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ORIGINAL ARTICLE

Predicting levator avulsion from ICS POP-Q findings

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Abstract

Introduction and hypothesis Levator avulsion is a common consequence of vaginal childbirth. It is associated with symptomatic female pelvic organ prolapse and is also a predictor of recurrence after surgical correction. Skills and hardware necessary for diagnosis by imaging are, however, not universally available. Diagnosis of avulsion may benefit from an elevated index of suspicion. The aim of this study was to examine the predictive value of the International Continence Society Pelvic Organ Prolapse Quantification (ICS POP-Q) for the diagnosis of levator avulsion by tomographic 4D translabial ultrasound.

Methods This is a retrospective analysis of data obtained in a tertiary urogynaecological unit. Subjects underwent a standardised interview, POP-Q examination and 4D translabial pelvic floor ultrasound. Avulsion of the puborectalis muscle was diagnosed by tomographic ultrasound imaging. We tested components of the ICS POP-Q associated with symptomatic prolapse and other known predictors of avulsion, including previous prolapse repair and forceps delivery with uni- and multivariate logistic regression. A risk score was constructed for clinical use.

Results The ICS POP-Q components Ba, C, gh and pb were all significantly associated with avulsion on multivariate analysis, along with previous prolapse repair and forceps delivery. A score was assigned for each of these variables and patients were classified as low, moderate or high risk according to total score. The odds of finding an avulsion on ultrasound in patients in the "high risk" group were 12.8 times higher than in the "low risk" group.

Conclusion Levator avulsion is associated with ICS POP-Q measures. Together with simple clinical data, it is possible to predict the risk of avulsion using a scoring system. This may be useful in clinical practice by modifying the index of suspicion for the condition.

Keywords Avulsion · Levator ani · Transperineal ultrasound · Prolapse · POP-Q · Tomographic imaging

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Introduction

Female pelvic organ prolapse (POP) is a common condition [1]. On examination, 22% of the adult female population [2] and 41% of postmenopausal women [3] present with some form of significant pelvic organ descent. Treatment options include conservative therapy (i.e., pessaries, pelvic floor muscle training and/or behavioural management) and surgery. It has been estimated that a woman's lifetime risk of undergoing surgery for POP in the USA is almost 13% [4]. Recurrence of POP after surgery continues to be an issue. It has been reported that up to 30% of procedures for POP are performed to treat recurrence [5].

Avulsion of the puborectalis muscle is a common consequence of childbirth [6] and a major source of future morbidity, especially in the form of POP [7]. It also seems to be a major predictor of prolapse recurrence after surgical correction [8]. Recent studies have shown that, in the presence of an avulsion, using transvaginal mesh (TVM) for the correction of prolapse of the anterior compartment may significantly reduce the risk of recurrence [9, 10]. This implies that diagnosis of levator trauma should be part of the routine assessment of women suffering from POP [11], as it would allow proper preoperative counselling and may affect surgical planning for the treatment of POP.

Levator avulsion can be diagnosed by translabial ultrasound [6] and magnetic resonance imaging (MRI) [12]; however, the skills and hardware required are not universally available. Alternatively diagnosis can also be made by digital palpation, but this seems to require longer training and findings may be less repeatable [13]. An elevated index of suspicion may be useful to help diagnose the condition, e.g., when considering imaging in individual patients.

The International Continence Society (ICS) recommends that the description and staging of POP be conducted according to the Pelvic Organ Prolapse Quantification (POP-Q) system [14]. This quantification system is now commonly used by urogynaecologists. In this study, we examined the predictive value of individual ICS POP-Q parameters for the diagnosis of levator avulsion by tomographic 4D translabial ultrasound.

Materials and methods

This study is based on the analysis of data obtained in a tertiary urogynaecological unit between January 2012 and July 2013. We included all patients assessed at our unit during this time frame. Patients were excluded if they had incomplete data, if they refused or were unable to undergo pelvic examination, or if ultrasound volume data sets could not be retrieved. All subjects underwent, as is routine practice in our unit, an in-house standardised interview, multichannel urodynamic testing (Neomedix Acquidata; Neomedix, Sydney, NSW, Australia), ICS POP-Q [14] examination and 4D translabial pelvic floor ultrasound using a GE Voluson 730 Expert (GE Medical Systems, Zipf, Austria), supine and after voiding, as previously described [15]. Ultrasound postprocessing was performed by the first author on a desktop PC using the proprietary software 4D View v 10.7 (GE Kretz Medizintechnik), blinded against all clinical data. Avulsion of the puborectalis muscle was defined as an abnormal levator ani insertion visible on tomographic ultrasound imaging (TUI) on at least three consecutive axial plane slices at and above the level of minimal hiatal dimensions, obtained at an interslice interval of 2.5 mm as previously described [16]. Figure 1 shows an example of a full right-sided and partial left-sided avulsion. Hiatal area was measured on the axial plane in the plane of minimal hiatal dimensions on maximum Valsalva, as previously described [17]. Hiatal ballooning was defined as a hiatal area equal to or greater than 25 cm^2 [18].

