or more were performed in the remaining six women ~~as shown on Table 2~~. Transperineal measurement of the HPD was well tolerated by all the patients also thanks to the short duration of sonographic acquisitions. Indeed, the single sonographic acquisition lasted 5 seconds, with the probe in a fixed transversal transperineal position, and was followed by 20 seconds of fully automatic image processing.

A statistically significant correlation was found between the HPD measurements performed by the algorithm and those obtained by the expert manual segmentation. The results of the Inter-method agreement analysis are ~~Inter-method agreement~~ shown in Table 1 in which we can observe the optimal Intra-CC value of 0.994 and the bias and 95% limits of agreement relative to the average measurement of both methods (0.18 + 3.16 mm), whose actual meaning is graphically illustrated in the measurement agreement plot (Figure 3). Finally the high values of the coefficient of determination (r^2 = 0.98) and the low residual error, RMSE = 2.01 mm (4.9%), confirmed the good accuracy provided by the automatic method. ~~The measurement agreement plot (Figure 3) demonstrated an overall mean difference in HPD measurement of 0.18 ± 3.16 mm.~~

DISCUSSION

Intrapartum ultrasound has been introduced in the last decade to evaluate the fetal head descent during labor [8-9,16-17.22-23][~~5,11-15,25,26~~]. Different sonographic parameters have proved to be more reproducible and reliable than digital examination is assessing the fetal station[4-7,24][~~1-5,27~~] . Among them, the HPD and the AoP have been demonstrated to be more valuable than clinical skills in predicting the labor outcome and the failure of operative vaginal delivery [~~16-19,27-30~~][10-13,24-29]. Based on the available literature, the routine measurement of the HPD has been recommended by the ISUOG guidelines on labor ultrasound before considering or performing an instrumental vaginal delivery[15][~~21~~]. However, the use of intrapartum transperineal ultrasound in clinical routine is still limited, mainly because of the lack of expertise in obtaining the proper images and in measuring the sonographic parameters. More recently, newly developed automated devices available in research settings have offered the opportunity to measure the fetal head progression in labor[~~23-24~~][19-21]. Such tools are operator-independent and in some instances may optimize the acquisition of the sonographic parameters of interest. With some devices more than one parameter can be obtained and calculated at once on the same scanning plane, so that the results of the ultrasound study can be more easily integrated and interpreted for clinical purposes.

The present study introduced a new methodology for the automatic measurement of the HPD during labor, according to the scanning technique originally proposed by Eggebø *et al.*[2] The algorithm for HPD calculation was constructed in accordance with a previously established approach which had been used for automatic assessment of the AoP and had been validated in a previous study [19]~~[23]~~.

More specifically, automatic segmentation and tracking algorithms were used to identify the reference anatomical landmarks which allow the automatic measurement of the HPD. This technique was applied to 40 transperineal axial ultrasound acquisitions and the corresponding results were compared with those obtained through the manual tracking of the same anatomic landmarks performed by an experienced operator. A strong and statistically significant correlation was found between the two methods.

In principle, we cannot exclude that during the image acquisition a small systematic error in the HPD measurement could be introduced by the variable degree of external compression of the soft tissues. However, considering that a firm pressure during the acquisition was applied, we can assume a good reproducibility of the measures.

During the implementation of the algorithm, in fact, a major simplification has been intentionally made. The fetal skull was approximated to a circumference, which is not strictly correct, but in order to calculate the HPD value, only the leading edge of the fetal skull has to be considered, and therefore we can assume this as a reasonable approximation. Furthermore, the same assumption had been made in the previous study in which the accuracy and reliability of a new ultrasound technique for automatic calculation of the progression angle during labor monitoring was demonstrated[19].

The fact that the fetal head was not always exactly in the center of the ultrasound image is not likely to have affected the HPD measurement, since the lines drawn by the software guaranteed that the distance from the leading edge of fetal skull and the central point of the maternal perineal interface was always correctly measured (Figure 1b4).

In conclusion, our work has shown that the automated measurement of the HPD during labor is feasible and shows good correlation with gold standard manual measurement performed by senior experts. This newly developed algorithm has the potential to support clinicians in performing intrapartum ultrasound, which has been ~~been~~ recently suggested to improve the the management of labor.

