Current Obstetrics and Gynecology Reports (2019) 8:15–25
https://doi.org/10.1007/s13669-019-0256-8

UROGYNECOLOGY (P NIKPOOR, SECTION EDITOR)

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# Vaginal Birth and Pelvic Floor Trauma

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Published online: 18 March 2019


## Abstract

**Purpose of Review** Over the last two to three decades, a growing body of research has shown that vaginal childbirth is more traumatic to mothers than generally assumed. Apart from obstetric anal sphincter tears which have been extensively studied, trauma to the levator ani muscle is a form of maternal injury that is less well recognised and often undiagnosed. In the context of an increasing push towards vaginal birth, this article will review the recent literature to better inform health care providers regarding the significance of pelvic floor trauma.

**Recent Findings** Imaging studies have shown that levator avulsion, where the puborectalis muscle has detached from the os pubis, occurs in up to 1/3 of vaginally primiparous women, depending on demographic factors and obstetric management. Forceps is a well-established risk factor for levator avulsion with an odds ratio of 4–5 compared to vacuum, which does not seem to convey additional risk over unassisted vaginal birth. Levator injuries are significantly associated with pelvic organ prolapse and treatment failure. Such trauma can also lead to significant psychological morbidity, up to and including post-traumatic stress disorder. Antenatal prediction does not appear feasible. Modification of obstetric practice by abandoning forceps would significantly reduce pelvic floor trauma and the future need for prolapse surgery.

**Summary** Vaginal childbirth is more traumatic than commonly assumed. Levator trauma is associated with significant physical and psychological morbidity. Perinatal health care providers need to understand and recognise the significance of maternal birth trauma and its potential impact on women's health.

**Keywords** Avulsion · Childbirth · Imaging · Levator ani · Pelvic floor · Ultrasound

## Introduction

Childbirth is an important experience in a woman's life. This life event is often described as joyful and empowering. Vaginal delivery is generally considered to be more physiological, natural and hence a superior way to give birth compared to caesarean section (CS). As a result, the rising CS rate seen worldwide is considered problematic and has led to increasing pressure on clinicians to modify clinical practice.

This article is part of the Topical Collection on *Urogynecology*

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Epidemiological studies have shown that childbirth is an important risk factor for pelvic floor disorders [1–4]. Parous women are more likely to experience pelvic organ prolapse (POP) and to suffer from urinary and faecal incontinence than nulliparous women. While both the hormonal and mechanical effects of pregnancy may contribute to pelvic floor dysfunction [5], mode of delivery plays a central role, mediated by childbirth-related mechanical trauma. Women after vaginal birth are more commonly found to suffer from pelvic floor dysfunction than women after CS [6]. The accumulating scientific evidence in this field over the last two to three decades has helped us understand the etiological link between vaginal birth and pelvic floor disorders. It is now evident that vaginal delivery is more traumatic than generally assumed.

## What Is Pelvic Floor Trauma?

What we call the pelvic floor usually refers to the muscles of the pelvic diaphragm. It consists of the levator ani and the coccygeus muscle; pelvic floor trauma commonly refers to trauma to the levator ani. While there is a lack of agreement in regard to the components of the levator ani and their nomenclature, the V-shaped muscle sling that attaches to the os pubis bilaterally and runs posteriorly around the anorectum seems to be of most relevance in the context of maternal birth trauma. We call this part of the levator ani the 'puborectalis muscle'.

The puborectalis muscle together with the pubic bone encloses the levator hiatus, the largest potential hernia portal in the human body. Traversing through the hiatus are the urethra anteriorly, the vagina in the middle and the anorectum posteriorly (Fig. 1). The levator ani plays a role in supporting various body functions in a woman's life including controlled evacuation of body wastes, support of pelvic organs against displacement due to the pressure differential between inside and outside and due to gravity, as well as reproductive function. Childbirth is a particular challenge to the pelvic floor in view of the relative size of the baby's head.

## Levator Trauma

In 1943, Howard Gainey, a Kansas City Obstetrician, reported a study on 1000 patients in a postnatal clinic where about 20% of women were diagnosed with a detachment of the pubococcygeus muscle (which we would call the puborectalis muscle), a condition we now describe with the term 'levator avulsion' [8]. Unfortunately, Gainey's report was ignored until the late 1990s. Recent advances in imaging technologies using magnetic resonance (MR) and ultrasound (US) have confirmed these 70-year-old observations. Levator avulsion has been demonstrated on MR [9, 10], on three-dimensional US [11, 12], in the delivery suite [13] and in cadavers [14]. Figure 2 shows ultrasound images of a patient diagnosed of levator avulsion before and after a first vaginal birth.

