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Full length article

Perineal body and anal sphincter biometrics and stiffness using elastography during labor: a feasibility study

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ABSTRACT

Objectives: The study aimed to evaluate the biometrics and stiffness of the perineal body and anal sphincter using 2D-mode ultrasound and shear wave elastography (SWE) during labor and to assess their association with perineal tears.

Methods: A prospective observational study was conducted on pregnant women. The perineal body (PB), the external anal sphincter (EAS), the internal anal sphincter (IAS) and the anal mucosa (AM) biometrics and stiffness were measured during labor using a transperineal 2D-mode ultrasound and shear wave elastography (SWE), respectively, at rest and during Valsalva maneuvers.

Results: Among the 10 women who underwent a vaginal delivery, 6 (60.0 %) perineal tears occurred. All were first degree perineal tears. Before expulsive efforts, the PB area at rest was statistically higher in women with perineal tears (1.0 ± 0.1 cm2 vs 0.3 ± 0.1 cm2, $p < 0.01$). The perineal body length, height and area seemed to decrease between the onset of labor and the beginning of expulsive efforts. The PB Youngs' modulus at rest at the onset of labor or before expulsive efforts were 11.9 ± 3.6 kPa and 25.7 ± 18.9 kPa, respectively. The PB elastic modulus at rest and at the onset of labor (11.3 ± 4.1 vs 12.9 ± 2.9 kPa, $p = 0.6$) or before expulsive efforts (18.0 ± 15.9 vs 37.4 ± 18.6 kPa, $p = 0.1$) tended to be higher in women with a perineal tear at delivery, but it was not statistically significant.

Conclusion: In vivo assessment of both the perineal body and anal sphincter biometrics and stiffness during labor in women is feasible. The perineal body area during labor could be a predictive factor for perineal tears, suggesting a potential link between its stiffness and tear risk.

Trial registration: The study was registered on https://clinicaltrials.gov (NCT05556304): https://classic.clinicaltrials.gov/ct2/show/NCT05556304.

Introduction

In the biomechanical context of vaginal delivery, the perineum undergoes morphological and dynamic modifications in response to fetal descent, depending on its biomechanical resistance to the exerted pressures [1]. The perineum thins under the fetal presentation induced by compressive forces, occasionally causing lacerations. The severity of perineal tears are classified according to the RCOG classification [2]. Severe perineal trauma such as obstetric anal sphincter injury (OASIS) stages III and IV occur between 0.25 and 6 % in the general population, between 1.4 and 16 % in primiparous patients and 0.4 and 2.7 % in multiparous patients [3]. These injuries are clinically significant, leading to complications such as anal incontinence, chronic perineal pain or sexual dysfunction [3–5].

During pregnancy, passive (extracellular matrix) and active (smooth muscle) properties of rat vaginas are significantly altered likely as a mechanism to increase vaginal distensibility and reduce the risk of a birth injury to the mother and fetus [6]. According to Buyuk et al.,

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pregnancy and delivery significantly modify the perineal body dimensions [7]. In-vivo assessment of perineal biomechanical properties are difficult because of ethical issues gathering human tissues. An innovative and non-invasive methods to obtain biomechanical properties of the perineum in women is shear wave elastography (SWE). It allows to determine tissue stiffness, similarly to palpation used in the physical examination [8]. Its reliability has been recently reported for levator ani muscle, the perineal body and the external anal sphincter (EAS) in women, including during pregnancy [9,10]. But the external and internal anal sphincter stiffness during labor has never been studied before, nor has the perineal body and anal sphincter biometry using 2D-mode ultrasound.

We hypothesized that perineal body and anal sphincter biometrics and stiffness during labor could be associated with perineal tears. The aim of this study was to evaluate de biometrics of the perineal body and anal sphincter using 2D-mode ultrasound and their stiffness using SWE during labor and to assess their association with perineal tears.

Materials and methods

Settings

This prospective observational and monocentric study was conducted in the department of Obstetrics and Gynecology of Besancon University Hospital (France) between January 2023 and August 2023.

Population

Pregnant women over 18 years old, volunteers, with a normal singleton pregnancy, non in labor and who agreed to participate in the study were recruited during their ninth prenatal visit. The exclusion criteria were as follows: women with a history of pelvic floor disorder (urinary incontinence, anal incontinence and/ or pelvic organ prolapse, history of genital excision, women with a body mass index (BMI) higher than 35 kg/m^2, women with a chronic muscular disease or connective tissue disease, women with a psychiatric pathology requiring a hospitalization and women unable to understand the French language.

