Antepartum 2-dimensional sonographic evaluation of levator ani muscle coactivation and correlation with labor outcomes in nulliparous women at term gestation

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BACKGROUND: Levator ani muscle (LAM) coactivation consists in the inappropriate contraction — i.e. shortening — of the LAM during pushing effort. The condition is reported to occur in up to 30% of pregnant women prior to active labor, and has been associated with increased duration of the second stage in the context of the so-called soft tissue dystocia.

OBJECTIVE: This study aimed to evaluate the correlation between levator ani muscle coactivation and labor outcome in a cohort of nulliparous women with singleton pregnancy at term.

STUDY DESIGN: This was a single-center prospective observational study that included nulliparous women with low-risk term pregnancy with a cephalic-presenting fetus who were enrolled between 39 and 40 weeks of gestation. During routine term obstetrical assessment, trained midwives performed transperineal ultrasound on the midsagittal plane to evaluate the anteroposterior diameter of the levator ani muscle. The minimal distance between the posteroinferior border of the pubic symphysis and the anterior border of the puborectalis muscle was evaluated at rest and at the acme of a pushing effort. Levator ani muscle coactivation was defined as a reduction in the anteroposterior diameter of the levator hiatus during the pushing efforts. The primary outcome was to compare the duration of the second stage of labor between coactivating and noncoactivating women and evaluate the occurrence of composite adverse labor outcome as defined by the occurrence of any of the following conditions: episiotomy, vacuum or cesarean delivery for second-stage dystocia, obstetrical anal sphincter injury, or severe postpartum hemorrhage.

RESULTS: A total of 201 women were included, of whom 42 (20.9%) had levator ani muscle coactivation. Compared with women without levator ani muscle coactivation, those with levator ani muscle coactivation showed longer active second stage of labor duration (64±45 minutes vs 84±50, respectively; P=.02) and higher rates of composite adverse labor outcome (12.5% vs 31.0%, respectively; P<.01) and obstetrical anal sphincter injury (5.4% vs 0.0%, respectively; P<.01). Levator ani muscle coactivation only was associated with composite adverse labor outcomes (34.3% in women with levator ani muscle coactivation vs 18.1% in those without levator ani muscle coactivation; P<.01).

CONCLUSION: Within a population of women with singleton term pregnancies at low risk, the antepartum demonstration of levator ani muscle coactivation at transperineal ultrasound was associated with an increased duration of the second stage of labor and a higher frequency of composite adverse labor outcomes, including obstetrical anal sphincter injury.

Key words: labor dystocia, pelvic floor ultrasound, perineal care, perineum, transperineal ultrasound

Introduction

The levator ani muscle (LAM) consists of the anatomic and functional interactions of the pubococcygeus, iliococcygeus, and coccygeus muscles[1] and plays a crucial role in the support of pelvic organs, forming the pelvic floor diaphragm.[2] Moreover, LAM is involved in the processes of childbirth.[3] The LAM can increase its length up to 3-fold at the end of the active second stage of labor from an anatomic perspective,[4] whereas maternal pushing effort is physiologically associated with relaxation of the LAM, increased pelvic floor dimensions, and descent of the fetal head in the birth canal from a functional perspective. Optimal synergy occurs when abdominal muscle contraction is synchronized with relaxation of the LAM, which widens the pelvic hiatus and reduces soft tissue resistance.[5]

LAM coactivation involves the inappropriate contraction—that is, shortening—of the LAM during pushing effort. The condition is reported to occur in up to 30% of pregnant women before active labor[6–8] and has been associated with an increased duration of the second stage of labor[8] in the context of soft tissue dystocia.[5]

The clinical assessment of the anatomy and function of the pelvic floor is complex and associated with poor reproducibility.[9] Conversely, transperineal ultrasound (TPU) has been proposed as a simple, noninvasive, and reproducible tool[10,11] to evaluate the mechanics of the LAM. It allows for the investigation of changes in the diameters of pelvic floor muscles at rest and during pushing effort,[5] thereby assessing LAM coactivation and the width of the anteroposterior diameter (APD) of the hiatus. Such an assessment has been proposed to predict the length of the second stage of labor and the need for operative delivery.[12,13] This study aimed to compare the duration of the second stage of labor and the occurrence of labor complications between women with and without LAM coactivation with an uncomplicated pregnancy at term.

