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ORIGINAL ARTICLE

Alteration of anal sphincter function in patients with levator avulsion: observational study

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Abstract
Introduction and hypothesis The prevalence of levator avulsion after vaginal delivery ranges from 10 to 30 %. To our knowledge, no previous studies have used anorectal manometry (AM) to assess this injury's impact on the functionality of the anal sphincter complex. We hypothesized that women with levator avulsion have lower manometric pressures.
Methods A prospective observational study was conducted on 83 women, 61 in the birth group and 22 in the control group. Patients in the deliveries group were recruited in the period immediately postpartum. The control group was recruited through hospital announcements. All patients underwent 3D transperineal (3D TPUS) and 2D endoanal ultrasound (2D EAUS), as well as AM at 6 months postpartum. Median maximum resting and squeeze pressures were measured, and the presence or absence of levator ani muscle (LAM) avulsion and/or occult sphincter injury was evaluated.
Results Hiatal area at rest was significantly higher in women with vaginal birth compared with controls (p=0.02) and there was a trend toward statistical significance compared with the cesarean section group (p=0058). No statistical differences were observed for the hiatal area regarding Valsalva, external anal sphincter thickness, and internal anal sphincter thickness among groups. There was a significantly higher prevalence of levator avulsion in the vaginal birth group (32.43 %) compared with the controls (0 %) and the cesarean section group (5.8 %; p<0001). There were 5 occult sphincter injuries detected at ultrasound, all of them in the vaginal birth group. Lower squeeze pressure was observed in patients with levator injury compared with control group patients and patients without avulsion (112.2 mmHg vs 128.2 mmHg and 121.2mmH; p=0.032). Finally, there was no difference in resting pressure (p=0.541) or squeeze pressure (p=0.449) between patients with and those without occult anal sphincter injuries.
Conclusions Levator avulsion is associated with lower manometric squeeze pressure (p=0.032).

Keywords 3D transperineal ultrasound · Anorectal manometry · Endoanal ultrasound · Levator avulsion · Obstetric anal sphincter injuries · Pelvic floor function

Abbreviations

AM	Anorectal manometry
EAS	External anal sphincter
EAUS	Endoanal ultrasound
IAS	Internal anal sphincter
FI	Fecal incontinence
LAM	Levator ani muscle
OASIS	Obstetric anal sphincter injuries
POP	Pelvic organ prolapse
PRM	Puborectalis muscle
TPUS	Transperineal ultrasound
UI	Urinary incontinence

Introduction

Childbirth is one of the most important risk factors for the development of pelvic floor abnormalities. Pelvic floor dysfunction results in urinary (UI) or fecal incontinence (FI), or pelvic organ prolapse (POP) [1], which may appear early during a woman's reproductive years or later in life.

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The prevalence of clinically diagnosed obstetric anal sphincter injuries (OASIS) is 0.5–3 % [2]. However, previously published studies report that up to 35 % of occult sphincter injuries detectable by ultrasound are either underdiagnosed in the delivery room or occur in patients with an intact perineum [3, 4].

Various risk factors for anal sphincter injury during childbirth have been identified, such as the use of obstetric instrumentation during delivery (higher incidence with forceps than with suction cup), midline episiotomy [5], primiparity, fetal macrosomia, posterior presentation, prolonged second stage of labor, epidural anesthesia, advanced maternal age, and Caucasian race [6]. Multiparity and mediolateral episiotomy are considered protective factors [7], although in some studies this kind of episiotomy has been regarded as a risk factor as well [8]. The controversy seems to be related to the angle of the episiotomy, as has been suggested in some articles [9].

Anal sphincter and levator ani muscle (LAM) injuries have shared risk factors [10]. Therefore, a significant number of women with LAM avulsion also have a sphincter injury [11]. The prevalence of puborectalis muscle (PRM) injuries after vaginal birth ranges from 10 to 30 % [12, 13].

Regarding clinical manifestations, only a third of clinically recognized anal sphincter injuries are symptomatic after repair [14]. Complete LAM avulsion is currently associated with an increased risk of prolapse and recurrence [15], but no statistically significant association with UI [16] or FI has been found [17]. Because the role of the PRM in the physiology of fecal continence is well known, this lack of association may be due to studies where the role of the sphincter complex was not objectively quantified [18].

