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REVIEW ARTICLE

Can pelvic floor injury secondary to delivery be prevented?

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Abstract The number of women suffering from pelvic floor disorders (PFD) is likely to grow significantly in the coming years with a growing older population. There is an urgent need to investigate factors contributing to the development of PFD and develop preventative strategies. We have reviewed the literature and analyzed results from our own study regarding the association between delivery mode, obstetrical practice and fetal measurements, and damage to the pelvic floor. Based on our findings, we have suggested a flowchart helping the obstetrician to conduct vaginal delivery with minimal pelvic floor insult. Primiparity, instrumental delivery, large fetal head circumference, and prolonged second stage of delivery are risk factors for PFD. Pelvic floor integrity should always be seriously considered in every primiparous woman. All efforts should be aimed at minimizing any insult, which might have a significant impact on the woman's pelvic integrity and future quality of life.

Keywords Pelvic floor damage · Mode of delivery

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Introduction

"Be fruitful and multiply" is the first commandment mentioned in the Bible (Genesis 1:28). However, after Eve sinned by eating the apple from the tree in the Garden of Eden, the woman was cursed as follows: "It will be with anguish that you will give birth to children" (Genesis 3:16). What does the word "anguish" imply? Pain, sorrow, discomfort, or insult to the pelvic floor?

In this paper, we will try to answer two questions. First, is there an association between the natural process of birthing and damage to the pelvic floor, and do we have enough data on the impact of delivery mode on the pelvic floor to alter obstetrical practice?

In addressing the first question, from an evolutionary point of view, it is hard to accept the fact that the most important role of human kind such as multiplying might involve sacrificing one's own health; however, there are examples from lower species, such as octopuses, salmon, and squid, where delivery can be associated with the end of the mother's life.

Pelvic floor disorders (PFD) may present with a combination of some or all of the following conditions: stress urinary incontinence (SUI), flatal and fecal incontinence (FI), and pelvic organ prolapse (POP).

Approximately one third of adult women in the USA suffer from various degrees of PFD. The condition has a profound adverse impact on their quality of life and constitutes a significant economic burden [1–4]. Despite the fact that many women are managed conservatively, Olsen et al. surveyed almost 150,000 women, at age 80, and found that 10% of women underwent pelvic surgery and up to 30% had repeated corrective operations [5]. DeLancey has described this as a hidden epidemic where 10% of women will require surgery for pelvic floor

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dysfunction [6]. This number is likely to grow significantly in the coming years with a growing older population and the development of more minimally invasive surgical techniques to correct various symptoms of PFD.

What is the proof for the association between birthing and PFD?

Many publications have shown that PFD is more prevalent among women who have delivered at least one child [6–21]. This is further emphasized in at least two studies of twin pregnancies that showed that despite the fact that both twin sisters share similar genetic background, the parous twin sister has a three to four times higher risk of developing PFD [11, 12]. Furthermore, it has been shown that parous premenopausal women have a higher incidence of SUI compared with nulliparous women [22].

Whereas in the premenopausal women, the association between parity and PFD is clear, this is not true in postmenopausal women. One group reported that older nulliparous women are just as likely to suffer SUI as older parous women [24]. This does not exclude the association between parity and PFD, but emphasizes the role of age-related changes such as collagen depletion, menopause, and chronic diseases associated with increased intraabdominal pressure on pelvic floor strength later in life [21]. However, in women who participated in the Women's Health Initiative study, it was shown that PFD was more common among postmenopausal parous women compared with non-parous women [8]. A recent report of a large, case-controlled, Swedish, registry cohort study of 33,167 women having only cesarean deliveries versus age- and date-matched women having only vaginal deliveries between 1973 and 1983 showed an increasing incidence of anti-incontinence and prolapse surgery in women who delivered vaginally over three decades when compared to those women only having cesarean sections. In the cesarean-only cohort, there was little increase in the rate of surgery for prolapse over 30 years after the first delivery, but there was a linear increase in the rate of prolapse surgery in the vaginal delivery cohort reaching a peak of 27 cases per 10,000 women years about 28 years after the first vaginal delivery [23].