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Angeli Laura[1], collecting data, analysing data**,** writing the manuscript

Conversano Francesco[2], analysing data, statistical analysis, writing the manuscript

Dall'Asta Andrea[1]; collecting data, analysing data, statistical analysis, writing the manuscript

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Sergio Casciaro[2] , analysing data, collecting data

Frusca Tiziana[1]; analysing data

Ghi Tullio[1] analysing data, writing the manuscript, devising the study project

Statement of Ethics

The research was conducted ethically in accordance with the **World Medical Association Declaration of Helsinki**.

Disclosure Statement

CONFLICTS OF INTEREST

F. Conversano, M. Di Paola, and S. Casciaro are shareholders of Amolab S.r.l., a National Research Council Spin-off company that may or may not benefit from the results of this study

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Tables

~~**Table 1**: Characteristics of the study group (n=30)~~

~~**Table 2**: Distribution of the 40 performed acquisition sessions among the 30 enrolled patients.~~

Table 1~~3~~: Analysis of the differences in~~Intra-CC reproducibility of~~ HPD measurements between expert manual segmentation and automatic algorithm (*n*=40)

Difference between the two methods (mm)								
ICC	*Mean*	*95% CI of mean*	*1.96 SD*	*Lower limit*	*Upper limit*	*95% CI of lower limit*	*95% CI of upper limit*	*Range*
0.994	0.18	-0.33 to 0.67	3.16	-2.98	3.34	-3.86 to -2.09	2.45 to 4.22	-3.65 to 2.72

Figures legends:

Fig. 1. a) Automatic segmentation of a typical ultrasound image acquired transperineally on the axial plane: the HPD value is identified by the length of the vertical segment between the dotted lines; b). Example of automatic image segmentation when the fetal head was not in the center of the ultrasound image

Fig. 2. Schematic representation of the adopted algorithm for HPD calculation.

Fig. 3. Measurement agreement plot for the comparison of manually- and automatically-measured HPD values (dotted lines identify the 95% limits of agreement).

~~**Fig. 4:** Steps for the automatic identification of fetal head in a typical ultrasound image frame: (a,b) 'raw' identification of fetal head upper (a) and lower (b) edges, according to pixel position in the image and to their gray-level values, and conversion to a binary map; (c,d) median filter application and morphological evaluation on fetal head upper (c) and lower (d) edges; (e,f) hole-filling for fetal head upper (e) and lower (f) edges; (g) merging of fetal head structures; (h) determination of fetal head center and radius.~~

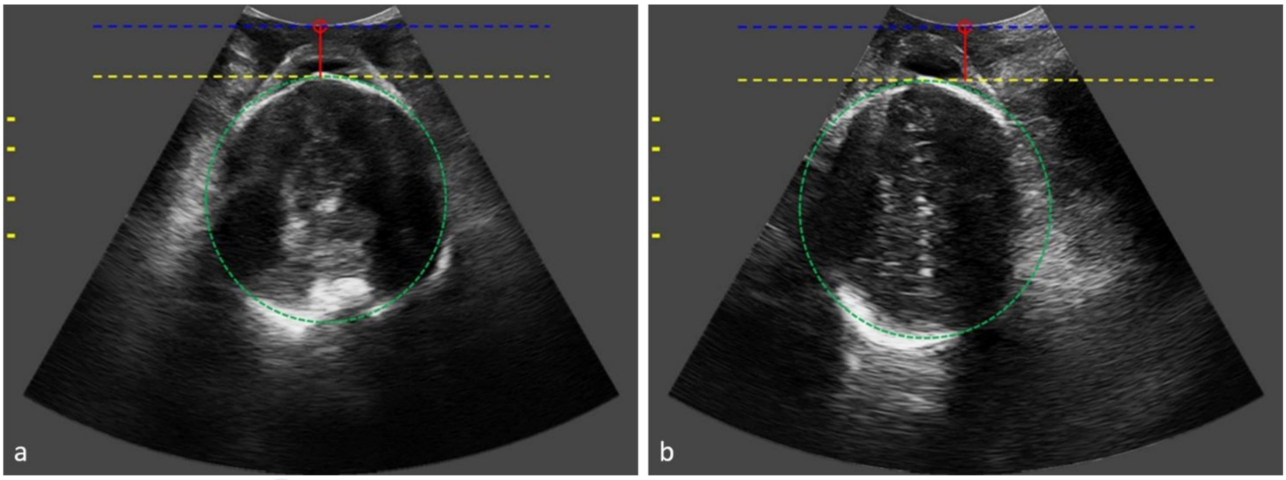

Fig. 1. a) Automatic segmentation of a typical ultrasound image acquired transperineally on the axial plane: the HPD value is identified by the length of the vertical segment between the dotted lines; b). Example of automatic image segmentation when the fetal head was not in the center of the ultrasound image