In recent years, thanks to the contribution of 3D ultrasound, various authors have studied the relationship between the PRM and childbirth [19]. However, more studies are needed to correlate anatomical lesions with posterior pelvic floor compartment functionality. Anorectal manometry (AM) is the ideal method for the quantitative study of anal pressures [20]. We hypothesized that women with LAM avulsion may have reduced manometric anal squeeze pressures and echographically diagnosed anal sphincter tears were associated with reduced manometric anal squeeze pressure. The purpose of the present study was to investigate the impact of LAM injury on anorectal function.

Materials and methods

We designed a prospective observational study that was conducted at Clínica Universidad de Navarra between September 2010 and September 2012. The study included 83 women: 22 in the control group and 61 in the birth group. The control group consisted of nulliparous women of childbearing age voluntarily recruited through hospital announcements.

Inclusion criteria for the birth group were: primiparity, 6 months postpartum, no colorectal abnormality (grade III–IV hemorrhoids or history of severe constipation), and signed written informed consent. Thirteen women had delivered spontaneously, 31 had assisted deliveries, and 17 were delivered by cesarean section.

All patients underwent a 3D transperineal ultrasound (TPUS), a 2D endoanal ultrasound (EAUS), and AM.

The demographic variables studied were age, body mass index (BMI), birth weight, and mode of delivery. The outcome variables investigated were the median maximum resting and squeeze pressures, measured by AM; the presence or absence of LAM avulsion, analyzed by 3D TPUS; and the presence or absence of occult sphincter injury, evaluated by 2D EAUS.

Anorectal manometry was performed using a four-channel catheter with a balloon (Albyn Medical, Smart Medical Group, Navarra, Spain). Water was infused at 0.3 ml per minute and manual removal of the catheter was performed centimeter by centimeter.

Injury to the IAS was studied using 2D EAUS, which remains the gold standard for the study of the sphincter [21]. An endoanal ultrasound system with multi-frequency rotating probe 5.0–12.0 MHz, $R=8$ mm, 360 °, focus range 15–25 mm (Albit equipment; Albyn Medical) was used with the patient in left lateral decubitus. Regarding the technique, the transducer was placed in the middle anal canal and sphincter thickness was measured at 3 and 9 o'clock. All images were obtained and interpreted by the same observer (MAG) and subsequently reviewed by an expert. An ultrasound diagnosis of injury was made when loss of continuity of the sphincter was observed, accompanied by other characteristic signs, such as the presence of irregular borders in the suspicious area or marked asymmetry (Fig. 1).

The 3D TPUS was performed using a GE Voluson 730 expert system with a high-frequency transvaginal probe (5–9 MHz; GE Medical Systems, Zipf, Austria) placed at the vaginal introitus. The images were later processed on a personal computer using 4D View® v. 10.0 software (GE Medical Systems). Analysis of 3D TPUS data volumes was blinded to clinical data. Hiatal area was measured at the plane of minimal hiatal dimensions [22]. An ultrasound diagnosis of LAM avulsion was made when continuity defects were found in three central slices using tomographic ultrasound imaging (TUI) mode on maximum pelvic floor muscle contraction [23]. Levator injury was confirmed with a levator–urethral gap (LUG) distance>2.5 cm (Fig. 2) [15].

This study was approved by the local human research ethics committee (University of Navarra reference 004/2010).

The statistical analyses were performed using SPSS 19.0 software (SPSS, Chicago, IL, USA). Qualitative variables were expressed as absolute numbers and percentages. The Kolmogorov–Smirnov test was employed to assess the normal