The available literature, however, cannot conclusively distinguish between pregnancy and delivery mode on pelvic floor health. Although vaginal delivery plays an important role in PFD, the pregnancy itself might significantly adversely impact pelvic floor integrity [21, 24].

SUI and FI are more common during pregnancy than before pregnancy, and it has been shown that during pregnancy, there is a deterioration of pelvic organ support probably due to increased elasticity of the pelvic structures preparing the pelvis for the upcoming delivery. However, significantly more women will complain of SUI after vaginal delivery than before pregnancy and 10% of women will suffer SUI complaints only after delivery [25].

Most prospective trials have shown that 70% of women with onset of SUI during pregnancy spontaneously resolve their symptoms postpartum [24, 26–30], while the prevalence of incontinence, as well as its severity and frequency, decline in the first year after delivery [24, 26–29]. Most studies demonstrated that onset of UI during pregnancy and its persistence 3 months after delivery represents one of the most important risk factors for UI in later life. In fact, it has been reported that up to 90% of women who still complain of UI 3 months after vaginal delivery will be incontinent 5 years after [31]. Moreover, women without incontinence during pregnancy are at risk for incontinence in the postpartum period [24, 32]. Pregnancy and delivery do not improve preexisting PFD [33, 34]. Data regarding the prevalence of pelvic organ prolapse (POP) during pregnancy and in the postpartum period are conflicting. Pelvic support usually deteriorates following delivery [24, 32]; however, other systemic conditions such as obesity [35], chronic lung disease [36], and aging play an important role in the etiology of POP [37, 38].

How pregnancy and delivery injure the pelvic floor has not been conclusively shown. Data suggest that pregnancy and delivery contribute to pelvic floor injury through different mechanisms. While during pregnancy, compression and stretching play an important role in PFD, stretching, nerve injury, muscular tearing, connective tissue disruption, or a combination of all or some of these insults are more prominent during delivery [39].

Perineal trauma affects around 85% of women undergoing vaginal birth. It can be spontaneous, occurring secondary to interventions such as episiotomies, or in association with instrumental deliveries [40]. The accepted classification of perineal tears described originally by Sultan et al. [41] and adopted by the International Consultation on Incontinence and the Royal College of Obstetrics and Gynecologists (Table 1) classifies perineal trauma in four categories according to the tissues and structures involved. Most childbirth-related perineal trauma falls into the first or second degree classifications involving only the perineum, while the more severe forms of perineal trauma fall into the third or fourth degree classifications involving the anal sphincter with a reported incidence of 0.5–3% [7]. These are associated with serious long-term interference with quality of life.

There are numerous risk factors associated with PFD mentioned in the literature (Table 2). We have chosen to divide them into two columns, those appearing in the left

Table 1 Perineal tear classification as first described by Sultan

First degree	Injury to skin only
Second degree	Injury to the perineum involving muscles but not involving anal sphincter
Third degree	Injury to the perineum involving the anal sphincter
	3a<50% of external anal sphincter (EAS) torn
	3b>50% EAS torn
	3c Internal anal sphincter (IAS) torn
Fourth degree	Injury to perineum involving the anal sphincter complex (EAS and/or IAS) and anal epithelium

column associated with genetic and environmental factors, while the right column reflects those which may be influenced by obstetricians.

Some of these risk factors are associated with hard evidence, while others represent assumptions. Some of these factors are preventable and should be a focus for future research to try and detect women at risk for developing PFD following delivery. In the future, we may be able to offer this subgroup of women an alternative method of delivery.

Genetic and environmental risk factors for PFD

Twin and other studies have shown that there is a genetic tendency to develop PFD [11, 12, 22, 42–44]. UI was also found to be more prevalent in white women of European origin and Hispanic women, compared to Black women [8, 42–47]. These differences might be due to differences in collagen types or the type of collagen laid down to repair injuries to the pelvic floor.

Smoking and low socioeconomic status were found to correlate with PFD, indicating their impact on tissue integrity [43, 48].