In a computer modelling study using MR data of a healthy nulliparous woman, Lien et al. showed that the most ventromedial aspect of the levator ani muscle has to stretch the most (by a factor of 3.26) and over the shortest period of time during vaginal delivery [15]. In a retrospective observational study using 3D US data of 224 pregnant nulliparous women, the required muscle distension during vaginal delivery of a baby of average size was shown to vary widely in the general population, i.e. from 25 to 245% [16]. Given the degree of muscle distension, it is not surprising that vaginal delivery frequently leads to pelvic floor muscle trauma.

Studies using US and MR have now shown levator avulsion rates of 2–36% in primiparous women after vaginal delivery [9, 17–24], depending on demographics and obstetric practice [25]. Imaging before and after childbirth has confirmed vaginal delivery as the direct cause of such trauma [11]. The condition is not found in women after CS [11, 23, 26].

Levator avulsion is usually occult, likely due to greater distensibility of vaginal tissues compared to the muscle-bone interface of the puborectalis muscle. This explains the lack of progress in understanding the condition after Gainey's first report. Occasionally however, an avulsion is directly visible due to a large vaginal tear. Figure 3 shows levator avulsion as seen through a large vaginal tear after vaginal delivery, on US and on MR 3 months after vaginal delivery. Recent studies have shown that vaginal and 3rd/4th degree perineal tears are clinical markers for levator avulsion and may help detection of the condition [27, 28].

While avulsion can be palpated digitally [29], the diagnostic gold standard at present is tomographic translabial ultrasound (multislice imaging or TUI) [30]. Figure 4 shows a TUI representation of a full unilateral avulsion. Anatomical improvement over time has been documented in imaging studies; however, it is much less common than persistence of the condition [31–33].

Considering the degree of muscle distension required for vaginal delivery, it is plausible that vascular, neuromuscular and connective tissue changes, that is, other forms of damage apart from gross avulsion injury may occur. From muscle physiology research, it can be assumed that substantial

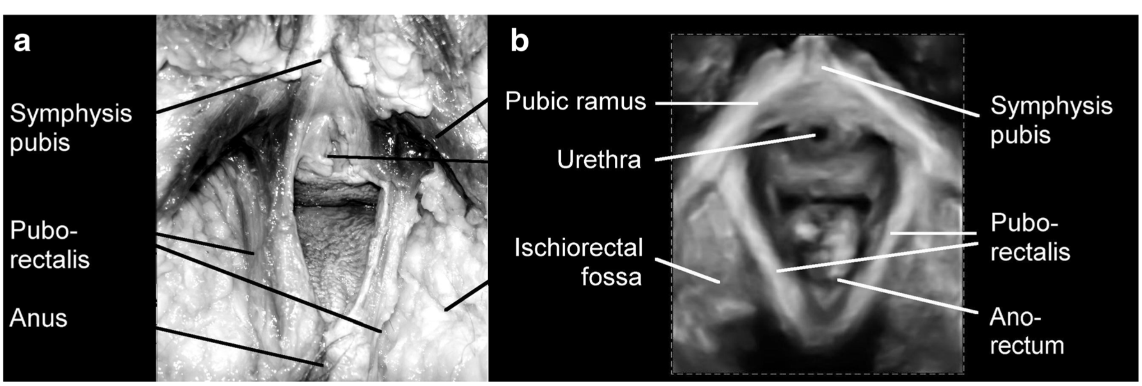


**Fig. 1** **a** Intact puborectalis muscle in a fresh cadaver, dissected from caudally. The vulva, mons pubis, clitoris, perineal muscles, perineum to the anus, peri- and postanal skin and the fibrofatty tissue of the ischiorectal fossa have been removed. **b** The appearance of the intact puborectalis muscle in a rendered volume in the axial plane on 3D translabial ultrasound. Reproduced from Dietz with permission [7]

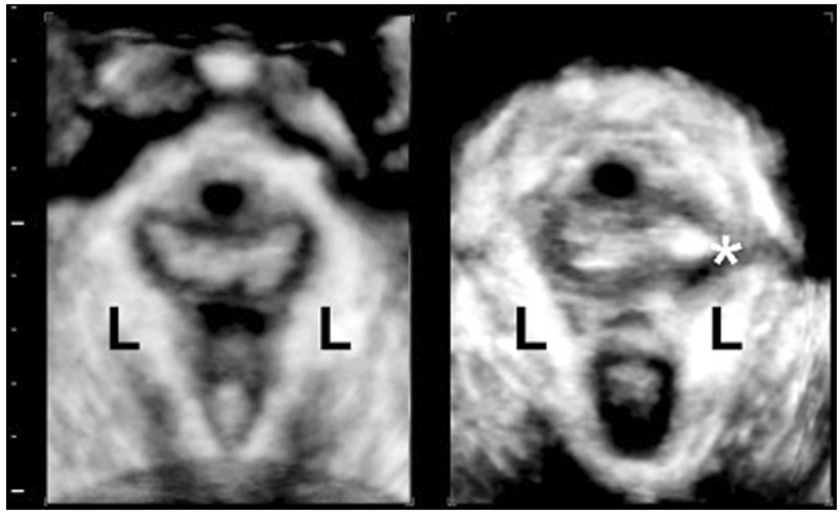


**Fig. 2** The levator ani muscle (L) as seen before (left) and after (right) vaginal delivery. The site of avulsion is marked by the asterisk

ultrastructural trauma, up to and including disruption of sacromeres, may occur if skeletal muscle is stretched to beyond 1.5 times its original length [34]. It is plausible that muscle atrophy, impairment of muscle function and alterations in pelvic floor distensibility may occur as a result of vaginal delivery. However, as no evidence of permanent denervation and muscle atrophy was found in women suffering from obstetric fistula, denervation seems unlikely as an important pathophysiological mechanism in child birth-related pelvic floor muscle injury [35].