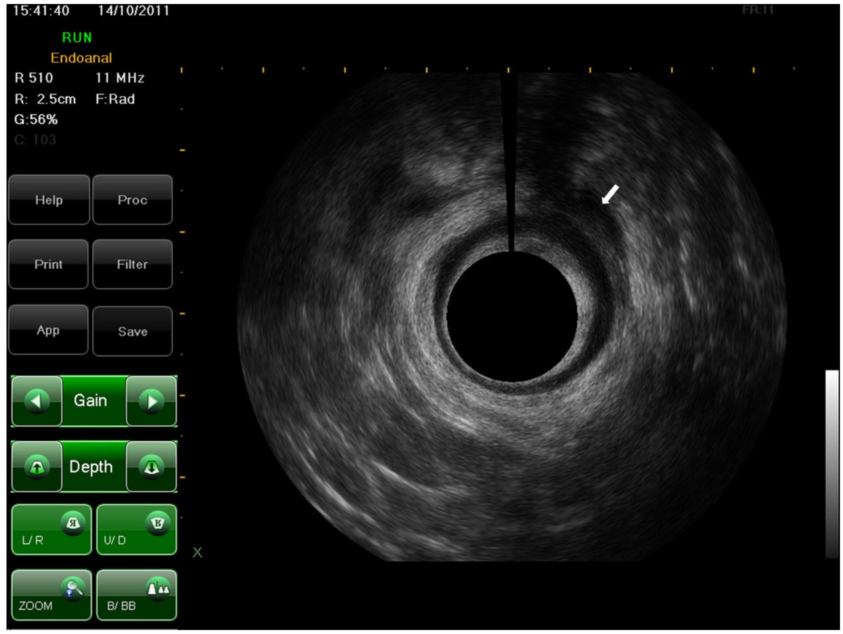

Fig. 1 Image of sphincter injury (endoanal ultrasound)

distribution of continuous variables. Continuous variables were expressed as a mean and standard deviation (SD) or median with interquartile range (IQR), based on data distribution. Qualitative variables were compared using the Chi-squared test with Yate's correction. Continuous variables were compared using ANOVA with the post-hoc Bonferroni test or the Kruskal–Wallis test, as a function of the data distribution. A p value of <0.05 was considered to indicate statistical significance.

Results

Sixty-one women in the birth group fulfilled the eligibility criteria and agreed to participate in the study after providing signed informed consent. As stated above, 13 women had vaginal spontaneous delivery, 31 had assisted deliveries, and 17 were delivered by cesarean sections. Twenty-two patients were included in the control group. Thus, three groups were considered for comparison (controls, vaginal birth, and

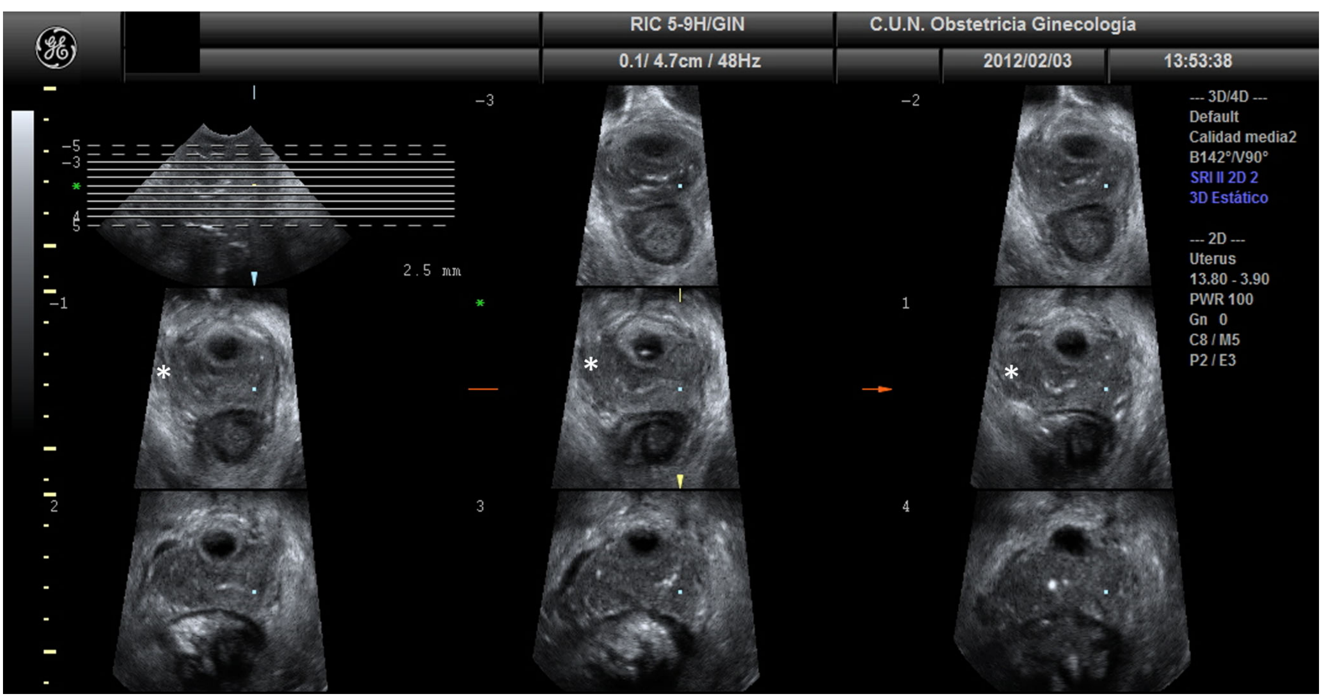

Fig. 2 Image of avulsion (tomographic ultrasound imaging)

cesarean section birth). Seven samples (8.4 %) of the total 3D TPUS samples studied could not be assessed for the presence or absence of LAM avulsion owing to poor image quality, all of them within the vaginal birth group.