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AJOG MFM at a Glance

Why was this study conducted?

This study aimed to investigate the feasibility of the transperineal sonographic assessment of levator ani muscle (LAM) coactivation by trained midwives and compare the duration of the second stage of labor and the occurrence of labor complications between women and without LAM coactivation with an uncomplicated pregnancy at term.

Key findings

In a population of low-risk nulliparous women electively evaluated at term gestation by trained midwives, the sonographic demonstration of LAM coactivation at 2-dimensional (2D) ultrasound was associated with a longer duration of the second stage of labor and adverse labor outcomes, including obstetrical anal sphincter injury.

What does this add to what is known?

The antepartum demonstration of LAM coactivation at transperineal 2D ultrasound in the context of routine obstetrical care may represent a "window of opportunity" for the implementation of targeted strategies, such as biofeedback and perineal relaxation, to improve perineal health before the onset of labor and reduce the risks of labor complications.

Materials and methods

This was a single-center prospective observational cohort study that was conducted at the University of Parma, Italy, over 12 months between January 1, 2024, and December 31, 2024. A nonconsecutive series of nulliparous women with a singleton cephalic-presenting fetus and low-risk pregnancy at term was included. Patient recruitment was performed in an outpatient setting during routine obstetrical assessment at term pregnancy. Low-risk patients underwent routine obstetrical assessment of the maternal and fetal well-being in accordance with the local protocol. During such evaluation, midwives submitted to a dedicated training in TPU preliminarily to the study - which consisted of 1 theoretical session and 5 practical sessions under the supervision of a senior member of the study group with dedicated expertise in pelvic floor ultrasound (M.D.S.) - performed TPU to measure the APD of the LAM at rest and under the Valsalva maneuver.

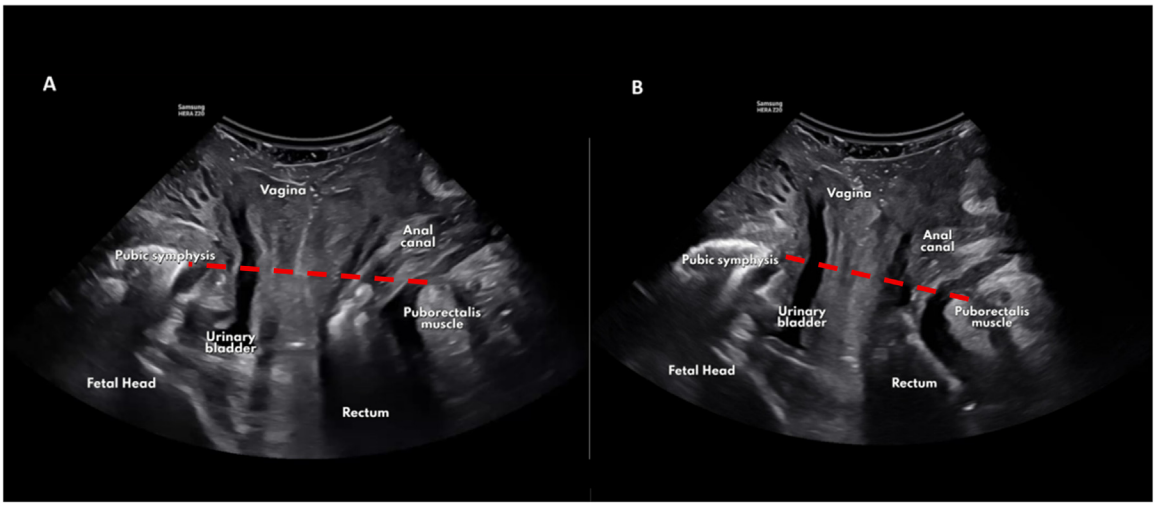
TPU was performed with the patient in the lithotomy position and with a semifull bladder, as described by Youssef et al,[8] that is, by placing the ultrasound transducer between the maternal labia majora in a midsagittal plane. The anatomic structures included in the ultrasound views were the pubic symphysis, urethra, bladder, vagina, anorectal angle, and puborectalis muscle (the main component of the LAM) and the fetal head (Figure). During the TPU assessment, the patient was asked to perform pushing efforts for at least 6 seconds. In accordance with the previous definition, the APD of the hiatus of the LAM was calculated as the distance from the posteroinferior border of the pubic symphysis to the anterior border of the puborectalis muscle.[5] The difference in the measurement of the APD of the LAM at rest and at the acme of the pushing effort (delta LAM length) was quantitatively evaluated (Video 1). Coactivation of the LAM was diagnosed when the APD of the genital hiatus during the pushing effort was shorter than that observed at rest. Such information was collected blindly and not reassessed before delivery. Therefore, patients with LAM coactivation and the clinicians in charge of labor management were unaware of the sonographic findings.