In a prospective imaging study comparing the hiatal area before and after a first vaginal birth at a mean of 5 months postpartum, 19% of women with an intact levator were found to have > 20% peripartum increase in hiatal area on Valsalva together with ballooning, i.e. an abnormally distensible hiatus defined as a hiatal area on Valsalva = > 25 cm$^2$ based on previous studies in non-pregnant nulliparae [36] and in the symptomatic population [37]. These findings suggest that the levator may have been overstretched [38]. On comparing imaging data on hiatal area obtained at 3–6 months and 2–3 years after the first birth, no evidence of regression or healing was found suggesting that over-distension of the puborectalis or levator 'micro-trauma' may be irreversible [31] (Fig. 5).

## Risk Factors

Levator avulsion and micro-trauma are largely the consequences of the 1st vaginal birth [39, 40]. Older maternal age at first birth is an established antenatal risk factor [9, 22, 41–43] for levator trauma as well as for OASI. An odds ratio of 1.064 for overall risk of injury was noted for each increasing year of age past age 18 years [43] (Fig. 6). This has important implications since women in many societies increasingly delay child bearing.

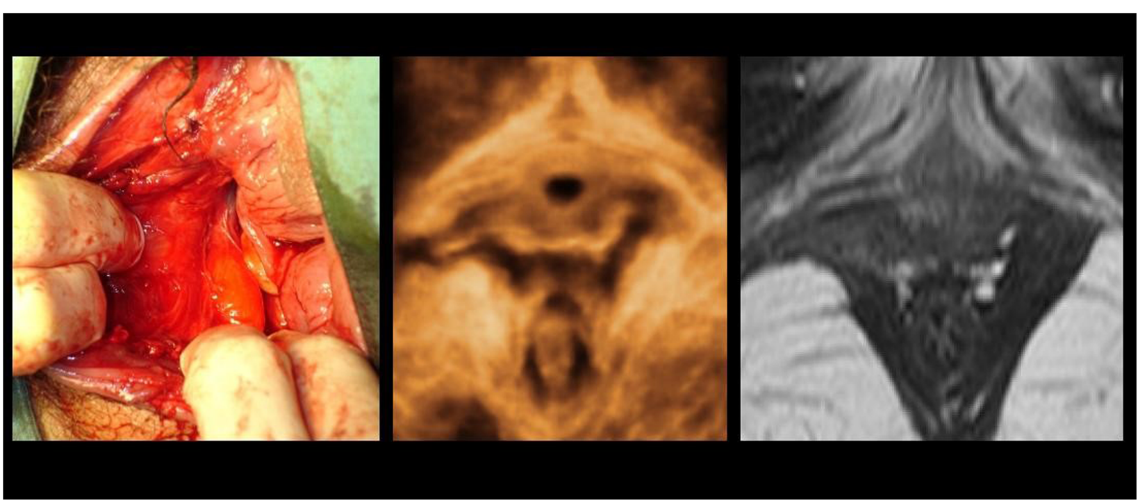

**Fig. 3** Levator avulsion as seen through a large vaginal tear (left), on US (middle) and on MR (right) 3 months after vaginal delivery. Reproduced from Dietz et al. with permission [13]

