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Pregnancy and delivery after pelvic fracture in fertile-aged women: A nationwide population-based cohort study in Finland

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ABSTRACT

Objective: Only a few small studies have assessed the effects of pelvic fractures on pregnancies, deliveries, and rates of cesarean sections. We aimed to evaluate the effect of pelvic fractures on subsequent pregnancy and delivery in Finland.
Study design: In this retrospective register-based nationwide cohort study, data on all fertile-aged (aged 15–49) women with a pelvic fracture during our study period (1998–2018) were retrieved from the Care Register for Health Care. The data were subsequently combined with data from the National Medical Birth Register. Women with pelvic fracture before pregnancy were compared with a no-fracture group consisting of 621 141 women who had had 1 156 723 singleton deliveries without a preceding pelvic fracture. We used logistic regression to analyze preterm deliveries, cesarean sections, and neonatal health. Results are reported as adjusted odds ratios (AOR) with 95% confidence intervals (CI).
Results: A total of 2 878 women with a previous pelvic fracture were identified. Of these, 596 women had 1 024 singleton deliveries after pelvic fracture. In the no-fracture group, 621 141 women had 1 156 378 singleton deliveries. Compared to the no-fracture group, women with a previous pelvic fracture had higher rates of cesarean sections (22.6% vs 15.9%) (AOR 1.55 CI 1.32–1.80), higher rate of preterm deliveries (6.2% vs 4.6%) (1.32 CI 1.01–1.69), and a higher rate of neonates requiring intensive care unit treatment (13.5% vs 10.0%) (AOR 1.35 CI 1.13–1.62).
Conclusion: Vaginal delivery was the primary mode of delivery despite the higher rate of cesarean section among women with a previous fracture of the pelvis. The rate for preterm deliveries and need for neonatal intensive care was also higher, but the clinical importance of these findings is unclear. Our results suggest that vaginal delivery after fractures of the pelvic circle is generally safe for both mother and neonate.

Introduction

The incidence of pelvic fractures in the younger population is approximately 20/100 000 person-years. [1] In younger populations, fractures of the pelvic circle are typically the result of high energy collisions, such as falls from height or traffic accidents, whereas falls from standing height are more common in older populations. [1] Among the Finnish adult population during the years 1997–2014, around 8.2% of all pelvic fractures were treated surgically [2]. The main aim for surgical treatment of pelvic fracture is to restore stability and allow for mobilization and healing. [3] Allowing faster mobilization of the patient and shortening the recovery period lowers the total treatment costs when compared with those treated conservatively. [4]

Fractures of the pelvic circle may affect the sexual health of fertile-aged women, causing pain during sexual intercourse and sexual dysfunction.[5] To date, there have only been a few small studies that have assessed deliveries and pregnancies after pelvic fractures. It seems that even though pelvic fractures have affected

Abbreviations: AOR, adjusted odds ratio; CI, confidence intervals; CS, cesarean section; MBR, the National Medical Birth Register; OR, odds ratio.

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the mode of delivery, vaginal delivery is still possible after pelvic trauma.[6–8] Indeed, even after operatively treated pelvic fractures with associated damaged pubic symphysis, vaginal delivery is still possible.[5]

According to the findings of previous studies, patients who have suffered a pelvic fracture have a notably higher proportion of cesarean section (CS) (30–60%), even though the reason for this remains unclear.[9] There are no previous studies reporting major challenges during pregnancy after pelvic fracture when delivery itself is not considered. Copeland et al. found that patients with a pelvic fracture with over 5 mm dislocation had an increased risk for CS. The same study showed that pelvic fractures did not have a notable effect on miscarriage or fertility. Currently, it is suggested that the reason behind the increased risk for CS is most likely multifactorial and requires further investigation.[10]

As previous studies have all been relatively small and have only focused on the mode of delivery, we aimed to examine the mode of delivery and neonatal health in women with pelvic fracture on a larger scale. The aim of our nationwide register study is therefore to report the incidence of pelvic fractures in fertile-aged women and to investigate the effects of pelvic factures on subsequent pregnancy and delivery.