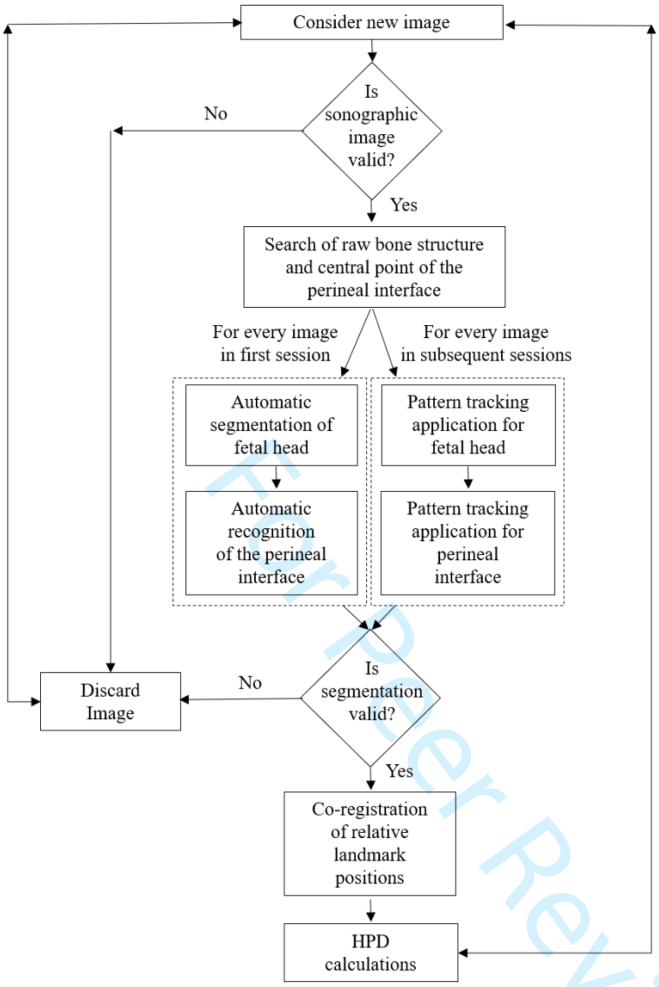

Fig. 2. Schematic representation of the adopted algorithm for HPD calculation.

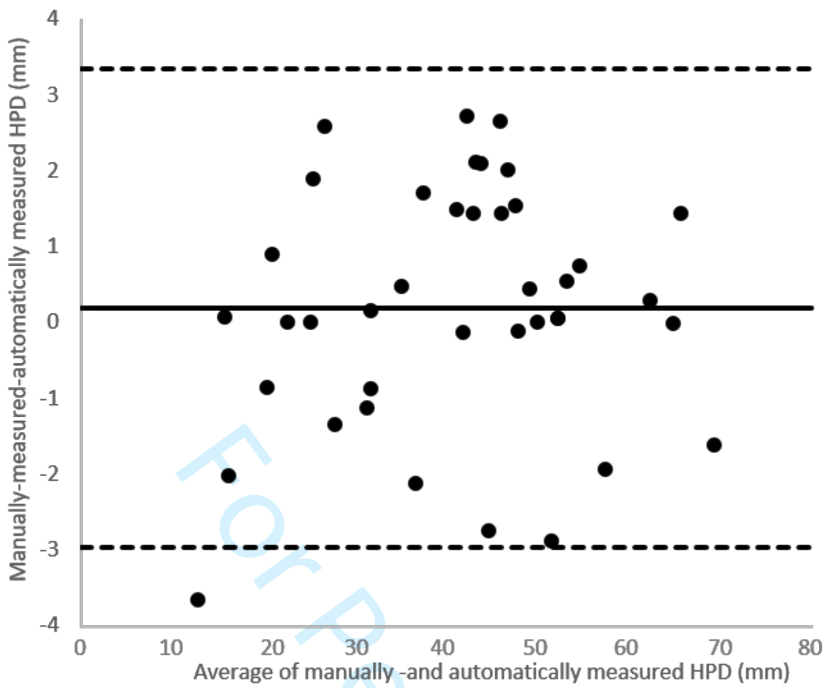

Fig. 3. Measurement agreement plot for the comparison of manually- and automatically-measured HPD values (dotted lines identify the 95% limits of agreement).