Significant POP was defined clinically as ICS POP-Q stage II or higher, i.e. Ba/Bp/C at or beyond −1. Gh and pb were measured during Valsalva manoeuvres. We then tested these individual components of the ICS POP-Q that have been shown to be associated with the pathophysiological consequence of avulsion, i.e. symptomatic prolapse [7, 19], other known predictors of avulsion such as history of forceps delivery [6] or previous prolapse surgery [20], and other risk factors for POP not directly associated with avulsion (age, body mass index, previous hysterectomy) [2]. Other variables were not tested. In addition, we created multivariate models from those univariate predictors that were shown to be significant ($p < 0.05$) using SAS v 9.3 (SAS Institute, Cary, NC, USA) for PC. |The likelihood ratio test and Akaike information criterion (AIC) were used to compare different models. We then constructed a risk score using significant predictors for clinical use. These risk score points were based upon the estimates from a logistic regression analysis. Patients were then categorized into three groups based on risk (bottom 25%, middle 50%, upper 25%).

This study was approved by the Nepean Blue Mountains Local Health District Human Research Ethics Committee (NBMLHD HREC reference no. 13–30). A test–retest series on 40 cases for levator avulsion on TUI was performed by the first and second authors, yielding a Cohen's kappa of 0.875, i.e., "very good" agreement.

Results

Between January 2012 and July 2013, a total of 719 patients were seen for assessment. Of those, we were able to retrieve the ultrasound volume data sets of 677. Eight women did not have a full clinical examination due to vaginal stenosis or refusal leading to a final data set of 669 patients. All reported data relates to this population.

Patient characteristics along with prevalence of symptoms, relevant medical history and findings on physical examination are summarized in Table 1.

In terms of translabial ultrasound findings, mean hiatal area on Valsalva was 29.3 ± 9.8 cm^2, with 64.3%of patients ($n = 430$) having an abnormal hiatal area equal to or greater than 25 cm^2 (ballooning). A right-sided avulsion was diagnosed in 23.8%of patients ($n = 159$) and a left-sided avulsion

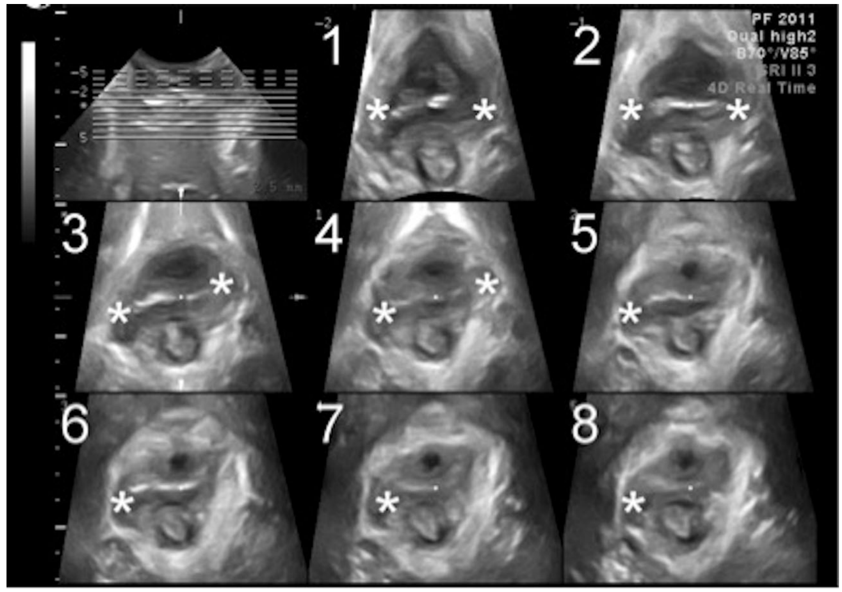

Fig. 1 Full right-sided avulsion (left side of individual slices) and partial left-sided avulsion in a patient with multicompartment prolapse. Defects are indicated by *asterisks*. Tomographic imaging is rated as positive for a full avulsion if slices 3–5 are all abnormal on one side

in 19% ($n = 127$). The avulsion was unilateral in 15.8% ($n = 106$) and bilateral in 13.5% ($n = 90$).