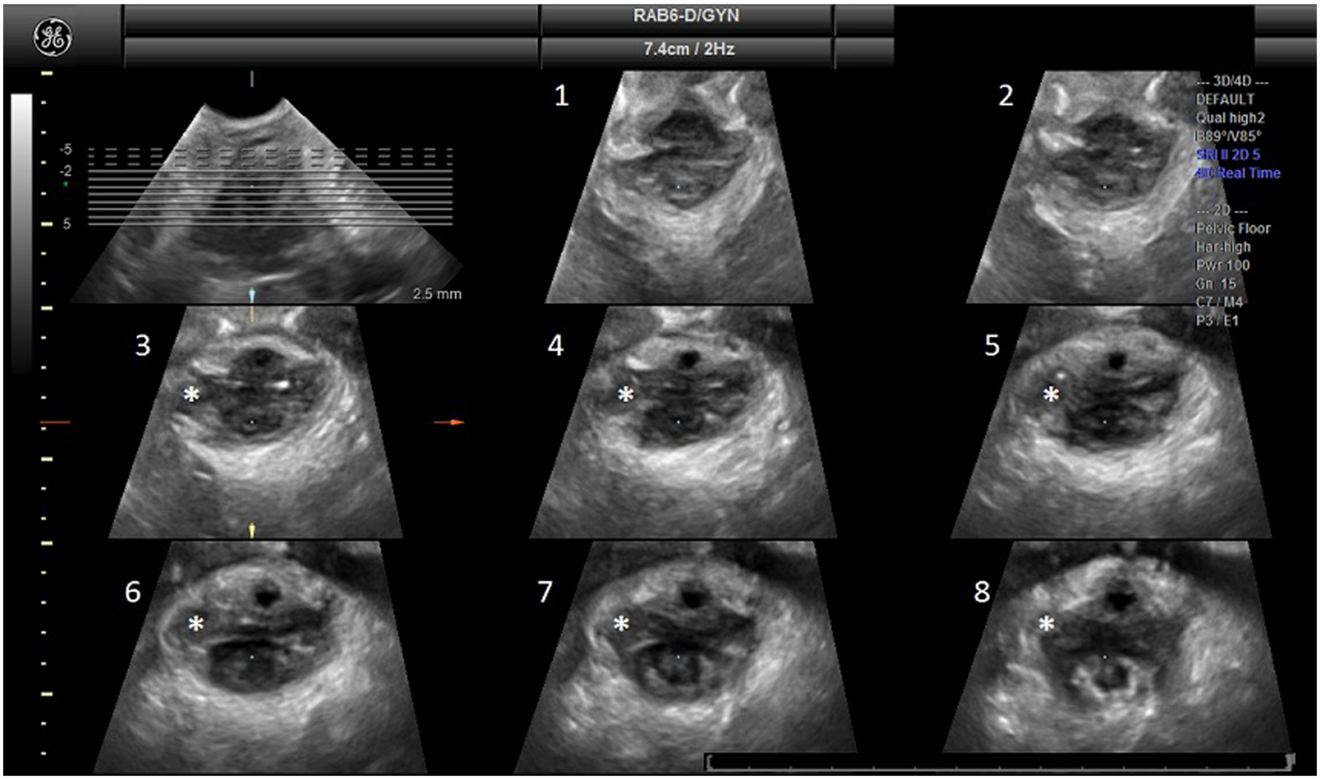


**Fig. 4** Tomographic ultrasound imaging showing a complete right-sided levator avulsion. The site of the avulsion is marked by asterisk

Other antenatal risk factors shown to be associated with avulsion include a lower maternal body mass index and reduced bladder neck descent, a measure that may reflect a stiffer pelvic floor [22, 44]. A family history of CS was found to be associated with micro-trauma [22].

Foetal head circumference, foetal head position other than occipito-anterior and a prolonged 2nd stage of labour have variously been shown to be associated with levator trauma [18, 38, 45, 46]. Forceps delivery, however, is the most important and best-established risk factor for avulsion. In a recently published meta-analysis, forceps was shown to carry an OR for avulsion of 6.94 (4.93–9.78) compared to NVD and an OR of 4.57(3.21–6.51) compared to vacuum birth [47••]. The excess risk of avulsion in forceps delivery cannot be fully explained by an increase in space requirement during delivery. The shortened time to maximum distension and increased overall force during forceps are likely the main factor in the excess risk observed due to forceps [48].

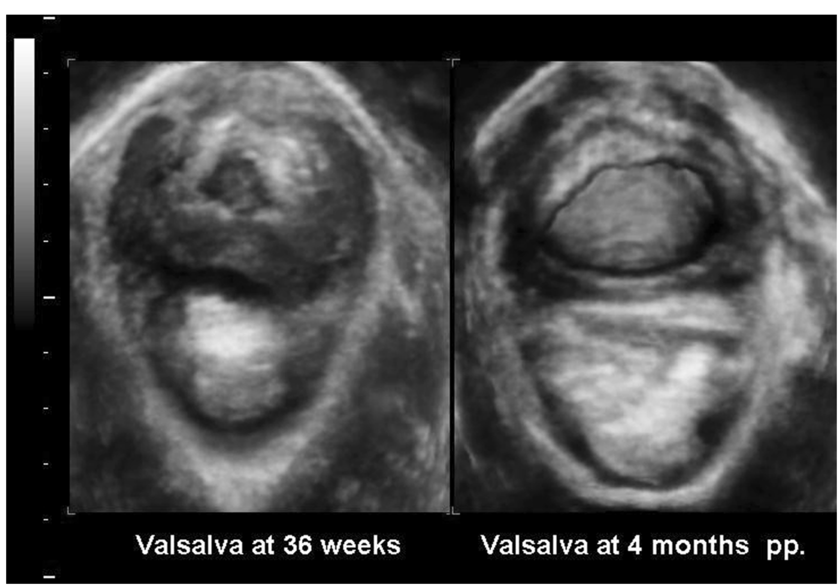


**Fig. 5** Antepartum and postpartum ultrasound images in the axial plane on Valsalva of a primiparous woman with irreversible levator over-distension or levator microtrauma. Hiatal area on Valsalva was 26 cm$^2$ at 36 weeks and 34 cm$^2$ at 4 months after a normal vaginal birth