The exclusion criteria were presence of uterine contractions, symptoms of vulvodynia, vaginism, fecal or urinary incontinence, pelvic organ prolapse, and previous surgery on the uterus or pelvic floor.

Medical history and maternal characteristics were retrieved from the patients' clinical records and included maternal age, body mass index, gestational age at delivery, induction of labor, and epidural analgesia. Labor dystocia was defined based on the recommendations of the American College of Obstetricians and Gynecologists/Society for Maternal-Fetal Medicine for the safe prevention of primary cesarean delivery.[10] Labor arrest in the second stage of labor was diagnosed when the duration of active pushing was at least 3 hours in nulliparous women on epidural analgesia or 2 hours in the event of no epidural analgesia. The diagnosis of labor dystocia was made by the senior obstetrician in charge of patient care, who was blinded to the findings of the antenatal TPU evaluation. Obstetrical intervention for labor dystocia was performed when the criteria for arrest of dilatation or arrest of labor in the second stage of labor were fulfilled.[10] Postpartum hemorrhage was defined as an estimated blood loss of >500 mL. Perineal tears were classified according to the classification of the Royal College of Obstetricians and Gynaecologists[11] into first- and second-degree tears; obstetrical anal sphincter injury (OASI)—which included third- and fourth-degree perineal tears—and episiotomy. In addition, information concerning fetal outcome, such as umbilical artery and vein pH, Apgar score at 1 and 5 minutes, and birthweight, was retrieved.

This study aimed to investigate whether the antepartum demonstration of LAM coactivation by trained midwives is associated with an increased duration of the second stage of labor. Power sample size calculation was performed as follows: 1 previous study by Youssef et al[14] reported a longer mean duration of the second stage of labor of 18 minutes (81±61 vs 63±43 minutes; P=.03) in women showing LAM coactivation. Based on the assumption that the transperineal sonographic demonstration of LAM coactivation could increase the duration of the second stage of labor by 30%, the total sample size of patients required to obtain a

FIGURE
Transperineal sonographic assessment on the midsagittal plane



Visualization of the pubic symphysis, urinary bladder, vagina, anal canal, rectum, puborectalis muscle, fetal head, and APD of the levator ani muscle at rest (**A**) and during the pushing effort (**B**) in a patient showing coactivation of the levator ani muscle. The *red dashed line* represents the APD of the levator ani muscle.

APD, anteroposterior diameter.

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statistical power of 90% with a 2-sided type I error rate of 5% would be 182.

The secondary outcome was the relationship between LAM coactivation and composite adverse labor outcomes (CAOs). This was defined as the occurrence of one of the obstetrical interventions (vacuum extraction or cesarean delivery) due to labor arrest in the second stage of labor, OASIs, episiotomy, or postpartum hemorrhage of >1000 mL.

Statistical analysis was performed using IBM SPSS Statistics (version 28; IBM, Armonk, NY). Categorical and continuous variables were compared using the chi-squared or Fisher exact test and the independent samples *t* test or Mann-Whitney *U* test, respectively. The relationship between the APD of the LAM under pushing effort and the duration of the second stage of labor was assessed using the Pearson correlation. Data were presented as mean and standard deviation, median (interquartile range), or number (percentage), as appropriate. A *P* value of <.05 was considered statistically significant. The study was approved by the local ethics committee. Data were recorded and stored in a Microsoft Excel pseudonymized database, which was only accessible by the members of the research team. All study participants provided written informed consent before being enrolled in the study.