Table 2 Risk factors for pelvic floor disorders divided by genetic and environmental factors and those influenced by obstetricians

Genetic and environmental factors	Obstetrical factors
Genetics	Parity
Race	Vaginal birth
Smoking	Instrumental deliveries
Advanced age	Episiotomy
Obesity	Birth weight
Low socioeconomic status	Labor induction
Labor-intensive occupation	Second stage duration
	Epidural anesthesia
	Fetal presentation
	Delivery position
	Early Pushing

Aging has an adverse impact on tissue integrity and elasticity as demonstrated by the fact that PFD are more common among older women. Hornemann et al. [37], in a retrospective study performed in 2,967 women, found maternal age to be the second most important risk factor for severe perineal lacerations. However, owing to the methodology of the study, clear cut-off threshold values for maternal age could not be defined. Rortveit and Hunskaar [38], however, showed that maternal age older than 25 years at the first delivery increases the risk for UI, and specifically SUI, compared with younger primiparas, and Groutz et al. [49] showed that a maternal age >37 years old at time of delivery represents a risk factor for postpartum UI.

Obesity is recognized as a risk factor for PFD following vaginal delivery [35, 50]. The threshold values and the morbidity associated with alternative modes of delivery are not, however, defined. Bump et al. [51] have shown that significant improvement in lower urinary tract function and incontinence have occurred in women after surgically induced weight loss. This may result from lower abdominal pressure with physical stress and improved transmission of this stress to the urethra with decreased axial mobility of the urethra.

Obstetrical related risk factors for PFD

Parity Much data have been collected regarding parity and the relative risk for PFD. Not all investigators agree that the more deliveries a woman experiences, the more likely it is that she will develop PFD. Some [1, 52] agree that vaginal delivery is a risk factor for PFD, but the risk is not increased with each delivery, as opposed to those, like DeLancey [53] who demonstrated an increased risk with each delivery (Fig. 1). Leijonhufvud et al. [23] also showed an increased risk of subsequent surgery for both stress incontinence and genital prolapse with increasing parity in

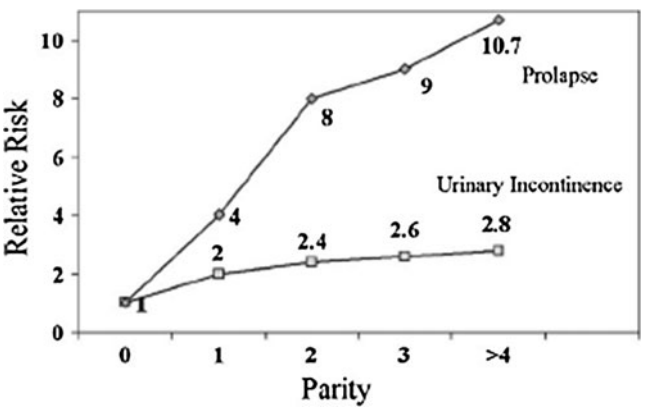

Fig. 1 Graph of the effect of vaginal parity on the development of urinary incontinence and pelvic organ prolapsed

63,229 women delivered only by vaginal delivery in 1973–1983 with no corresponding increase in incidence of surgery in those women only undergoing cesarean delivery. Others [54] even consider multiparity as a protective factor for third degree perineal injury. This is likely true only for women whose first delivery caused no damage to the pelvic floor. DiPiazza et al. [55] showed that risk factors for sphincter tears in the multiparous patient are similar to those of the nulliparous woman.

Primiparity Sultan et al. [6] was one of the first to recognize that the first delivery is the most deleterious to the integrity of the pelvic floor, especially regarding anal sphincter insult (Fig. 2). Since the publication of Sultan et al., many researchers have agreed that the first delivery is the most destructive to the pelvic floor. A possible explanation for the negative impact of the first delivery is the inelasticity of the perineum [56, 57].

Instrumental deliveries Are usually associated with a higher risk of anal sphincter injury [54, 58]. Forceps seem to be more risky; however, Handa et al. [39] found that vacuum delivery was more harmful compared to forceps, and Eskandar and Shet [59] have even shown that instrumental delivery can be used as a protective method to reduce the risk of high grade perineal injury in delivery with occipitoanterior position. The Cochrane Review found that the use of the vacuum extractor for assisted vaginal delivery when compared to forceps delivery was associated with significantly less maternal trauma [62]. The recent report by Leijonhufved et al. showed a dramatic increased risk for subsequent prolapse surgery following forcep delivery, which was double that seen with both spontaneous vaginal and vacuum-assisted delivery and 20 times higher than the rate found following cesarean deliveries [23].