Women were informed of the study during a prenatal visit by their obstetrician and/or midwife. Eligible women were contacted by the investigator to further inform them about the study and to include them if they were volunteers. Pregnancy follow-up was carried out as usual, without any modification of the latter. The delivery was conducted in the usual way with the midwife and the obstetrician if necessary. None of the measures impacted the delivery progress. During deliveries, the fetal head was usually supported by the accoucheur through the perineum during expulsion. After the head restitution, the Couder's maneuver (delivery of the anterior arm) was usually performed.

Data collection

Each recruited patient's demographic and obstetrical data were retrieved from electronic medical chart. During their ninth prenatal visit, the following demographic and obstetrical data were collected from the medical record: age, height, current weight, gestational age, skin phototype according to the Fitzpatrick classification, smoking during pregnancy and the uterine height.

During delivery, obstetrical data were collected such as follow: spontaneous or induced labor, no analgesia, epidural analgesia or end-of-labor spinal anesthesia, duration of the active phase of labor, duration of the second stage of labor (descent phase and expulsion phase), duration of the expulsion phase (duration between the onset of pushing efforts and birth, in minutes), delivery mode (spontaneous vaginal delivery, instrumental vaginal delivery or caesarean section), performance of Couder's maneuver, performance of an episiotomy, diagnosis of a perineal tear or not according to the RCOG classification [3], and diagnosis of anterior perineal tear. The following neonatal characteristics were collected from the medical record: neonatal weight, height and head circumference.

Ultrasound B-mode assessment of the perineum

Once the woman who was recruited during their ninth month of pregnancy was in labor, two B-mode ultrasound assessment of the perineum was performed with the AIXPLORER device (Supersonic™ MACH30 Imagine, C6-1X probe, Supersonic, Aix-en-Provence, France) in a gynecological position: once at the onset of labor (before 5 cm of cervix dilatation) and one just before the pushing efforts (usually after 2 h at 10 cm of cervix dilatation for multiparous woman and 3 h for nulliparous). Ultrasound B-mode characteristics of the anal sphincter and the perineal body were studied in B-mode ultrasound at rest by a translabial perineal approach described by Dietz et al., Asfour et al. and Rostaminia [10–12] (Fig. 1). The perineal body (PB) length, height and area were measured in the sagittal plane. The external anal sphincter (EAS), interna anal sphincter (IAS) and anal mucosa (AM) anteroposterior and lateral diameters were measured in the transversal plane. EAS and IAS thicknesses were measured at 12o'clock from its outer to inner border in the transversal plan. Measurements were made 5 times at rest. A mean value was then calculated for each variable.

Shear wave elastography assessment of the perineum

In the same time, two SWE assessment of the perineum was performed once at the onset of labor (before 5 cm of cervix dilatation) and one just before the pushing efforts (usually after 2 h at 10 cm of cervix dilatation for multiparous woman and 3 h for nulliparous). The ultrasound shear wave elastography is a method to determine tissue stiffness in real time [8,13]. In this technique, ultrasound induces the propagation of a shear wave along the main axis of the ultrasound probe. The propagating speed [14] of the generated shear wave is reported in meters per second (m/s) but can also be converted to elastic modulus values in kilopascals (kPa) by applying the formula $E = 3\rho Vs^2$, where E is tissue elasticity, Vs is the shear wave speed, and ρ is the density of tissue in kg/m^3. Making the assumption that the tissue is considered incompressible, the density ρ remains constant and the fomlula becomes E = 3Vs2. The speed of the wave's propagation is correlated to the shear modulus and the tissue stiffness. The stiffer the tissue is, faster the wave's propagation is. SWE device produces a color-coded quantitative map of tissue elasticity in kPa.

Perineal SWE measurements were performed with the AIXPLORER device (Supersonic™ MACH30 Imagine, C6-1X probe, Supersonic, Aix-en-Provence, France) in a gynecological position. For imaging, the probe was placed on vulvar fourchette while avoiding any pressure on the tissue, as excessive pressure applied by the probe could interfere with measurements [15]. A B-mode ultrasound was always performed before SWE measurements to identify PB, EAS, IAS and AM. Then, measurements were performed according to Gachon et al. [16,17] for the EAS and Rostaminia et al. and Chen et al. [10,18] for the PB. The SWE measurements of the IAS and AM were performed using the same technique. For the PB, the region of interest (ROI) was manually drawn over its global area (Fig. 2). An homogeneous circular ROI manually drawn along the margin of the structure being evaluated from its outer to inner border at 12o'clock for the EAS, IAS and AM. Measurements were made 5 times at rest and 5 times during 5-second Valsalva maneuvers. Mean values at rest and during the Valsalva maneuvers were then calculated for each variable.