Results

A total of 201 women were included in the study, of whom 42 (20.9%) showed LAM coactivation before birth. Table 1 shows the comparison of demographic and labor characteristics between the cases with and without

TABLE 1
Comparison of the antenatal characteristics and labor outcomes between cases with and without LAM coactivation

Variable	No coactivation (n=159)	Coactivation (n=42)	*P* value
White ethnicity, n (%)	140 (88.1%)	33 (78.6%)	.12
Maternal age (y), mean±SD	30.6±4.5	30.9±4.6	.67
Gestational age (wk), mean±SD	41 0/7±0 3/7	41 0/7±0 3/7	.72
Booking BMI (kg/m^2), mean±SD	22.7±4.6	22.6±2.9	.85
Augmentation, n (%)	67 (42.1%)	21 (50.0%)	.36
Induction of labor, n (%)	78 (49.1%)	16 (38.1%)	.21
Epidural, n (%)	107 (67.3%)	32 (76.2%)	.22
LAM APD at rest (cm), mean±SD	4.8±0.7	4.8±0.9	.94
LAM APD at pushing (cm), mean±SD	5.6±0.8	4.5±0.9	<.01

APD, anteroposterior diameter; *BMI*, body mass index; *LAM*, levator ani muscle.

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TABLE 2
Comparison of the perinatal outcomes between cases with and without LAM coactivation

Variable	No coactivation (n=159)	Coactivation (n=42)	*P* value
Length of the first stage of labor (min), mean±SD	365±224	413±219	.24
Length of the second stage of labor (min), mean±SD	65±45	84±50	.02
Length of the total labor (min), mean±SD	430±243	497±238	.13
Spontaneous vaginal delivery, n (%)	130 (81.3%)	29 (69.0%)	.12
Fetal size at birth, n (%)	AGA: 134 (84.3%) SGA: 11 (6.9%) LGA: 14 (8.8%)	AGA: 33 (78.6%) SGA: 3 (7.1%) LGA: 6 (14.3%)	.57
Vacuum extractor for dystocia, n (%)	9 (5.6%)	5 (11.9%)	.16
Obstetrical intervention for labor dystocia, n (%)	15 (9.5%)	7 (16.6%)	.18
OASI, n (%)	0 (0%)	2 (5%)	.01
Estimated blood loss of >500 mL, n (%)	39 (24.5%)	14 (33.3%)	.42
Second-degree obstetrical tears, n (%)	46 (28.9%)	17 (40.5%)	.15
Episiotomy, n (%)	8 (5.0%)	5 (11.9%)	<.01
Apgar score of <7 at 5 min, n (%)	1 (0.6%)	1 (2.4%)	.31
Neonatal acidemia, n (%)	1 (0.6%)	1 (2.4%)	.31
CAO, n (%)	23 (14.5%)	12 (28.6%)	.01

AGA, appropriate for gestational age; *CAO*, composite adverse outcome; *LAM*, levator ani muscle; *LGA*, large for gestational age; *OASI*, obstetrical anal sphincter injury; *SGA*, small for gestational age.

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LAM coactivation. Women with LAM coactivation showed no difference in terms of APD of the LAM at rest but had shorter APD of the LAM during the pushing effort than those in the control group (5.6±0.8 vs 4.5±0.9 cm, respectively; $P \leq .01$). The comparison of labor and perinatal outcomes between the cases with and without LAM coactivation is presented in Table 2. Women with LAM coactivation showed longer second stage of labor duration than those without LAM coactivation (64.7±45 vs 84±50 minutes, respectively; $P=.02$). Furthermore, compared with women without LAM coactivation, those with LAM coactivation had higher rates of composite adverse outcomes (28.6% vs 14.5%, respectively; $P<.01$), episiotomy (11.9% vs 5.0%, respectively; $P=.001$), and OASIs (5.0% vs 0.0%, respectively; $P=.02$). There was no significant difference in the rate of obstetrical intervention for dystocia between the 2 groups. The Pearson correlation showed a weak negative correlation between the APD of the LAM during the pushing effort and the duration of the second stage of labor (-0.226; $P<.01$). The comparison of the antepartum characteristics between cases experiencing CAO and those that did not showed an increased frequency of LAM coactivation (34.3% vs 18.1%, respectively; $P<.01$) in the former group (Table 3).