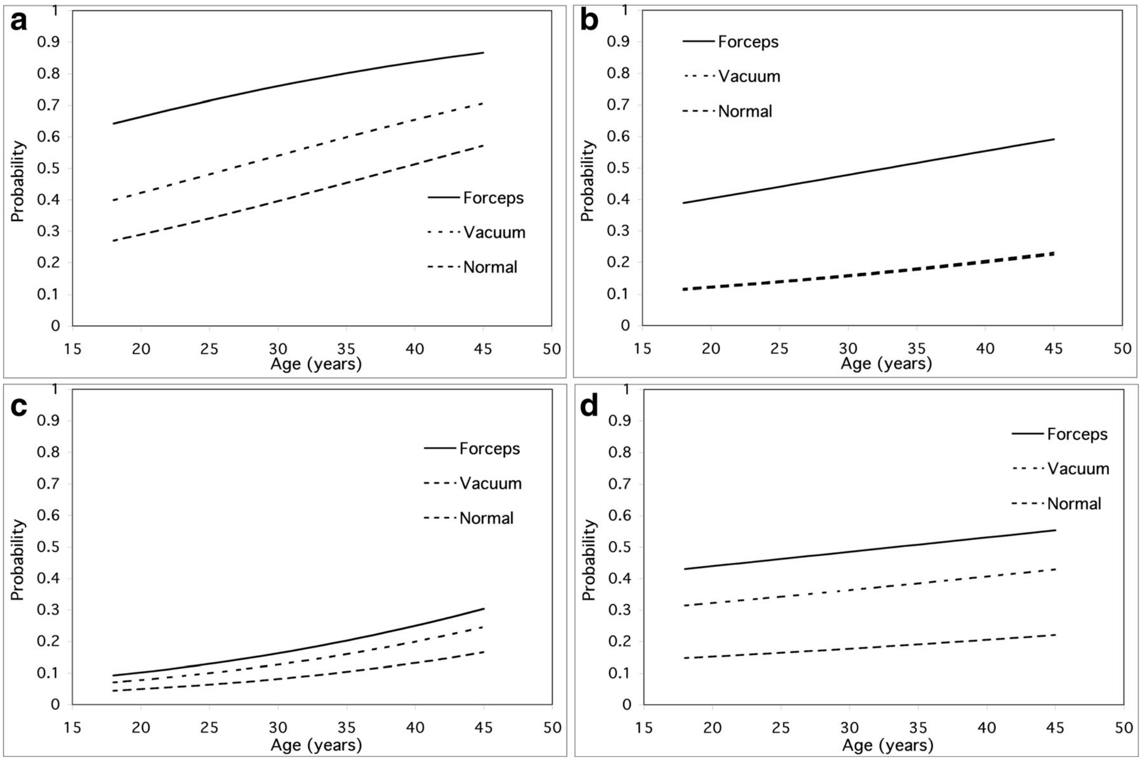


**Fig. 6** Estimated probability of **a** any major injury, **b** levator avulsion, **c** hiatal over-distension, i.e. hiatal area on Valsalva => 25 $cm^2$, and **d** obstetric anal sphincter injuries as a function of age for each mode of vaginal delivery. Reproduced from Rahmanou et al. with permission [43]

It has been hypothesised that low forceps and non-rotational forceps may be less traumatic to the pelvic floor than mid forceps and rotational forceps. The literature regarding this issue is controversial [49, 50].

The indication for forceps may be associated with avulsion risk. Forceps delivery performed for second stage arrest as compared to delivery for foetal distress with short second stage was found to be associated with a higher major levator defects rate (63 versus 42%) though this did not reach statistical significance ($P = 0.07$), likely due to a power issue [51]. Vacuum is not a risk factor for avulsion [47••].

The role of episiotomy in the pathogenesis of levator avulsion is intriguing. Some authors have shown a positive correlation with avulsion [9, 52] while others failed to show any association [38, 46, 53]. A positive correlation between avulsion and episiotomy may of course reflect a difficult vaginal delivery rather than a cause and effect relationship. Epidural anaesthesia may be protective against levator injury [18, 54] by preventing premature maternal pushing and/or by paralysing the pelvic floor muscle.

## Consequences of Levator Trauma

The pelvic floor is important for pelvic organ support and the levator hiatus is a potential hernia portal through which POP may develop, and it also plays a role in the maintenance of anal and urinary continence and sexual function. Trauma to the pelvic floor, not surprisingly, can lead to various morbidities.