Episiotomy There is controversy regarding the association between episiotomy and PFD. Some consider it a risk factor for perineal tear and recommend abstention from routine performance of episiotomies [37, 39], while others look upon it as a sphincter protective procedure [54, 59]. Others find no association between episiotomies and sphincter tears [58, 60].

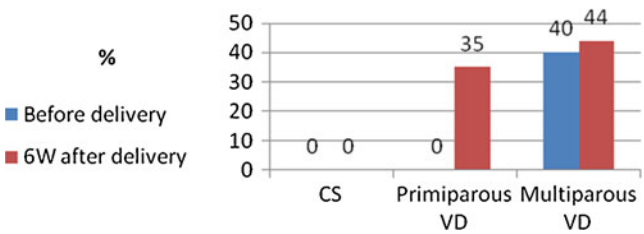

Fig. 2 Incidence of anal-sphincter defects in women following delivery, according to parity

There are also differences of opinion with regard to the type of episiotomy (median vs. mediolateral). Hornemann [37] did not differentiate the type of episiotomy and regarded it as the most significant risk factor for severe perineal laceration. Most do differentiate between the types of episiotomy and associate the different types with either a significant increase, decrease [7, 39, 58, 61], or no effect on the risk for III° and IV° perineal tears [54, 58, 60].

Instrumental delivery and midline episiotomy The combination of these two procedures seems to be an even more prominent hazard to the integrity of the anal sphincter [62].

The Argentine Episiotomy Trial Collaborative Group concluded that routine episiotomy should be abandoned and that episiotomy rates above 30% cannot be justified. The Cochrane Review in 2009 concluded that episiotomies performed only when indicated offer significantly less risk to the pelvic floor compared with routine episiotomies. They recommended avoiding the practice of routine episiotomy, which was the standard of care in most delivery rooms 20 years ago [63].

Birth weight Most researchers have found a positive correlation between high birth weight and perineal injury during delivery [7, 37, 54, 64]. However, there is no specific threshold where vaginal delivery should be avoided, similar to gestational diabetes, in which vaginal delivery is contraindicated with an estimated fetal weight >4.5 kg to avoid shoulder dystocia. Multiple maternal and fetal factors, including BMI, pelvic bone structure, and fetal fat distribution, need to be considered. Estimation of the fetal head circumference might be a more precise modality to correlate with PFD following vaginal delivery and is a focus of our current research.

There is controversy regarding the association between induction of labor and perineal injury during vaginal delivery. Investigators have found anywhere from no correlation [45] a weak association [54, 61] to protection [59]. This correlation is probably confounded by other factors such as parity, indication for induction, need for augmentation during labor, use of epidural anesthesia, mode of induction, birth weight, and the use of instrumentation.

Second stage duration Although Sultan et al. [6] did not find a correlation between second stage duration and PFD, others have found that the longer the second stage the higher the prevalence of clinically identified third- or fourth-degree tears [65]. Conversely, some investigators have found that the length of the second stage was inversely proportional to the frequency of severe perineal tears [59], which may have been due to a slower and more controlled second stage with less expulsive force. This was a retrospective trial of >3,000 women for risk factors for

III° and IV° perineal tears. It is possible that with a very slow descent of the head visual tears may be avoided, but there may be occult injury to the pelvic floor.

Both active and passive second stage duration >3 h in women and longer than 2 h in women experiencing vaginal births after cesarean section (VBACs) is considered as an indication for cesarean section (CS), due to risk of uterine rupture [66]. Nobody has limited the duration of the second stage to avoid damage to the pelvic floor. It may be that 2 h in the second stage is already too long in preventing pelvic floor injury.

Epidural is considered by some as a risk factor for PFD [67]; however, Altman et al. [52] found no increased risk with epidural anesthesia, and Eskander et al. [59] found it protective against anal sphincter injury.

Neither delivery position nor early pushing has been found to be significantly associated with PFD [61].