Discussion

Principal findings

The findings of this study showed an increased duration of the second stage of labor in low-risk nulliparous women demonstrating LAM coactivation at term pregnancy before the onset of labor. Furthermore, our data showed an association between LAM coactivation with CAO and the occurrence of OASIs.

Results in the context of what is known

In our population, sonographically evaluated by means of TPU by trained midwives, the frequency of LAM coactivation was consistent with that from previous studies conducted by obstetricians with dedicated expertise, showing figures ranging between 18% and 31%.[7,8] Previous studies evaluating the presence or absence of LAM coactivation concerning the occurrence of labor dystocia in the second stage of labor consistently showed an increasing duration of the second stage of labor in the event of LAM coactivation in nulliparous women.[10,11,13–17] In addition, this finding was confirmed by Kamel et al,[7] who demonstrated a longer duration of the second stage of labor after induction of labor in cases of LAM coactivation.

Such inappropriate contraction of the LAM negatively affects the descent of the presenting part in the context of soft tissue dystocia.[15–17] In addition, the findings of our study indicated a longer duration of the second stage of labor, which was not associated with an increased rate of operative delivery or with operative delivery due to labor dystocia. Consistently, previous data from

TABLE 3
Comparison of the antenatal characteristics between cases with and without composite adverse labor outcomes

Variable	No composite adverse labor outcome (n=166)	Composite adverse labor outcome (n=35)	*P* value
Maternal age (y), mean±SD	30.6±4.6	30.7±4.4	.95
Obesity, n (%)	8 (4.8%)	1 (2.8%)	.64
Augmentation, n (%)	70 (42.1%)	18(51.4%)	.24
Induction of labor, n (%)	74 (44.6%)	20 (57.1%)	.12
Epidural, n (%)	110 (66.3 %)	26 (74.3 %)	.23
Fetus LGA, n (%)	16 (9.6%)	4 (11.4 %)	.70
LAM APD at rest (cm), mean±SD	4.8±0.8	4.8±0.7	.81
LAM APD at pushing (cm), mean±SD	5.4±1.0	5.2±0.9	.13
LAM coactivation, n (%)	30 (18.1%)	12 (34.3%)	<.01

APD, anteroposterior diameter; *CAO*, composite adverse outcome; *LAM*, levator ani muscle; *LGA*, large for gestational age.

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another unit reporting higher rates of cesarean delivery and instrumental delivery could not demonstrate any association between LAM coactivation and operative delivery.[8]

In our population, the LAM APD at rest was similar between the LAM coactivation and noncoactivation groups. Therefore, based on our data, we hypothesize that the negative effect on head progression and descent is dependent on the inappropriate contraction of the LAM during active pushing only and not on a short APD of the LAM at rest. This result is consistent with a previous study by Brunelli et al,[18] where an increase in the APD of the LAM from rest to Valsalva maneuver before the onset of labor at term was associated with a shorter duration of the active second stage of labor.

Another—and previously unreported—finding from our study was the association between LAM coactivation and OASIs. Here, the overall incidence of OASIs was 1% in the context of the limited number of included cases, which is consistent with the rate reported from centers with dedicated expertise in perineal care.[11,19] However, both cases of OASI were recorded among women with LAM coactivation. We believe that such a finding is clinically—other than statistically—relevant. From a pathophysiological perspective, the increased rate of OASIs in women with LAM coactivation can be explained by the fact that patients with coactivation often show hypertonicity and reduced distensibility of the pelvic floor.[15–17] Other potential explanations include the dysfunctional distribution of pressure in the birth canal resulting in increased stretching tension on the posterior compartment in the event of LAM CoA[20] together with the increased frequency of perineal edema resulting in reduced distensibility and increased fragility of the perineal tissue.[16] Finally, LAM CoA has been reported to increase the duration of the second stage of labor, hence indirectly represents a risk factor for operative vaginal delivery[5], which is also acknowledged as a risk factor for OASIs. In our study no difference in the frequency of operative vaginal delivery nor for operative delivery due to labor dystocia was recorded between coactivating and non-coactivating patients, however this finding may be dependent upon the inadequate number of included cases to assess such association.