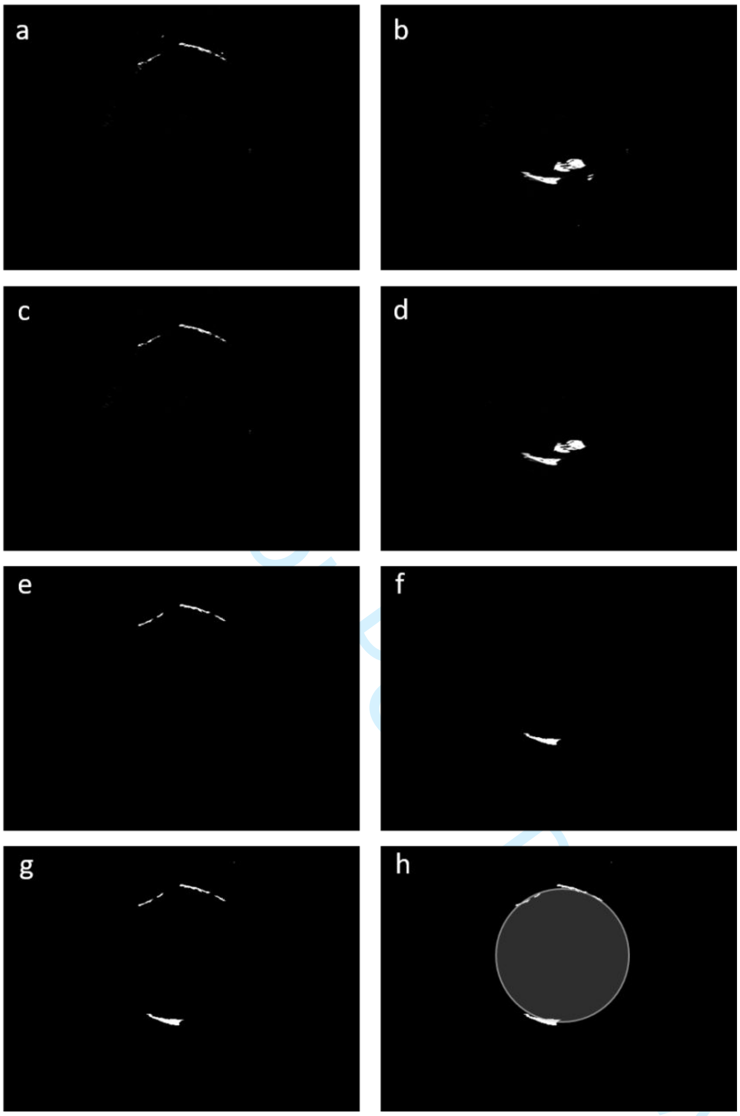

Fig. 4: Steps for the automatic identification of fetal head in a typical ultrasound image frame: (a,b) 'raw' identification of fetal head upper (a) and lower (b) edges, according to pixel position in the image and to their gray-level values, and conversion to a binary map; (c,d) median filter application and morphological evaluation on fetal head upper (c) and lower (d) edges; (e,f) hole-filling for fetal head upper (e) and lower (f) edges; (g) merging of fetal head structures; (h) determination of fetal head center and radius.

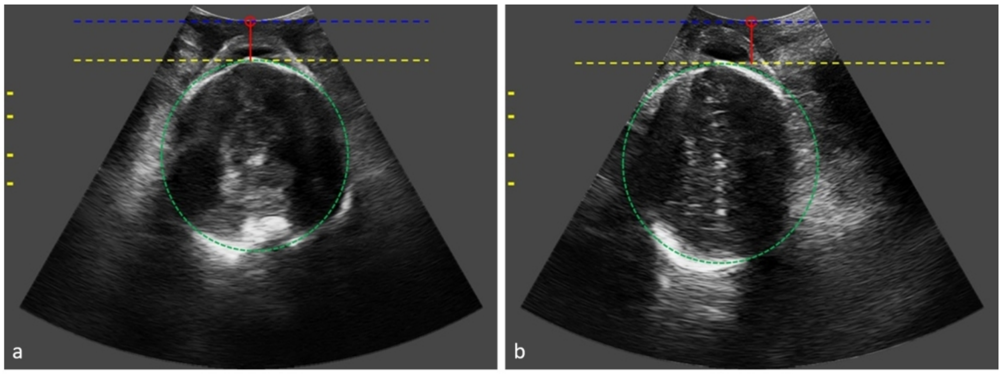

Fig. 1. a) Automatic segmentation of a typical ultrasound image acquired transperineally on the axial plane: the HPD value is identified by the length of the vertical segment between the dotted lines; b) Example of automatic image segmentation when the fetal head was not in the center of the ultrasound image