Results from our own study

We [68] have tried to identify risk factors associated with PFD following vaginal delivery. Two hundred ten primiparous women undergoing normal vaginal delivery were examined and divided into two subgroups: 39 women with levator ani (LA) defects detected by 3D transperineal ultrasound and 171 women with no LA defect. We compared several risk factors in both groups and found no differences between the two groups regarding episiotomy and the use of vacuum extraction. However, birth weight, head circumference (HC), and duration of the second stage of labor were significantly increased in women who were detected to have LA defects (Fig. 3). We calculated cut-off values for risk of LA injury: the relative risk to develop LA trauma is doubled when the head circumference is ≥35 cm, and it increases to almost 3.5 when the HC is ≥35.5 cm. When the second stage duration reaches 90 min, the risk of LA trauma is doubled; when the duration is >160 min, the RR for levator injury is 3.55. We concluded that during pregnancy, no LA injury occurred; elective CS was protective for PFD; VD was associated with PFD; and large head circumference and prolonged second stage of labor are risk factors for LA injury. We are currently conducting further prospective trials to establish obstetric risk factors for PFD and develop a predictive model for avoidance of LA trauma during VD.

Head circumference

Cut- off value	HC≥35.0 cm (the 80th percentile)	HC≥35.5 cm (the 90th percentile)
OR for LA trauma	2.08	3.43

Second stage length

Cut- off value	90 min (the 70th percentile)	160 min (the 90th percentile)
OR for LA trauma	2.05	3.55

Risk factors for levator ani obstetric trauma, assessed by 3DTUS, & its significance in the development of pelvic floor disorders. Valsky DV, Messing B, Pomp R, Bord A, Hochner-Celnikier D, Lavy Y, Yagel S. 2009

Fig. 3 Increased head circumference and second stage duration as risk factors for LA injury

Can we prevent PFD?

Prophylactic pelvic floor muscle exercises

Despite the fact that prophylactic pelvic floor muscle exercises (PFMEs) is an accepted treatment for urinary and fecal incontinence, opinions differ as to whether it assists in the prevention and long term protection against PFD [39, 50, 69].

Antenatal perineal massage

It has been shown that antenatal perineal massage, besides being well accepted by women, reduced the likelihood of perineal trauma requiring suturing and episiotomy and decreased postpartum perineal pain in women who had prior VD [70], but offers no protection against sphincter damage [71].

Cesarean delivery

The performance of elective CS to reduce or prevent PFD is controversial. Observational studies have suggested that CS is associated with a lower rate of future UI and PFD than vaginal delivery. However, no randomized controlled trials have examined this. Furthermore, confounders such as maternal age, macrosomia, and obesity interfere with our ability to reach conclusions as to the preventive role of elective CS on PFD. The prophylactic benefits of CS are limited. Borello-France et al. [72] showed that 22.9% of 124 primiparas in a prospective cohort study complained of urinary incontinence 6 months after undergoing elective CS. Only <1% had urinary incontinence prior to the pregnancy, and thus, CS prior to labor failed to prevent urinary incontinence. In the International Term Breech Trial, mothers were randomly assigned to CS or vaginal delivery. On short-term analysis, CS was slightly protective against urinary incontinence, but secondary analysis revealed no difference between the two groups in the incidence of UI and FI 2 years after delivery. Press et al. [73] have shown that elective CS was effective in reducing stress urinary incontinence, but less effective in preventing other PFD. An expert panel of the NIH concluded that there

is only weak evidence to support a preventive role for elective CS, and it has been estimated that seven women would have to deliver all of their children by CS to prevent one woman from developing PFD later in life [1]. Even if it assists in the reduction of PFD, the morbidity of elective CS should be weighed against this benefit. A survey performed among 282 obstetricians in 31 obstetric units in London [74] revealed liberal attitudes toward CS among obstetricians, reflecting concern regarding evidence linking vaginal deliveries with stress urinary incontinence and anal sphincter damage. Eighty percent requesting CS did so out of fear of perineal damage as a result of VD, and all indicated fear of long-term sequelae including stress urinary incontinence and levator ani damage.