## Pelvic Organ Prolapse

POP is highly prevalent with women's lifetime risk for POP surgery in the order of 10–20% [55, 56]. Given its high prevalence, it is obvious that improved understanding of levator trauma should have a high priority. Both levator avulsion and ballooning, i.e. an abnormally distensible hiatus, are independent risk factors for both symptoms and signs of POP [12, 57–61]; the latter is associated with a 6–11% increase in the risk of symptoms and signs of prolapse for each square centimetre of hiatal area on Valsalva [59].

Avulsion has been shown to be associated with ballooning or an abnormally distensible hiatus, increased muscle distensibility and a weaker muscle [62, 63]. These mechanisms may underlie the obvious epidemiological association between avulsion and POP. Women with avulsion were about twice as likely to have POP of stage II or higher than those without; the effect is mainly on the anterior and central compartment [57, 61]. Interestingly levator avulsion is associated with Green type III cystoceles (cystoceles with an intact retrovesical angle) rather than cystourethroceles (cystoceles with an open retrovesical angle or Green II) contradicting the commonly held belief that Green type III cystoceles are caused by central rather than by lateral fascial defects [64].

The effect of avulsion on the posterior compartment is less, though an association of rectal intussusception and hiatal ballooning has been reported [65].

It is unclear why women tend to present with symptoms of POP decades after pelvic floor trauma though forceps delivery and older age at first birth are associated with a shorter time to presentation [66]. John Delancey's 'Ship in the dock' hypothesis may be a plausible explanation [67]. Though levator avulsion was found to be associated with more advanced POP stage, it is not associated with symptoms severity, symptoms bother or quality of life scores [41, 68, 69].

Levator trauma is not only significant as a cause of POP but also a risk factor for treatment failure. Avulsion was associated with a higher risk of vaginal pessary expulsion [70]. In a recent meta-analysis, avulsion carried an OR of 2.76 for POP recurrence after surgical repairs; hiatal area on Valsalva conveyed an OR of 1.06 for each square centimetre [71••]. Depending on the status of the pelvic floor, the risk of prolapse recurrence can be up to 90% in some women [72•] (Fig. 7).

While there has been a heated debate in regard to the use of transvaginal mesh in prolapse repairs [73, 74], POP in some women may be incurable without mesh implants [72•]. Transvaginal mesh has been shown to reduce risk of POP recurrence in women with avulsion compared with native tissue repair [72•, 75•, 76]. It however is not beneficial to women without avulsion [72•, 76]. In the modelling study by Rodrigo et al., it was implied that the risk of POP recurrence may be lowered by hiatal reduction surgery [72•]. It is obvious that a full pelvic floor assessment, preferably by imaging, should be part of the investigation of POP to allow full patient counselling and proper management; and especially in any POP treatment trials, given that both are significant confounders of recurrence risk.

## Urinary Incontinence

It is a commonly held opinion that the levator ani muscle is important in urethral support and for urinary continence. However, levator avulsion was not found to be associated with either symptoms of stress urinary incontinence (SUI) or urodynamic stress incontinence (USI) [12, 60, 77–79]. This observation is counterintuitive given that pelvic floor muscle exercises are commonly employed in the management of SUI and USI. It is plausible that pelvic floor muscle exercises 'train' not just the levator ani but also other muscles that are important for maintenance of urinary continence, in particular the urethral rhabdosphincter. Furthermore, while levator avulsion was found significantly associated with increased bladder neck mobility, it is mobility of the mid-urethra that is most strongly associated with symptoms of SUI and USI [80, 81].

## Faecal Incontinence

Faecal continence is achieved by the structural and functional integrity of the anorectal unit that includes the puborectalis muscle. It is plausible, therefore, that levator trauma may contribute to anal incontinence. Current evidence in this area, however, is conflicting with some showing levator avulsion as an independent risk factor for anal incontinence after primary repair of OASI [82] while other studies failed to show an association between avulsion or hiatal area and faecal incontinence [60, 83]. Again, this seems to contradict the common practice of referring patients for pelvic floor muscle exercises after OASI and for treatment of faecal incontinence; however, the same explanation as for SUI/USI may apply. Pelvic floor physiotherapy may strengthen other muscle groups that are important for anal continence apart from the puborectalis, in particular the external anal sphincter.