Table 1 shows the demographic characteristics of the patients included. A significant difference in age and BMI was observed between the control group and the vaginal birth and cesarean section groups.

When comparing all three groups we found that hiatal area at rest was significantly higher in the vaginal birth group than in the control group. There was a trend toward statistical significance between the vaginal birth group and the cesarean section group. We did not observe any differences in hiatal area on Valsalva, external sphincter thickness, and internal sphincter thickness among the groups. We found a significantly higher rate of LAM in the vaginal birth group and also all OSI were found in the vaginal birth group. We did not find any differences in the length of the second stage of labor between patients who had LAM (54.9 min, SD 35.6) and those who had no LAM (59.9 min, SD 39.9; p=0.712).

Correlation between LAM avulsion and mode of delivery

Regarding mode of delivery, the use of instrumentation has a significant effect on the presence of LAM avulsion (p=0.0001). LAM avulsions are more frequent in assisted deliveries and half of them occurred during vacuum extractions. There was, however, no difference between the control group, spontaneous deliveries or cesarean sections with regard to the presence of avulsion (Table 2).

Table 2 Presence of avulsion and mode of delivery

	n	No avulsion (%)	Avulsion (%)*
Control	21	21	0
Spontaneous cephalic delivery	11	11 (100)	0 (0)
Vacuum extraction	14	7 (50)	7 (50)
Cesarean section	17	16 (94.1)	1 (5.9)
Spatula delivery	13	7 (58.3)	5 (41.7)

*p=0.0001

Presence of avulsion and manometric correlation

Resting and squeeze manometric pressures in both groups were compared based on the presence or absence of avulsion. Patients with LAM injury had lower squeeze pressures compared with the control group and with patients without avulsion (112.2 mmHg vs 128.2 mmHg and 121.2 mmHg, p=0.032; Fig. 3).No differences were found regarding resting pressure, as all groups had a similar median (control group: 54.7 mmHg; avulsion group: 53.1 mmHg; no avulsion group: 60.2 mmHg, p=0.527).

Occult sphincter injury and manometric correlation

Anal pressure was analyzed in terms of the presence or absence of sphincter injury, diagnosed by 2D EAUS (Fig. 4). There were no significant differences in either resting pressure (p=0.541) or squeeze pressure (p=0.449) in the subgroups with and without sphincter injury.

Table 1 Demographic and morphological data

	Control group (n=21)	Vaginal birth (n=44)	Cesarean group (n=17)
Age* (years)	24.67 (3.30) [20–31]	31.09 (3.5) [21–39]	32.6 (3.1) [28–39]
BMI (kg/cm^2)	21.39 (2.53) [18.08–27]	24.08 (3.6) [20.40–38.40]	24.9 (4.7) [20.40–36.2]
Birth weight** (g)	NA	3,223.3 (410.09) [2,105–4,235]	3,059.2 (501.5) [2,150–3,960.0]
Duration of labor (min)	NA	59.4 (34.4) [5–158]	NA
Hiatal area at rest*** (cm^2)	15.28 (2.07) [11.34–18.56]	17.29 (2.53) [11.69–22.97]	15.53 (2.92) [11.04–22.23]
Hiatal area on Valsalva**** (cm^2)	17.07 (2.57) [12.90–23.26]	18.58 (2.84) [12.53–24.32]	17.60 (4.13) [11.44–23.38]
Avulsion*****	0/21	12/44	1/17
EAS thickness****** (mm)	6.98 (1.26) [3.80–8.70]	7.62 (1.70) [3.50–10.90]	7.32 (1.95) [4.10–10.15]
IAS thickness****** (mm)	2.09 (0.65) [1.30–3.60]	2.11 (0.64) [1.10–3.85]	2.28 (0.75) [0.80–3.85]
Anal sphincter injuries*******	0/21	5/37	0/17

Data expressed as mean, standard deviation in parentheses, and interquartile range in brackets, unless expressly indicated

BMI body mass index, *EAS* external anal sphincter, *IAS* internal anal sphincter, *NA* not applicable, *NS* non-significant