While elective CS is perceived to be an effective prevention strategy in some women, we need more information regarding its benefits vs. risks. Given that more than 350,000 in-patient surgeries are performed in the USA each year for treatment of PFD, the importance of effective prevention strategies and improved treatment plans is clear [53].

Can we predict women at risk for PFD during labor?

In the endeavor to identify women at risk for PFD, Williams et al. [67] performed a retrospective study in order to offer women at risk for PDF an alternative to vaginal delivery. One hundred twenty-three cases of women who sustained obstetric anal sphincter injuries (OASIS) were identified from a tertiary maternity unit in the UK; the investigators were unable to predict any risk factors.

An additional study performed in Australia during 2005–2008 sought to determine the feasibility of antepartum prediction of major levator trauma. It concluded that it may be impossible to do so and that future studies should focus on modification of current obstetric practices and antepartum interventions applicable to the general population [75].

Do we need to change our practice during labor?

Based on the accumulated data, forceps delivery as well as routine episiotomy should be avoided. Given the huge impact on everyday management in labor, the use of labor induction, oxytocin, and epidural anesthesia should be continued until reliable evidence is established to decide otherwise. The correlation among prolonged second stage, increased fetal weight, large head circumference, and PFD is strong, and we might need to define cut-off values beyond which we need to offer the laboring woman an alternative mode of birth. Once the risk factors for PFD are identified and well defined, we should consider including these issues in our discussions with patients with delivery planning.

Secondary Prevention of PFD

We have decided to start with secondary prevention of PFD, as there is more agreement among clinicians regarding steps that should be taken in order to avoid further insult to the pelvic floor in women who experienced damage in their previous delivery. Until we have level 1 evidence that CS is protective to the pelvic floor, vaginal delivery will remain the preferred mode for delivery. However, many have advocated that CS may be a good alternative for women who experienced PFD in their previous delivery or underwent corrective surgery for any symptoms associated with insult to the pelvic floor—although level 1 evidence is not available to support this (Fig. 4, flow chart 1).

There is, however, still controversy regarding the severity of PFD experienced in the previous delivery. Should a woman who had a IIIa° sphincter tear in her previous delivery be offered a CS, similar to a woman who had a IV° tear of the anal sphincter? Should we offer a woman with mild stress urinary incontinence a CS or rather go ahead with a VD and offer a potentially less morbid midurethral sling after completing her childbearing?

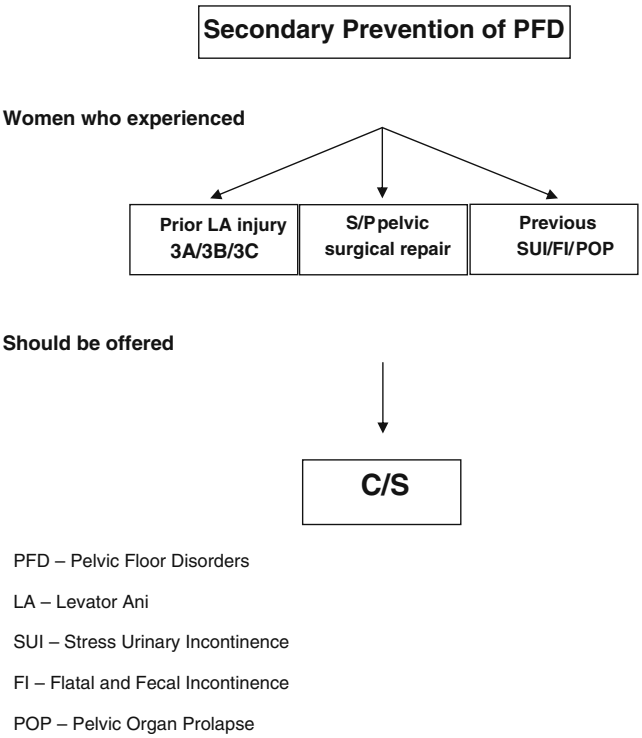

Fig. 4 Flowchart of secondary prevention of PFD

Primary prevention of PFD

Primary prevention of PFD remains an issue requiring much more data. Pre-delivery and intrapartum management, as well as biometric maternal parameters, fetal size, and genetic background, should all be taken into consideration before offering the laboring woman alternative modes of delivery to avoid PFD.