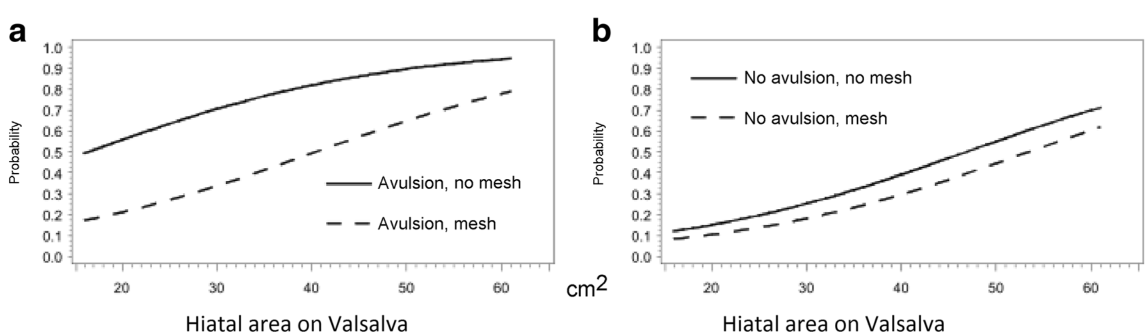


**Fig. 7** Estimation of recurrence risk: risk of prolapse recurrence (y-axis) at a mean of 2.5 years after anterior colporrhaphy with or without use of transvaginal mesh in women with levator avulsion (**a**) and in women with intact levator (**b**), relative to levator hiatal area on maximal Valsalva (x-axis) and levator avulsion ($n = 334$). Reproduced from Rodrigo et al. with permission [72•]

## Sexual Function

The puborectalis muscle is sometimes called the 'love muscle'. It is responsible for maintenance of the vaginal high pressure zone [84]. Not surprisingly, levator trauma may impact on sexual function. Women with avulsion seem to notice the effect of avulsion as a reduction in pelvic floor muscle contraction strength [85] and as increased vaginal laxity and reduced tone on intercourse [86, 87]. Sexual dysfunction as a result can impact on women's relationship with partners and may lead to marital disharmony [88]. The significance of the levator ani muscle in sexual function may become an important consideration given the resurgence of cosmetic genitoplasty procedures aiming at tightening the vagina.

## Psychological Consequences

Apart from physical morbidities, women may also suffer from psychological morbidities secondary to pelvic floor trauma. In a qualitative study on 40 women with known levator avulsion, 27 reported symptoms of post-traumatic stress disorder [88]. In this study, participants had experienced multiple barriers in seeking help and commonly felt abandoned by the system. Health care providers were reported to be dismissive, or they trivialised women's complaints. A lack of knowledge and understanding of levator trauma among health service providers may contribute to this attitude [89] which may further impact on women's mental health [88].

## Prediction

Though a number of antenatal risk factors for levator trauma have been identified, maternal age at delivery is the only firmly established risk factor [9, 22, 41, 42]. Risk assessment to identify women at high risk of levator trauma so as to allow preventative intervention does not currently seem feasible.

## Prevention

Levator trauma is a consequence of vaginal birth; hence, it is evident that CS prevents levator avulsion, childbirth-related levator over-distension and OASI. However, CS is not without risks. It is also considered more costly than vaginal birth though there is some evidence that this may not be the case [90]. If one takes into consideration the economic cost associated with loss of productivity and treatment of physical and psychological morbidities secondary to maternal trauma, CS may turn out to appear more favourable from the perspective of health economics, especially in women who intend to have only one or two children. Elective CS without medical indication is a topic of heated debate which is likely to continue [91–95].

It has been hypothesised that by changing the biomechanical characteristics of the pelvic floor muscle antenatally with a birth trainer, the EpiNo® device may prevent pelvic floor trauma. However in a large randomised control trial on the antepartum use of the device, no beneficial effect could be demonstrated [19].

Forceps is a well-established risk factor for pelvic floor trauma and the most important modifiable obstetric factor for prevention. Dropping forceps delivery will result in less pelvic floor injuries and will reduce the subsequent need for treatment as observed in Denmark and in the USA [96–98]. If assisted vaginal delivery is indicated, vacuum should be the instrument of choice.

It remains to be determined if limiting the length of 2nd stage or use of epidural/pudendal block to paralyse the pelvic floor muscle is protective against pelvic floor trauma.

## Treatment

Attempts at primary repair of levator avulsion in the delivery suite have been unsuccessful [13]. It may be difficult to effect a solid repair since the muscle is likely friable after major injury, and necessarily overdistended and elongated. Secondary repair of avulsion has been tested in a surgical trial in women with symptomatic POP deemed for surgery, but its effects on prolapse recurrence and hiatal dimensions were unsatisfactory in the majority of patients [99]. It appears that reattachment of the muscle may only make sense in a subset of patients with good muscle function and mild or absent ballooning.

Over a decade ago, a surgical procedure involving the placement of a mesh sling in the ischiorectal fossa, from one obturator foramen to the anococcygeal raphe and back to the contralateral side, was trialled in patients with faecal incontinence [100]. We have adapted this technique to develop the 'Puborectalis Sling' (PR Sling), aiming to reduce the size of the levator hiatus. In this procedure the ends of the mesh sling are anchored to the periosteum of the inferior pubic ramus bilaterally. Results of a pilot study showed that the PR Sling significantly reduced the levator hiatus by almost 30% with no major long-term complications [101]. A randomised control study of the PR Sling is ongoing.