The Aixplorer® device provided elastic modulus assessment (kPa) within the ROI. Larger elastic modulus indicates that the tissue is associated with greater stiffness.

Statistical analysis

Continuous variables were reported as means and standard

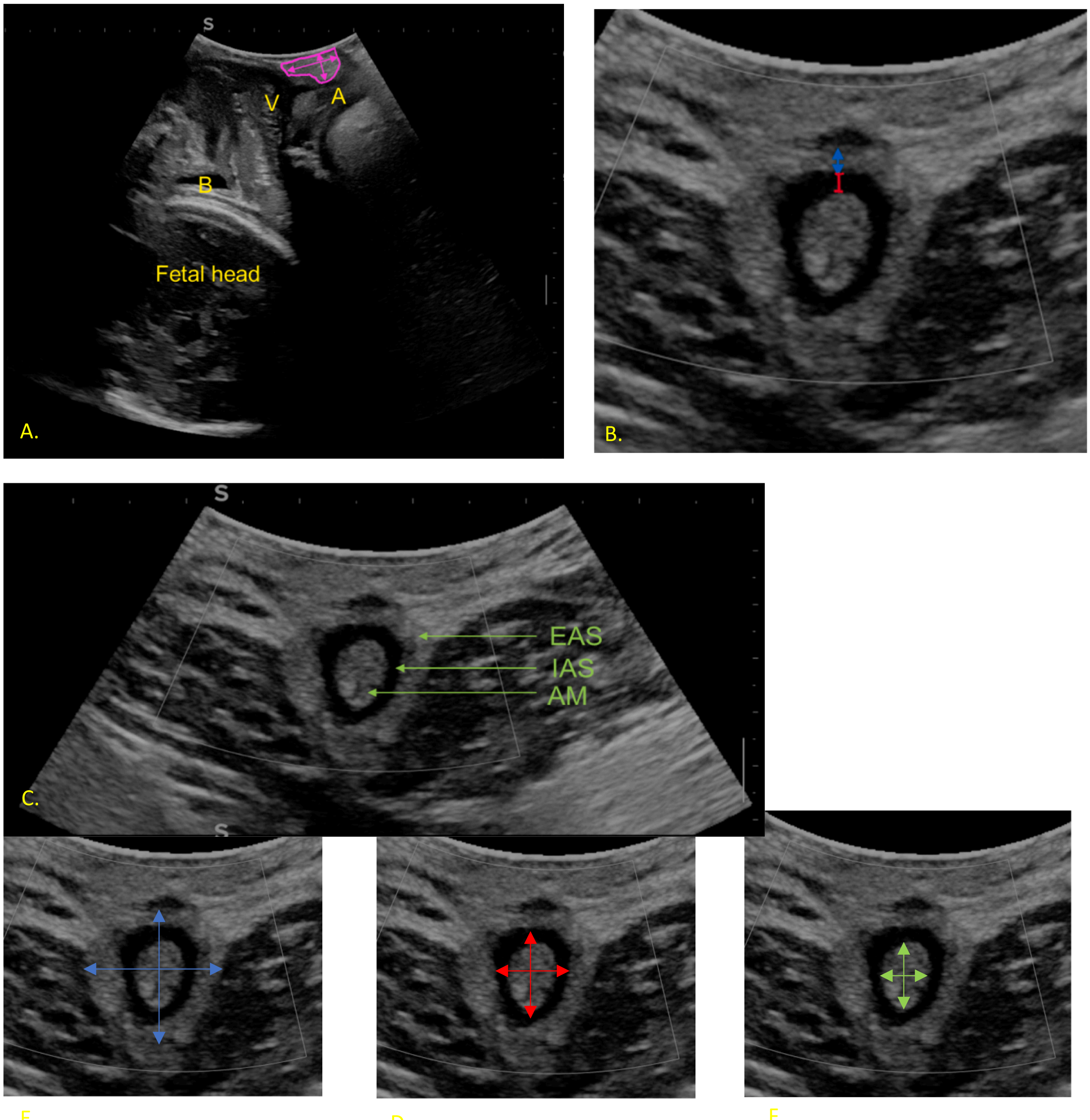

Fig. 1. Perineal body, anal sphincter and anal mucosa biometrics using B-mode Ultrasound with a transperineal approach (Supersonic™ MACH30 Imagine, Aix-en-Provence, France). Pelvic and perineal anatomy in sagittal plane. B: Bladder, V: Vagina, A: Anal canal. Pink marks: perineal body assessment in sagittal plane (its length, height and area). External anal sphincter thickness measured (blue mark) at 12o'clock and internal anal sphincter thickness measured at 12o'clock (red mark). Anal sphincter anatomy in transversal plane. EAS: External anal sphincter, IAS: Internal anal sphincter, AM: Anal mucosa. Anteroposterior and lateral diameters of the external anal sphincter. Anteroposterior and lateral diameters of the internal anal sphincter. Anteroposterior and lateral diameters of the anal mucosa. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

deviations. Categorical variables were reported as numbers and percentages. Demographic and obstetrical characteristics were compared between women with perineal tears at delivery (regardless of severity) and those with an intact perineum using a Student *t*-test or a Fisher test when data were quantitative or qualitative, respectively. The association between perineal B-mode ultrasound biometrics or SWE measurements with perineal tears at delivery was assessed using Student *t*-test. A Pearson correlation was calculated to evaluate a correlation between the PB area and PB elastic modulus.

Statistical analyses were performed with R software (version 4.3.0). For all analyses, significance was considered for $p < 0.05$.

Ethics consideration

The investigator orally informed and provided a written information to each woman prior to inclusion in the trial. To participate in the trial, the woman gave an informed consent. This study was approved by an ethical committee (Comité de Protection des Personnes SUD EST III) and is referenced with the ID RCB 2022-A01117-36. Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

Results

During the study period, 32 women were approached and 18 (56.3 %) women were included in the study. Then 8 women were excluded from the results because of 2 cesarean section deliveries and 6 were lost to follow-up because of unavailability of healthcare professionals (Fig. 3). Demographic and obstetrical characteristics of the 10 women who sustained a vaginal delivery are compared in Table 1. Four (40.0 %)