Clinical and research implications

The early identification of women with LAM coactivation may enable the implementation of corrective interventions, including targeted biofeedback or neuromuscular pelvic floor training, to optimize pelvic floor function and improve labor outcomes. Ultrasound visual feedback has been proposed as a potential tool to improve labor outcomes, given its potential to resolve coactivation by teaching patients to increase the APD of the hiatus during the pushing effort.[14] Previous data demonstrated that ultrasound visual feedback before the onset of labor may increase the dimensions of the LAM and reverse LAM coactivation in 16% to 50% of cases.[6,8] Such an approach enables women to visualize the dynamic changes of the LAM, which may enhance their ability to optimize relaxation of the LAM during the pushing effort.[6,18,21] This might positively affect the fetal head descent. Youssef et al[14] demonstrated a relationship between LAM coactivation and the sonographic indicators of head descent (ie, width of the angle of progression [AoP] at term pregnancy before the onset of labor. More specifically, LAM coactivation resulted in increased resistance to fetal head descent at rest and during the pushing effort, which translated into a narrower AoP.[17] Moreover, although no study has specifically addressed such an issue, we believe that it may be worth investigating whether coactivation and increased tone of the LAM are associated with failed instrumental delivery.

In addition, our data suggest that the screening of pelvic floor health before labor onset can be effectively undertaken in the context of routine

midwifery follow-up assessment at term pregnancy. Of note, 1 previous study from our group demonstrated that training midwives on ultrasound in labor leads to improved imaging quality and accuracy in the measurements.[20] Consistently, we hypothesized that training midwives in evaluating the presence or absence of LAM coactivation before labor—in the current case at routine antenatal clinic evaluation—may improve the antepartum identification of the patients that may benefit from visual biofeedback with or without the adjunct of perineal massage to reduce the rate of adverse labor outcomes related to LAM coactivation.

OASIs and perineal management represent crucial aspects of intrapartum care,[22] which are associated with short- and long-term morbidities, including anal incontinence[23] and urinary incontinence,[24] perineal pain, or dyspareunia.[25] The current study shows that LAM coactivation is a risk factor for OASI. The strategies, including "hands-on" protection of the perineum, woman free position, "shoulder-up" bundle, and perineum massage, have been proposed to reduce the risk and incidence of OASIs.[26] In such a context, identifying patients with LAM coactivation may allow tailored antepartum perineal management and intrapartum preventive strategies given their increased risk of OASIs.[22,27]

Strengths and limitations

The main strength of this prospective study is its original design, as we reported data on antepartum sonographic transperineal assessment of the LAM performed by trained midwives in the context of a routine evaluation at term pregnancy.

Concerning the limitations, the fact that the primary outcome is a composite one depends on the expected low frequency of labor complications in a low-risk population. In addition, only nulliparous women were included, and LAM coactivation was not reassessed during labor. Another limitation is that the ascertainment of OASIs was based on clinical findings shortly after delivery and not by a gold standard reference, which is represented by endoanal ultrasound 6 to 12 weeks after delivery. Therefore, an undefined number of OASIs may have been overlooked. Furthermore, the presence or absence of LAM coactivation was evaluated by means of 2-dimensional TPU on the midsagittal plane only and not by measuring transverse pelvic floor diameters by means of 3- and 4-dimensional TPUs as recently proposed by some independent research groups.[9,10,12,20] Finally, the single-center design may reduce the generalizability of the study findings.

Conclusion

Our study shows that, within a selected cohort of low-risk nulliparous women at term, the antepartum demonstration of LAM coactivation by midwives with dedicated training in TPU affects the labor outcome and is particularly associated with an increased duration of the active second stage of labor and rate of OASIs. Further studies are needed to investigate the effect of targeted interventions in improving labor outcomes in women with antepartum evidence of LAM coactivation. ■

CRediT authorship contribution statement

Maurizio Di Serio: Methodology, Investigation, Conceptualization. **Enrico Corno:** Writing – review & editing, Writing – original draft. **Sara dell'Omo:** Investigation, Data curation. **Patrizia Melioli:** Investigation. **Giorgia Contardi:** Investigation. **Adriane Nigro:** Investigation. **Serena Neri:** Investigation. **Tullio Ghi:** Writing – review & editing, Conceptualization. **Andrea Dall'Asta:** Writing – review & editing, Writing – original draft, Conceptualization.

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Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.ajogmf.2026.101901.

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