## Current Trends in Obstetrics

Pregnant women tend to be older and have a higher BMI today as compared to previous decades. In 2016, the average age of first-time mother in Australia was 29 years compared to 28.1 years in 2006 and 26.6 years in 1996 [102–104]. Almost half of mothers are overweight or obese at their first antenatal visit. Given this change in demographic characteristics, it should not be surprising that women are more likely to suffer medical complications and to require emergency operative delivery. One in three births in Australia is now by CS compared to 30.8% in 2006 [104].

The optimal CS rate is unknown and the WHO no longer recommends a maximum CS rate [105]. Nonetheless, the perception is that the current CS rate is unnecessarily high, driven by ill-informed public activism. Consequently, there has been increasing pressure on professional bodies, hospitals and individual practitioners to reduce their CS rates. One example was a policy directive by New South Wales Health in 2010 where a reduction of CS rates to 20% or less by 2015 was mandated [106]. Another example was the joint consensus document by the Society for Maternal-Fetal Medicine and the American College of Obstetrics and Gynecology in 2014 where the definitions of labour dystocia was revised, aiming to reduce primary caesarean delivery [107]. This document also recommends operative vaginal delivery, including forceps, in order to reduce CS in the second stage of labour.

In spite of a lack of safety data, such interventions have led to changes in obstetric practice. In some centres, longer labours are being tolerated [108] and in others dedicated efforts are made to promote vaginal birth after CS (VBAC) [109]. In some jurisdictions like the UK and Australia, we are seeing an increase in forceps use since forceps is more likely to achieve vaginal delivery than vacuum. In Australia, for instance, the forceps rate has risen from 3.5% in 2006 to 5.3% in 2016 [103, 104]. In one large Australian teaching hospital, trainees are required to become competent in forceps delivery before they are allowed to use vacuum [110].

These trends in Obstetrics are worrying and dangerous. While a policy change to tolerate longer labours may reduce the primary CS rate, this is likely to result in a higher rate of operative vaginal deliveries in nulliparae, higher risk of unplanned CS, higher rates of OASI, shoulder dystocia, postpartum haemorrhage, and a higher rate of arterial cord pH below 7.0 as well as admission to the neonatal intensive care unit [108, 111]. In a study on outcomes in a dedicated VBAC clinic, the authors reported more than 50% emergency operative deliveries, two perinatal deaths with one secondary to uterine rupture out of 160 VBAC cases [109]. Using modelling, doubling the forceps rate in UK between 2004 and 2014 may have resulted in over 100,000 additional major cases of levator trauma and OASI [112]. A change in training policy in instrumental delivery over a 5-year period as mentioned above was estimated to result in approximately 750 additional forceps deliveries and at least 150 additional cases of major maternal trauma [109, 113].

## Where Do We Go from Here?

Medicine is supposed to be scientific and evidence-based. Any change in medical practice should be supported by solid evidence and safety data, not ideology. Otherwise, we are at risk of causing harm to our patients as exemplified above. Obstetrics should be no different. As in other fields of Medicine, Obstetric patients are entitled to unbiased and full disclosure of options of management and material risks. This is both an ethical/moral and a legal requirement in many jurisdictions.

Antenatal consent for an attempt at normal vaginal delivery has recently been a subject of debate [114, 115]. Opponents of antenatal consent argue that childbirth is a natural process, not a procedure or treatment and hence antenatal consent is not indicated [115]. However in the 2015 case of Montgomery v Lanarkshire Health Board in the UK [116] and in a recent case in Australia [117], the courts were clear that clinicians have a duty to warn patients of all material risks, defined as all matters a patient is either known to, or would be likely to; consider important in their circumstances [118]. It has recently been shown that only about 1/3 of primiparous women aiming at vaginal delivery at two tertiary Australian obstetric units achieved a normal vaginal delivery without sustaining levator or anal sphincter injuries [119]. Women should be made aware of the degree of personal risk in an attempt at natural birth and the overall and relative risks of interventions that might be indicated through a proper informed consent process, and they should be involved in obstetric decision-making. They need to be treated as adults [114].

## Conclusion

Our fixation on the CS rate has driven changes in Obstetric practice that are dangerous. It is evident that vaginal birth is more traumatic than is generally assumed. Maternal birth trauma encompasses not just obstetric anal sphincter tears but also levator avulsion and hiatal over-distension. These forms of musculo-skeletal trauma can have long-term physical and psychological consequences. In the face of increasing pressure and interference from political activists ill-informed policy makers, professional bodies and peers, perinatal health care providers need to understand and recognise the significance of somatic birth trauma and its potential impact on women's health.

## Compliance with Ethical Standards

**Conflict of Interest** Ka Lai Shek reports an unrestricted educational grant from GE Medical during the time of this study and Peter Hans Dietz also reports honoraria and flight costs from GE Medical. Otherwise, the authors declare no other conflict of interest.

**Human and Animal Rights and Informed Consent** This article does not contain any studies with human or animal subjects performed by any of the authors.

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• Of importance
•• Of major importance


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