Materials and methods

In this retrospective nationwide register-based cohort study, we linked data from two national registers: the National Medical Birth Register (MBR) and the Care Register for Health Care. Both registers are maintained by the Finnish Institute for Health and Welfare. The study period was from 1998 to 2018, as we acquired data for these years.

The MBR contains information on all pregnancies, delivery statistics, and perinatal outcomes of births with a birthweight of $\geq$ 500 g or a gestational age $\geq 22^{+0}$, but only singleton deliveries were included in our study. The MBR has high coverage and quality (the current coverage is nearly 100%).[11,12]

Pelvic fracture was defined as a hospitalization period with one of the pelvic fracture ICD-10 codes (shown in supplementary file Table 1). Each patient with a hospitalization period with one of these ICD-codes was classified as a fracture patient. When forming the fracture group, only the first pelvic fracture for each woman was noted and each subsequent pregnancy after sustaining the pelvic fracture was added to the fracture group. Our data was limited to ICD-10 codes starting with S and NOMESCO (Nordic Medico-statistical Committee, Finnish version approved by the Finnish Institute for Health and Welfare) operation codes starting with N. All fertile-aged (15–49 years) women with a pelvic fracture during our study period (1998–2018) were included. Pelvic fracture surgery patients were included based on the operations codes of the Nordic version of the NOMESCO classification (Supplementary Table 1). Data from both registers were then combined by using the pseudonymized identification number of the mother.

Women with a pelvic fracture prior to delivery formed the patient cohort, which was categorized into operated and non-operated patients. A total of 604 women with 1 054 deliveries were identified in the group of women with a previous pelvic fracture. The identification of the fracture patients with subsequent deliveries was based on the date of the fracture in the Care Register for Health Care and the date of the pregnancy in the MBR. The date of the pregnancy is calculated from the last periods or confirmed with ultrasound. Conservatively treated fracture patients (570 women with 975 singleton deliveries) and operatively treated fracture patients (26 women with 49 deliveries) were analyzed separately. For clarity, they are presented together as the fracture group in tables and only significant findings have been presented separately. The no-fracture group consisted of 621 141 women who had 1 156 723 singleton deliveries without a preceding pelvic fracture (Fig. 1). Deliveries with missing information on the mode of delivery were excluded. In this study, each non-elective CS is considered as an urgent CS. The results of this study are reported according to the STROBE guidelines.[13]

Ethics

Both the MBR and the Care Register for Health Care used the same unique pseudonymized identification number for each patient. The pseudonymization was made by the Finnish data authority FINDATA. The authors did not have access to the pseudonymization key, as it is maintained by FINDATA. In accordance with Finnish regulations, no ethical approval or informed written consent was required because of the retrospective register-based study design. [14] Permission to use the data was granted by FINDATA after evaluation of the study protocol (Permission number: THL/1756/14.02.00/2020)

Statistics

Incidences per 100 000 person-years for hip fractures in fertile-aged (15–49 years) women were calculated with 95% confidence intervals. The baseline population was the number of females aged 15 to 49 years who were living in Finland at the end of a particular year, which was obtained from Statistics Finland (Stat.fi).[15] Means with standard deviation were calculated for continuous variables with expected normal distribution, and medians with interquartile range were used for non-normally distributed variables. Categorized variables were presented as absolute numbers and percentages. Subclass analyses were performed according to fracture diagnoses. A p-value under 0.05 was considered statistically significant. Logistic regression model was used to access the primary outcomes (gestational age at birth, mode of delivery, and neonatal health). CS (including elective and urgent) as an outcome was compared to vaginal delivery (including spontaneous and assisted vaginal deliveries) in a logistic regression model assessing mode of delivery. The need for intensive care for the neonate before being sent home from the hospital was used as an indicator for neonatal health. Maternal smoking during pregnancy, maternal diabetes during pregnancy, previous cesarean section and preterm delivery (in the model evaluating need for intensive care) were used as adjusting variables. Maternal smoking status during pregnancy is collected in women and child welfare clinics and can be either non-smoker, smoking during 1st trimester, smoking after 1st trimester or unknown. Maternal diabetes includes women with pregestational and gestational diabetes, and gestational diabetes is defined as pathological glucose tolerance test. Odds ratios with 95% CI were compared between groups. Statistical analysis was performed using R version 4.1103. Adjustments were made by choosing the variables for a multivariate model by using directed acyclic graphs (DAGs) constructed using the free online software Dagitty.[16] The variables included in the DAGs were chosen based on known risk factors and by the hypothesized causal pathways. DAGs are presented as a supplementary file (Supplementary Figs. 1-3).