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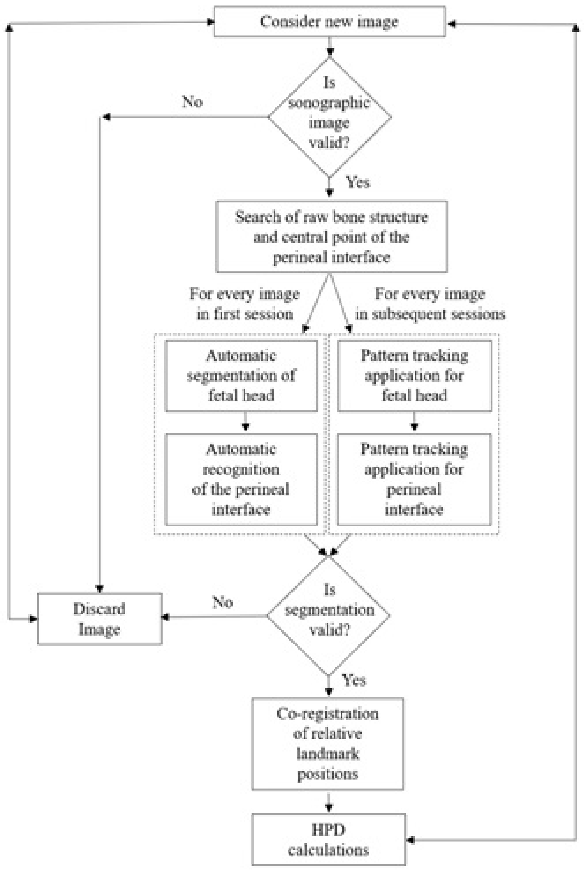

Schematic representation of the adopted algorithm for HPD calculation

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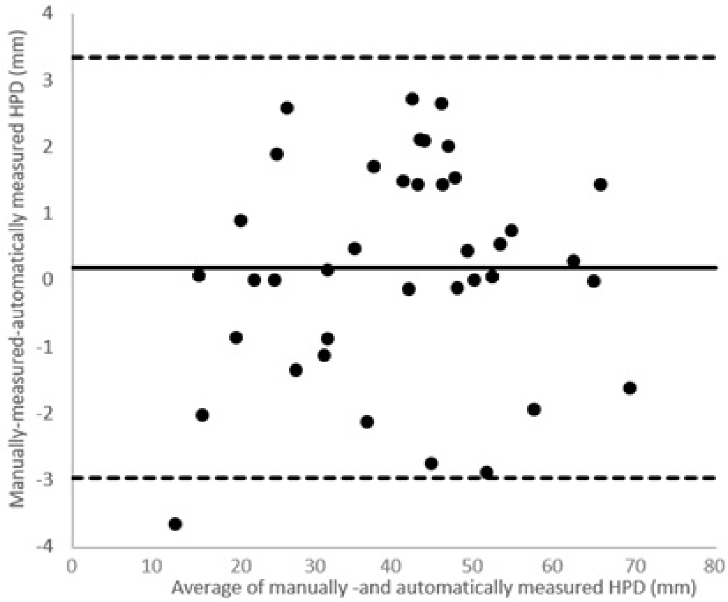

Measurement agreement plot for the comparison of manually- and automatically-measured HPD values (dotted lines identify the 95% limits of agreement).

150x129mm (96 x 96 DPI)

	Difference between the two methods (mm)							
CC	*ean*	*95% CI of mean*	*.96 SD*	*ower limit*	*pper limit*	*95% CI of lower limit*	*95% CI of upper limit*	*Range*
.994	.18	-0.33 to 0.67	.16	2.98	- .34	2.09 -3.86 to -	4.22 2.45 to	2.72 -3.65 to