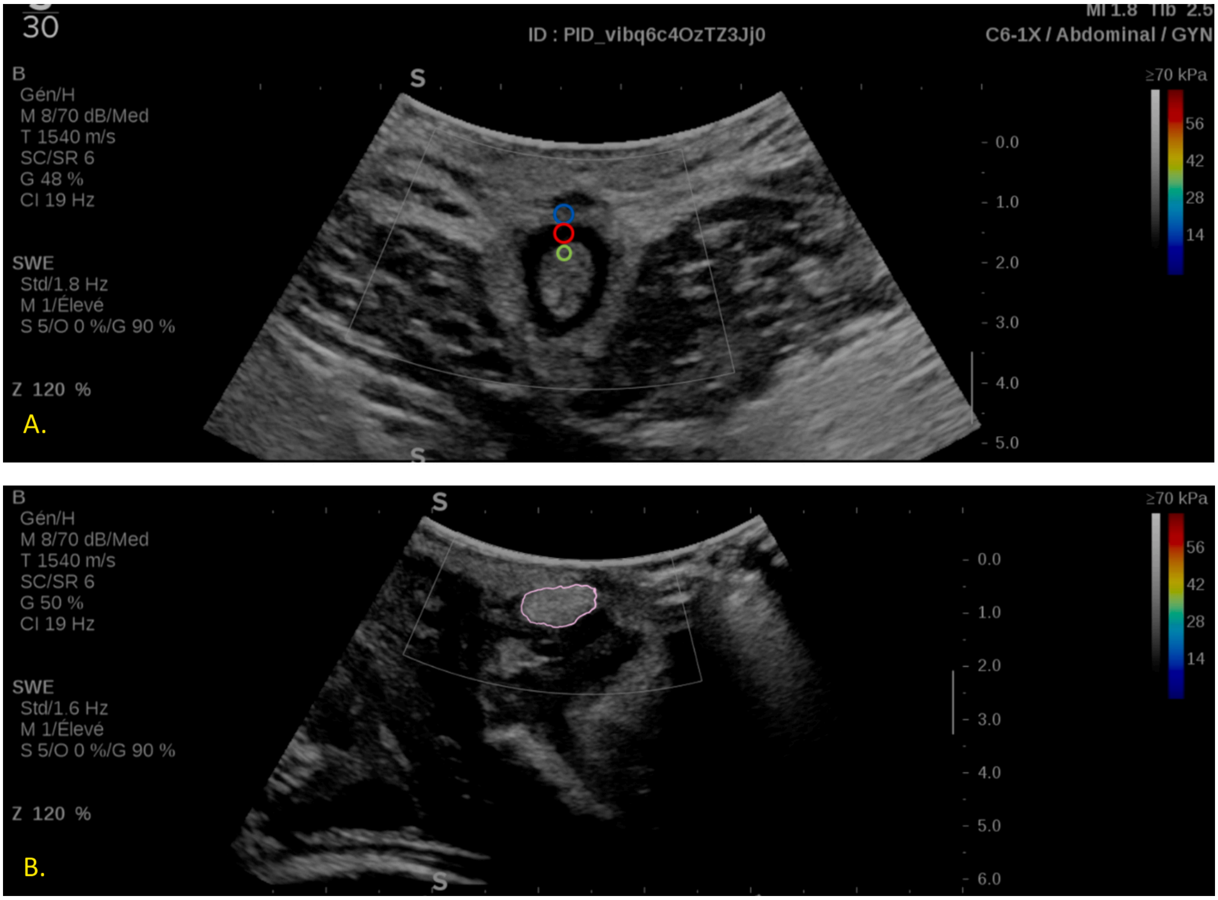

Fig. 2. Perineum assessment using Shear Wave Elastography (Supersonic™ MACH30 Imagine, Aix-en-Provence, France) using a transperineal approach. A. Transversal plane. B. Sagittal plane. Pink area: perineal body assessment. Blue circles: external anal sphincter assessment at 12o'clock. Red circles: internal anal sphincter assessment at 12o'clock. Green circles: anal mucosa assessment at 12 9o'clock. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

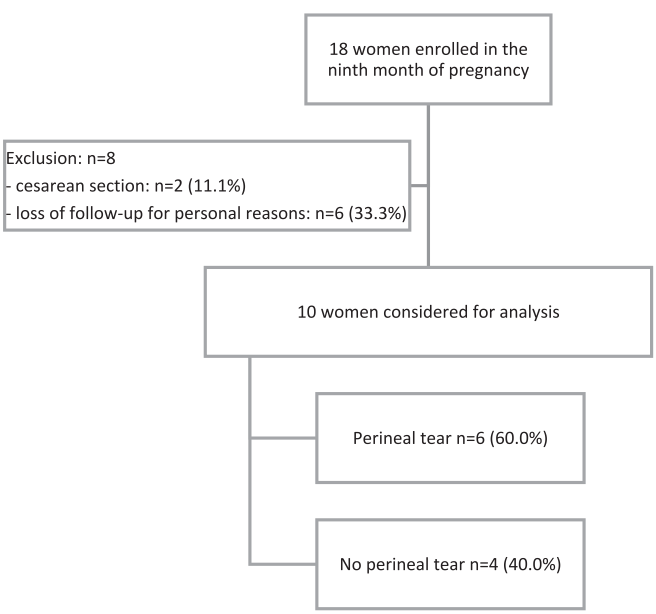

Fig. 3. Flow chart.

women were nulliparous. Among the 10 women who underwent a vaginal delivery, 6 (60.0 %) perineal tears occurred. All were first degree perineal tears. Women with a perineal tear had a higher body mass index (26 ± 3.7 kg/m^2 vs 20.5 ± 1.3 kg/m^2, $p = 0.01$). Before expulsive efforts, the PB area at rest was statistically higher in women with perineal tears (1.0 ± 0.1 cm^2 vs 0.3 ± 0.1 cm^2, $p < 0.01$) (Table 2). The perineal body length, height and area seemed to decrease between the onset of labor and the beginning of expulsive efforts. The lateral diameter of the EAS tend to increase a few millimeters before the beginning of expulsive efforts and tend to be higher before the expulsive efforts in women with perineal tears (2.9 ± 0.1 cm vs 3.3 ± 0.4 cm, $p = 0.07$). No other B-mode ultrasound measurements of the perineum at the onset of labor or before expulsive efforts were statistically different between women who had a perineal tear and those who did not.