In Fig. 5 (flow chart 2), we suggest guidelines to help the clinician offer his patients the safest mode of delivery. There are, however, many unanswered issues. There is no evidence for the efficacy of various antepartum modalities such as PFME, perineal massage, and EPI-NO (silicon inflatable perineal dilator) to prevent PFD [76]. Research should be aimed at identifying antepartum interventions that might decrease or prevent PFD. Most obstetricians agree that avoiding routine episiotomy and forceps delivery is desirable to prevent pelvic floor insult. Limiting second stage duration seems logical, but we do not yet have proven cut-off levels, beyond which we will perform CS to protect the pelvic floor. The integrity of the pelvic floor might be damaged before a second stage length of 60, 90, or more minutes, and performing a CS at this stage will offer no advantage to the pelvic floor. Moreover, should primiparous heavy (BMI>30/35) women, older than 35 years, with a family history of PFD, and those with a fetal head circumference >35.5 cm be offered an elective primary CS to save the integrity of their pelvic floor? To date, we have no level 1 evidence to offer primiparous women an alternative birthing mode, and every individual case should be handled separately. Ethically, we must examine whether we have a duty to share these data with the patient, and let her decide. The American College of Obstetricians and Gynecologists has suggested that it is the physician who has the ethical responsibility to evaluate the data and that elective cesarean section should not be routinely offered to patients to prevent PFD [77, 78].

Conclusion

With the extended longevity in developed countries, PFD might become one of the most prevalent problems a woman faces in her life. Pelvic floor integrity should therefore always be seriously considered in every primiparous woman. All efforts should be aimed at minimizing any insult, which might have a significant impact on the woman's quality of life.

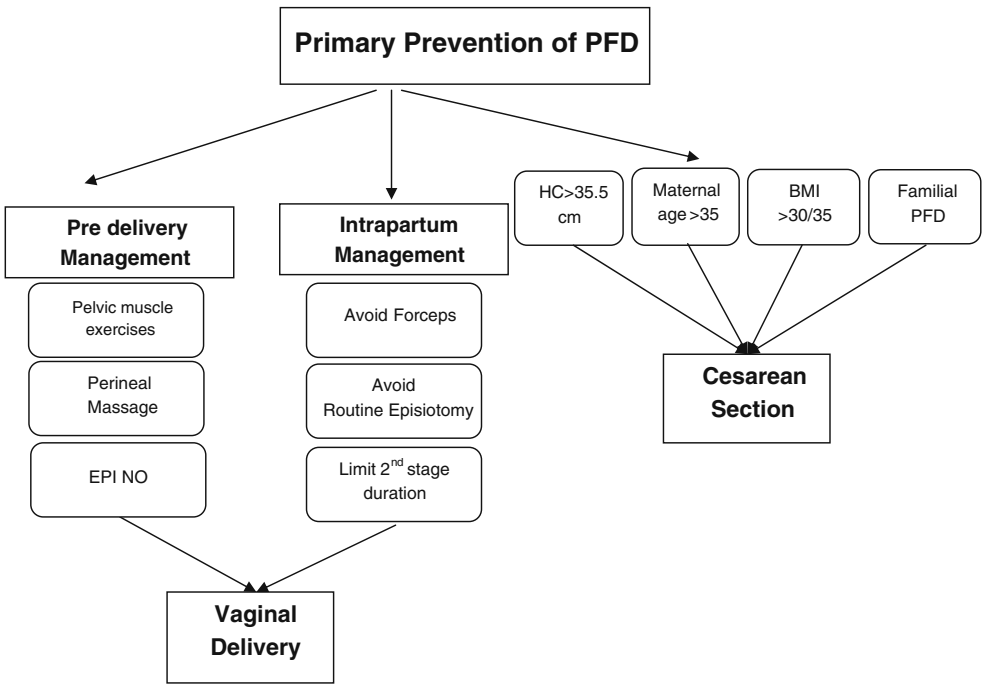

Fig. 5 Flowchart of primary prevention of PFD

Conflicts of interest None.

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