*p<0.001 controls vs birth, and control vs cesarean, NS birth vs cesarean; **p=0.053 (NS) birth vs cesarean; ***NS control vs cesarean, p=0.02 control vs birth, p=0.058 birth vs cesarean; ****NS among groups; *****p<0.001 birth vs control and birth vs cesarean; ******NS among groups; *******p=0.120 birth vs controls, p=0.132 birth vs cesarean

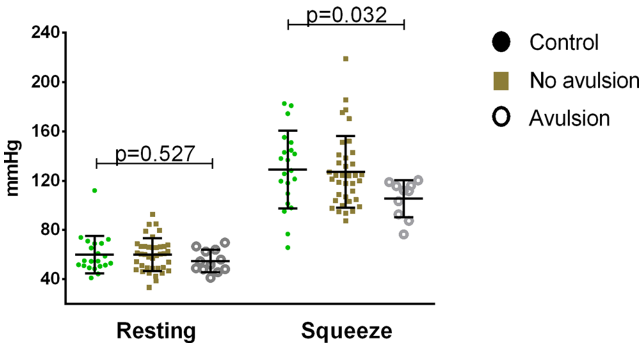

Fig. 3 Avulsion and manometric pressure

Discussion

The main finding of our study is that patients with LAM avulsion have lower manometric squeeze pressure (p=0.032).

However, our study has some limitations, the main one being its small sample size. Furthermore, 8 % of samples could not be analyzed because of poor quality 3D volume imaging. For this reason, we have only compared the groups with and without levator avulsion, avoiding distinctions between macro- and microtrauma [24], postponing this for future research. Additionally, there is a selection bias clearly shown in the rate of delivery modes. This selection bias may have affected the results. Finally, we did not perform a sample size calculation; hence, this has to be considered a pilot study.

Thanks to 3D ultrasound we are able to identify LAM injuries in the postpartum period [25]. The correlation of LAM injury with POP and risk of POP recurrence after surgery has been proven, but no association with FI or UI has been found [16, 17, 26]. Although for years it was thought that the LAM was fundamental to the anal continence mechanism, this is currently a controversial topic [2, 17, 27].

We found that patients with LAM avulsion have a worse functional assessment (Fig. 3). It is well known that many anal sphincter injuries are asymptomatic until the 5th decade of life [28, 29]. Could the patients with lower manometric pressure be those who will develop symptoms in the future? Could they benefit from a specific monitoring and/or rehabilitation program? Is rehabilitation effective in a damaged muscle?

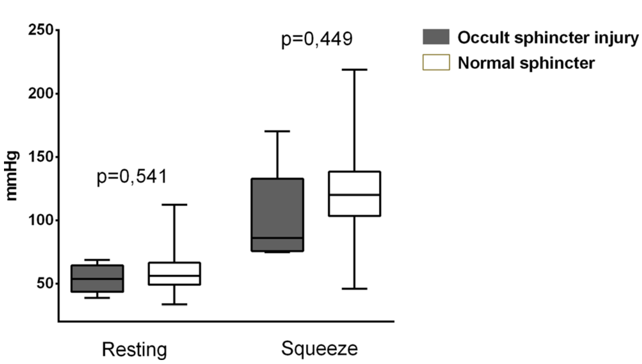

Fig. 4 Occult sphincter injury and manometric pressure

Several authors found decreased pelvic floor muscle contraction after delivery in women with LAM avulsion when studying these parameters with vaginal manometry [30] and clinically using either the modified Oxford scale [31] or digital palpation [18]. The novelty of our work is that it offers a functional study of LAM avulsion using AM.

We found no differences in manometric pressure in the subgroup of patients with anal sphincter injury (n=5) compared with those without injury. We had expected to find lower pressure in patients with sphincter injuries. This was not the case, which may have been due to the small sample size. On the other hand, most sphincter injuries (4 out of 5) were diagnosed in the group of patients without avulsion.

In summary, we have shown that LAM avulsion is associated with lower manometric squeeze pressure (p=0.032). To our knowledge, this is the first time that this information has been published in the scientific literature. This leads us to believe that perhaps, although a statistical correlation between LAM avulsion and FI has not yet been documented [17], LAM injury plays an important role in its pathophysiology. Further studies are needed, with more patients and longer follow-up periods, in order to determine manometric cutoff points and predict which patients are most likely to develop FI.

Conflict of interest The authors declare that they have no conflict of interest.

Contributions M. Aubá: project development, data collection and analysis, manuscript writing; J.L. Alcázar: project development and data analysis; J. Baixauli: project development; L. Juez: project development; B. Olartecoechea: project development; J.A. Mínguez: project development.

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