On univariate analysis, all of the tested components of the ICS POP-Q were associated with avulsion (Table 2). The strongest association was found for gh and pb. On multivariate analysis, controlling for potential confounders, all components of the ICS POP-Q remained significant, with the exception of Bp.

We then constructed models for the prediction of avulsion using POP-Q variables and the two main clinical risk factors, i.e. previous prolapse surgery and forceps delivery. ICS POP-Q parameters added significantly to the risk conveyed by

Table 1 Summary of patient characteristics

	Total ($N = 669$)	No avulsion ($n = 473$)	Avulsion ($n = 196$)
Age, years (mean ± SD)	56 ± 13.8	55.5 ± 14.2	57.3 ± 12.6
Mean BMI, kg/m^2 (mean ± SD)	29 ± 6.4	29.2 ± 6.4	28.7 ± 6.3
Vaginally parous (%, 95% CI)	88.8 (86.4–91.2)	85.4 (82.2–88.6)	96.9 (94.4–99.4)
Forceps delivery (%, 95% CI)	26.6 (23.2–30)	21.5 (17.7–25.3)	38.3 (31.4–45.2)
Menopausal (%, 95% CI)	60.7 (56.9–64.5)	58.6 (54.1–63.1)	65.8 (59–72.6)
Previous hysterectomy (%, 95% CI)	29.7 (26.2–33.2)	28.3 (24.2–32.4)	33.2 (26.5–39.9)
Previous POP surgery (%, 95% CI)	20.2 (17.1–23.3)	15.6 (12.3–18.9)	31.1 (24.5–37.7)
Symptoms			
POP (%, 95% CI)	52.2 (48.3–56.1)	46.1 (41.5–50.7)	66.8 (60.1–73.5)
SUI (%, 95% CI)	73.1 (69.7–77.5)	74.4 (70.4–78.4)	69.9 (63.3–76.5)
UUI (%, 95% CI)	72.6 (69.2–76)	73.4 (69.3–77.5)	70.9 (64.4–77.4)
Constipation (%, 95% CI)	26.8 (23.4–30.2)	27.5 (23.4–31.6)	25 (18.8–31.2)
Straining (%, 95% CI)	44.2 (40.4–48)	44.8 (40.2–49.4)	42.9 (35.8–50)
POP ≥ stage II (%, 95% CI)	77.1 (73.9–80.3)	72.1 (68–76.2)	89.3 (84.7–93.9)
Cystocele	54.9 (51.1–58.7)	48 (43.4–52.6)	71.4 (64.9–77.9)
Rectocele	57.8 (54–61.6)	56.2 (51.6–60.8)	61.7 (54.8–68.6)
Uterine/vault	12.4 (9.9–14.9)	7.8 (5.3–10.3)	23.5 (17.4–29.6)
Point Ba (mean ± SD)	−0.8 ± 1.9	−1.1 ± 1.8	−0.1 ± 1.9
Point Bp (mean ± SD)	−1.0 ± 1.4	−1.1 ± 1.4	−0.8 ± 1.5
Point C (mean ± SD)	−4.2 ± 2.7	−4.7 ± 2.3	−3.1 ± 3.2
gh (mean ± SD)	4 ± 1.1	3.8 ± 1	4.5 ± 1.2
pb (mean ± SD)	3.9 ± 0.8	3.8 ± 0.8	4.1 ± 0.8

CI confidence interval, *POP* pelvic organ prolapse, *SUI* stress urinary incontinence, *UUI* urge urinary incontinence

Table 2 Univariate and multivariate analysis of potential risk factors for avulsion

	Univariate		Multivariate	
	OR (95% CI)	*p* value	OR (95% CI)	*p* value
Age		N.S.		
BMI		N.S.		
Forceps	2.3 (1.6–3.2)	<0.0001	1.9 (1.3–2.8)	0.002
Previous hysterectomy		N.S.		
Previous POP surgery	2.4 (1.6–3.6)	<0.0001	2.5 (1.6–3.8)	<0.0001
Ba[a]	1.3 (1.2–1.5)	<0.0001	1.2 (1.0–1.3)	0.01
Bp[a]	1.2 (1.0–1.3)	0.009	0.9 (0.8–1.1)	N.S.
C[a]	1.2 (1.2–1.3)	<0.0001	1.1 (1.0–1.2)	0.04
Gh[a]	1.8 (1.5–2.1)	<0.0001	1.4 (1.1–1.8)	0.003
Pb[a]	1.9 (1.5–2.4)	<0.0001	1.6 (1.3–2.1)	<0.0001