Among the 10 women, the PB Youngs' modulus at rest at the onset of labor or before expulsive efforts were 11.9 ± 3.6 kPa and 25.7 ± 18.9 kPa, respectively. The PB elastic modulus at rest and at the onset of labor or before expulsive efforts tended to be higher in women with a perineal tear at delivery, but it was not statistically significant (Table 3). The EAS, IAS and AM elastic modulus at rest and at the onset of labor or before expulsive efforts tended to be lower in women with a perineal tear at delivery, but it was not statistically significant. Elastic modulus of the perineum during the Valsalva maneuver were not statistically different between women with or without a perineal tear. No correlation between the PB area and PB elastic modulus at rest and at the Valsalva maneuver was found ($p > 0.05$).

Table 1
Comparison of demographics and obstetrical characteristics between women who had a perineal tear or not during their vaginal delivery.

	Perineal tears		p-value
	No (n = 4)	Yes (n = 6)	
Age (y)	31.5 ± 1.7	27.2 ± 4.7	0.08
Parity	0.7 ± 0.5	0.7 ± 0.8	0.8
BMI (kg/m^2)	20.5 ± 1.3	26 ± 3.7	0.01
Cutaneous phototype	3.2 ± 1.7	2.8 ± 1.0	0.7
Tabacco use	0	0	/
Perineal massage	1 (25)	0	0.4
Birth Gestational age (weeks)	39.6 ± 1.0	40.2 ± 1.5	0.3
Uterine length (cm)	32.0 ± 1.1	32.2 ± 0.4	0.8
Inducted labor	0	1 (16.7)	1
Peridural analgesia	4 (100)	6 (100)	/
Active labor (5–10 cm) duration (min)	103 ± 94.8	246.7 ± 234.6	0.2
Labor second stage (10 cm-delivery) duration (min)	110.7 ± 58.8	170.7 ± 160.7	0.4
Pushing duration (min)	6.5 ± 3.8	14.2 ± 12.4	0.2
Mode of delivery			0.2
Normal VD	4 (100)	5 (83.3)	
Assisted VD		1 (16.7)	
Episiotomy	0	0	/
Couder's maneuver	4 (100)	6 (100)	/
Perineal tear degree			/
First degree	0	6 (100)	
Second degree	0	0	
OASIS	0	0	
Labia minora tear	0	3 (50)	0.2
Birth weight (g)	3335.0 ± 537.4	3608 ± 325.9	0.4
Head circumference (cm)	34.0 ± 1.4	34.8 ± 1.7	0.4

Data are expressed as mean ± SD or number of cases (percentage).
BMI: body mass index; VD: vaginal delivery; OASIS: obstetrical anal sphincter injury.

Table 2
Comparison of perineal biometrics at rest and during labor according to the occurrence or not of a perineal tear during vaginal delivery.

	Perineal tear		p-value
	No (n = 4)	Yes (n = 6)	
Perineal body			
Length (cm)			
BL	1.2 ± 0.1	1.2 ± 0.3	0.7
BEE	0.8 ± 0.4	1.2 ± 0.3	0.4
Height (cm)			
BL	1.0 ± 0.5	1.3 ± 0.4	0.4
BEE	0.6 ± 0.3	0.9 ± 0.4	0.2
Area (cm^2)			
BL	1.3 ± 0.5	1.5 ± 1.2	0.7
BEE	0.3 ± 0.1	1.0 ± 0.1	<0.01
EAS			
Anteroposterior diameter (cm)			
BL	3.1 ± 0.6	3.3 ± 0.7	0.8
BEE	3.0 ± 0.5	3.3 ± 0.4	0.4
Lateral diameter (cm)			
BL	2.6 ± 0.4	2.6 ± 0.4	1
BEE	2.9 ± 0.1	3.3 ± 0.4	0.07
EAS thickness			
At 12o'clock (cm)			
BL	0.5 ± 0.2	0.5 ± 0.2	0.5
BEE	0.4 ± 0.2	0.5 ± 0.1	0.4
IAS			
Anteroposterior diameter (cm)			
BL	2.0 ± 0.2	2.2 ± 0.5	0.6
BEE	2.0 ± 0.3	2.3 ± 0.3	0.3
Lateral diameter (cm)			
BL	1.5 ± 0.2	1.6 ± 0.3	0.8
BEE	1.9 ± 0.3	2.0 ± 0.4	0.8
IAS thickness			
At 12o'clock (cm)			
BL	0.3 ± 0.1	0.3 ± 0.1	0.6
BEE	0.3 ± 0.1	0.3 ± 0.0	1
Anal mucosa			
Anteroposterior diameter (cm)			
BL	1.3 ± 0.1	1.4 ± 0.3	0.4
BEE	1.4 ± 0.1	1.6 ± 0.3	0.2
Lateral diameter (cm)			
BL	1.0 ± 0.1	1.0 ± 0.1	0.7
BEE	1.3 ± 0.3	1.3 ± 0.3	0.9

Data are expressed as mean ± SD.
BL: Beginning of labor, BEE: Before expulsive efforts, EAS: External anal sphincter; IAS: Internal anal sphincter, AM: Anal mucosa.