Results

A total of 2 878 women with pelvic fracture were identified from the register. The incidence of fertile-aged patients with a pelvic fracture was 8.9 per 100 000 person-years in 1998. By 2018, this figure had in increased to 13.2 per 100 000 person-years (Fig. 2).

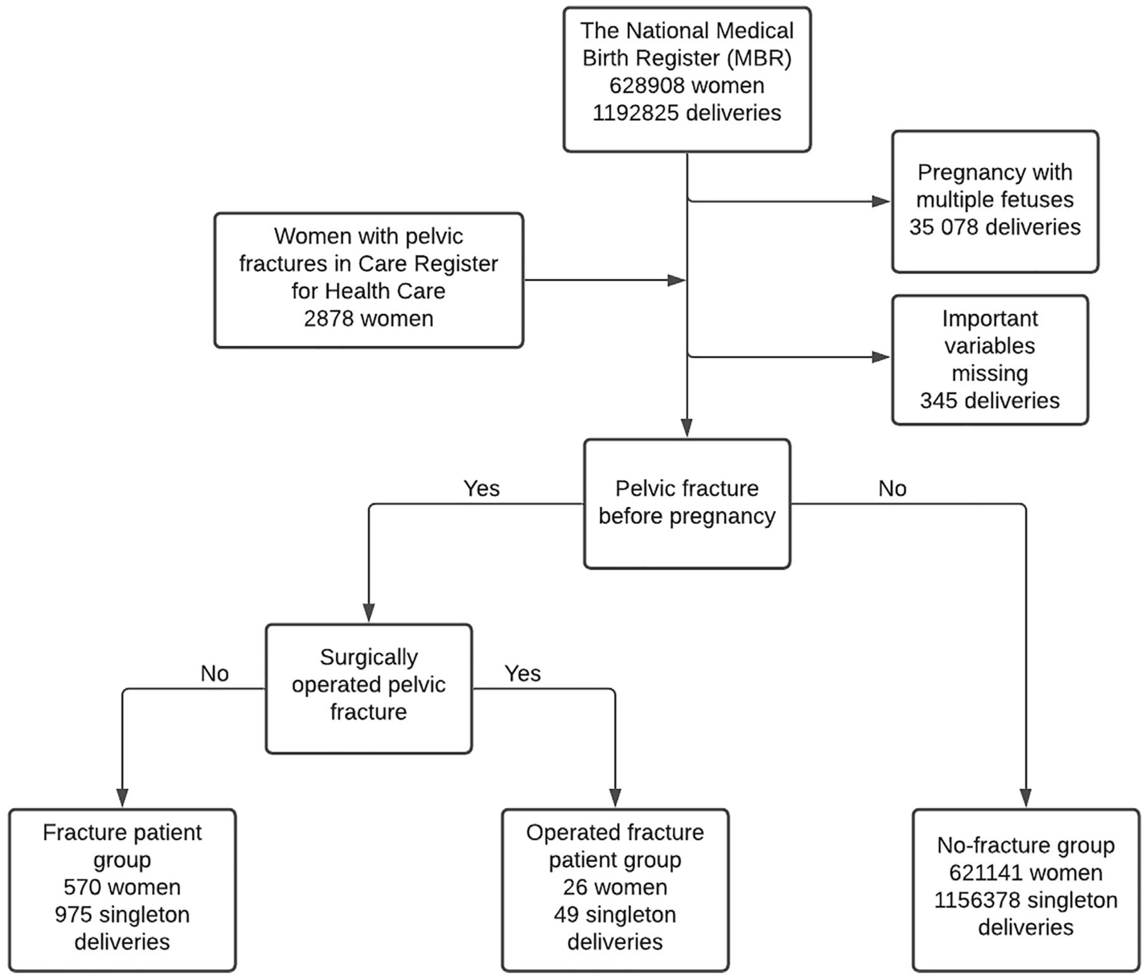

Fig. 1. Flowchart of the study population. Data from the MBR were combined with data on the diagnosed pelvic fractures in the Care Register for Health Care.