BMI body mass index

[a] Odds ratio (*OR*) for a 1-cm difference

forceps and previous prolapse surgery alone, as shown by the likelihood ratio test ($p < 0.0001$). AIC for a prediction model based only on forceps and previous prolapse surgery was 779, whereas after inclusion of POP-Q variables AIC was 708, demonstrating the superiority of the latter model. We then constructed a risk score using significant predictors, based on the odds ratio for each variable (Table 3). Low risk was defined as a score of less than 29, moderate risk as 29 to less than 47 and a high risk as 47 or higher. Table 4 presents odds ratios and confidence intervals for the three risk groups.

Discussion

In women presenting with pelvic organ prolapse, the diagnosis of levator trauma in the form of avulsion of the puborectalis muscle allows us to identify patients at increased risk of treatment failure [8]. Any efforts to reduce the risk of recurrence after prolapse surgery should be more likely to prove effective when tested in such a group of patients. Transvaginal mesh for the treatment of anterior compartment prolapse seems to have a particularly beneficial effect in women with avulsion [9, 10]. Hence, it seems feasible to individualise POP surgery by diagnosing levator avulsion in order to reduce the risk of recurrence. Even if mesh use is precluded for whatever reason, the diagnosis of avulsion will allow better patient counselling and reduce the likelihood of unrealistic expectations.

Levator avulsion can be diagnosed by either magnetic resonance imaging [21] or pelvic floor ultrasound [22], with a high degree of agreement between the two methods [23]. However, the imaging equipment and expertise required to diagnose levator avulsion are not universally available and, even if such facilities are available on principle, facilities with a high demand for female POP corrective surgery may find themselves unable to provide screening for all patients. Clinical diagnosis by palpation alone has the limitations of a long learning curve and lower reproducibility [13].

Our results show that on multivariate analysis POPQ coordinates or measurements Ba, C, gh and pb are all associated with levator avulsion. These variables can be included in a prediction model that is superior to using only the two main clinical risk factors, forceps delivery and previous POP surgery. We have developed a prediction score based on these data that categorises patients into three different groups

Table 3 Score assigned for each risk factor

Variable	Assigned score
Forceps	8
POP surgery	11
Ba	2
C	1
gh	4
pb	6

Forceps and POP surgery are categorical variables. For continuous variables (ICS POP-Q values) the score must be multiplied by the measured value (e.g. if gh is 4, this adds 16 points. If Ba is −3, this subtracts 6 points from the total score)

Table 4 Categorisation for risk groups

Group (points)	OR (95% CI)	Avulsion (%)
Low (<29)	1	15/168 (8.9)
Medium (29 to < 47)	3.6 (2.0–6.5)	86/330 (26.1)
High (≥47)	12.8 (6.9–23.5)	95/171 (55.6)

Left column shows OR with CI for each risk group. Right column shows the incidence of avulsion for each group in our study population according to avulsion risk. The odds of finding an avulsion on ultrasound in the high-risk group are 12.8 times higher than in the low risk group. With our scoring system, using readily available clinical data, we provide an easy method of identifying patients most likely to suffer from an avulsion. In a clinical setting with limited access to imaging, patients may be screened using this scoring system, selecting those with a high risk score for imaging. If imaging is not available, the calculated score may determine the index of suspicion with which the physician will expect to find an avulsion on digital palpation, hopefully improving diagnostic accuracy.

Finally, the score developed in this study may be a useful tool as an inclusion criterion for studies designed to assess strategies for reducing POP recurrence, acting as a proxy for avulsion without the need for imaging. By selecting a group of patients at a high risk of recurrence it should be possible to increase power.

Some limitations of our study have to be acknowledged. First, the study population was referred to a tertiary urogynaecology unit for subspecialty assessment for treatment of pelvic floor dysfunction, hence causing potential selection bias. Also, in order for the prediction model to be simple enough for practical purposes, we only studied those variables that we considered most relevant. However, there may be other factors with known or unknown links to the pathogenesis of prolapse and levator avulsion that were not included in our study. On the other hand, the large study population of nearly 670 is a strength of the study, as is the blinding of the diagnosis of avulsion against all clinical data.

In conclusion, levator avulsion is associated with POP-Q coordinates and measurements. This information may be used to modify the index of suspicion for the condition to improve clinical practice and benefit further studies through improved patient selection.

Compliance with ethical standards

Conflicts of interest None.

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