Discussion

Principal findings

We provided the first report of in vivo assessment of both PB and anal sphincter biometrics using B-mode ultrasound and stiffness using SWE during labor. We reported that women with a higher PB area before the expulsive efforts were more likely to develop perineal tears during childbirth. During labor, the PB size seemed to decrease. The PB elastic modulus at rest and at the onset of labor or before expulsive efforts tended to be higher in women with a perineal tear at delivery. In our small cohort, we did not observe any significant changes in the elastic properties of EAS, IAS and AM during labor.

Results in the context of known

The PB plays a key role in maintaining pelvic floor stability and provides flexibility and support as the fetus descends through the birth canal [19]. During birth, the birth canal tissues must stretch to more than 3 times their original length [20]. PB can be at risk of damage or overstretching during vaginal delivery, which may lead to complications like perineal tears [21]. PB imaging and research is emerging using transperineal ultrasound with abdominal transducer, endovaginal and endoanal ultrasound, and SWE [10,12,22–24]. In our study, the PB biometrics seemed to decrease during labor. This is explained by the fact that during the pushing phase of labor, the perineal body undergoes significant stretching as the baby moves through the birth canal. We reported that women who had a larger perineal body area before starting the pushing phase were more prone to developing perineal tears during delivery. The first hypothesis could be that a larger PB area indicates a denser concentration of connective tissue and muscle fibers which could be less flexible or elastic. If the tissues in a larger PB area are less elastic, they may not stretch as readily, increasing the likelihood of tearing as opposed to stretching. But we did not manage to demonstrate an elastic change between women with and without perineal tears. In our study, there was no correlation between the PB area size and PB elastic modulus. The second hypothesis could be that a larger PB are might mean a broader surface area that needs to stretch during delivery, potentially creating more tension in the perineal tissues. This increased stress could contribute to a higher risk of tearing, especially under the intense pressure exerted during the expulsive efforts of labor. The third hypothesis could be that a larger PB area could be associated with other anatomical variations that predispose to tearing such as stiff pelvic floor muscles or small vaginal introitus. None of these hypotheses has been studied in the literature.

In our study, elastic modulus of the PB at rest and at the onset of labor or before expulsive efforts tended to be higher in women who experienced a perineal tear at delivery. This finding is consistent with the study by Rostaminia et al. which showed that perineal tears were more common in women with a stiffer perineal body [10]. Their mean PB elastic modulus during labor (15.3 kPa) was similar to the mean PB elastic modulus at the onset of labor in our cohort (11.9 ± 3.6 kPa) and lower to the mean PB elastic modulus before the expulsive stage in our (25.7 ± 18.9 kPa).

In our study, we did not observe any significant changes in the elastic

Table 3
Comparison of perineal stiffness during labor using shear wave elastography (SWE) according to the occurrence or not of a perineal tear during vaginal delivery.

	Perineal tear (n = 10)		
	No	Yes	p-value
	N = 4	N = 6	
Beginning of labor			
PB Elastic modulus (kPa)			
Rest	11.3 ± 4.1	12.9 ± 2.9	0.6
Valsalva	22.8 ± 18.2	31.0 ± 32.0	0.7
EAS Elastic modulus (kPa)			
Rest	12.8 ± 6.4	8.2 ± 3.5	0.7
Valsalva	16.0 ± 8.5	11.6 ± 8.4	0.5
IAS Elastic modulus (kPa)			
Rest	12.4 ± 11.5	3.4 ± 3.1	0.2
Valsalva	12.3 ± 14.9	8.6 ± 7.9	0.7
AM Elastic modulus (kPa)			
Rest	10.2 ± 16.5	2.2 ± 1.2	0.3
Valsalva	8.4 ± 12.1	9.8 ± 7.6	0.8
Before expulsive efforts			
PB Elastic modulus (kPa)			
Rest	18.0 ± 15.9	37.4 ± 18.6	0.1
Valsalva	17.8 ± 3.9	15.0 ± 6.0	0.4
EAS Elastic modulus (kPa)			
Rest	13.1 ± 6.8	7.3 ± 3.3	0.1
Valsalva	14.0 ± 5.2	23.8 ± 24.1	0.5
IAS Elastic modulus (kPa)			
Rest	10.7 ± 8.1	5.7 ± 2.7	0.2
Valsalva	9.9 ± 4.0	16.4 ± 24.1	0.6
AM Elastic modulus (kPa)			
Rest	7.5 ± 6.0	5.6 ± 2.3	0.5
Valsalva	8.4 ± 4.5	12.7 ± 16.0	0.6

Data are expressed as mean ± SD.
EAS: External anal sphincter; IAS: Internal anal sphincter, AM: Anal mucosa.

properties of EAS, IAS and AM during labor. This fact has never been studied in the literature. The only study evaluating elastic properties of the anal sphincter using elastography was published by Gachon et al. [9]. They reported that women with perineal tears had a less stiff EAS at Valsalva maneuver in the third trimester of pregnancy prior to labor. This result is not consistent with the general principle that an increase of elastic modulus indicates an increase of stiffness and an increased likelihood of tissue rupture. This principle was confirmed by the *meta*-analysis of LaCroix et al. focusing on tendon stiffness and failure [25].

Clinical implications

From a clinical perspective, understanding the perineal biometrics using ultrasound and stiffness using SWE may help in developing targeted preventive strategies. These insights could be crucial for predicting and preventing perineal tears by using non-invasive and real-time device during a pregnancy follow-up. Firstly, it could be used to study the effect of perineal maneuver to prevent perineal trauma such as antenatal perineal massage, perineal warm compresses during labor, manual perineal protection and Couder's maneuver during delivery [26–29]. Second, it could be useful to inform high-risk women. In this group, women could be clearly informed about mode of delivery of emergency interventions that might be necessary during delivery such as episiotomy and for whom informed consent could be difficult to obtain [9].

Research implications

Perineal assessment using 2D-mode ultrasound and SWE is feasible. These tools are non-invasive and allow real-time results. Our findings open avenues for further research into pregnancy and labor management and prevention of perineal injuries. There could be a potential for developing new ultrasound-based techniques such as SWE or criteria for identifying women at higher risk of perineal tears. Larger and multicenter studies are necessary to investigate perineal elastic properties and biometrics during labor and pregnancy.

In vivo perineal mechanical properties such as elastic modulus could be used to improve birth Finite Element Model [30–34]. These model could be used to predict perineal tears during deliveries and better understand manual perineal protection technique [35].

Strength and limits

The main strength of this study is its originality. It is the first study to report in vivo assessment of both PB and anal sphincter biometrics and stiffness during labor in women. Second, SWE is a safe, non-invasive, real-time method for investigating the mechanical properties of tissue. It has the ability to evaluate specific anatomy such as the perineal body for example. SWE is a reliable tool for measuring elastic properties of PB and EAS [10,16,22,36].

The main limitation of this study is the small number of women included. This is due to the originality of the study, which is a pilot study on this research topic. This limitation does not allow us to investigate the association between second degree perineal tear and obstetrical sphincter anal injury at delivery and the elastic properties of the PB and the anal sphincter. Therefore, a larger prospective and multicenter study is needed to validate the usefulness of SWE in predicting perineal tears.

Conclusion

In vivo assessment of both the perineal body and anal sphincter biometrics and stiffness during labor in women is feasible. The perineal body deformation measurement during labor could be a predictive factor for perineal tears. There may be a possible association between the perineal body stiffness and the risk of perineal tears. This study highlights the potential of ultrasound and SWE in improving maternal care by identifying risk factors for perineal tears, thereby aiding in the development of more effective labor management strategies.

Authors contributions

ML designed the work, acquired, analyzed and interpreted data, and drafted the work. TK, acquired, analyzed and interpreted data, and revised the work, JC interpreted data, and revised the work 2, AL interpreted data, and revised the work, MC revised the work, EJ interpreted data, and revised the work and NM revised the work.

CRediT authorship contribution statement

Marine Lallemant: Writing – original draft, Visualization, Validation, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Tiguida Kadiaké:** Writing – review & editing, Investigation, Formal analysis. **Arnaud Lejeune:** Writing – review & editing, Formal analysis. **Michel Cosson:** Writing – review & editing. **Jérôme Chambert:** Writing – review & editing, Formal analysis. **Emmanuelle Jacquet:** Writing – review & editing, Formal analysis. **Nicolas Mottet:** Writing – review & editing.

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Declaration of competing interest

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