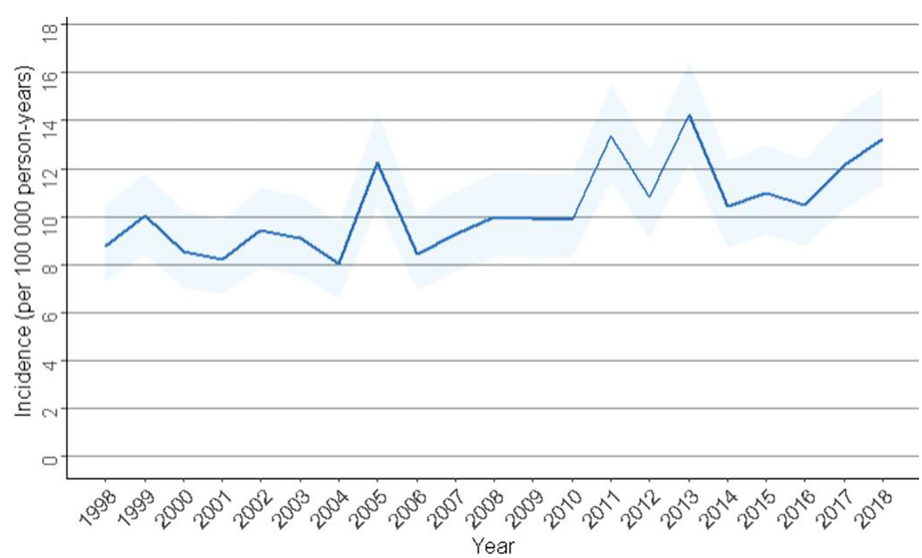

Fig. 2. Incidence of pelvic fractures among fertile-aged (15–49 years) women during the study period.

The mean age of the women in fracture group at the time of the delivery was 29.0 (SD 5.3) years and 29.7 (SD 5.4) in the no-fracture group. A higher rate of women were nulliparous in the fracture group compared to the no-fracture group (44.6% vs 41.4%). A higher percentage of fetuses in the fracture group were exposed to the smoking of the mother during pregnancy when compared to fetuses in the no-fracture group (23.1% vs 14.6%). The rate for previous CS was similar between the fracture and the no-fracture group. Basic background information on the deliveries in the fracture group and the no-fracture group is presented in Table 1.

In the fracture group, 6.2% of the neonates were preterm (gestational age at birth <37^{+0} weeks of gestation) and 3.5% had low birthweight (LBW, birthweight <2500 g), whereas 4.6% of neonates were preterm and 3.0% had LBW in the no-fracture group. Neonates had higher percentages in those variables related to the health problems of neonates (neonatal deaths, Apgar after 1 min, phototherapy, neonatal intensive care unit) in the fracture group. (Table 2).

Women in the fracture group had higher rates of elective CS when compared to the no-fracture group (11.3% vs 6.6%). However, no major differences were found in anesthetics or the rate of obstetrical interventions (amniotomy, use of oxytocin to induce or augment labor, episiotomy) (Table 3). Women in the fracture group had higher rates of preterm deliveries (AOR 1.32 CI 1.01–1.69), higher rates of cesarean sections (AOR 1.55 CI 1.32–1.80) and neonates requiring intensive care unit treatment (AOR 1.31 CI 1.07–1.58) (Table 4). The proportional amount of urgent CS was more common among the fracture group (AOR 1.29 CI 1.06–1.57).

Subgroup analyses based on given pelvic fracture diagnosis (Table 5 and Table 6) showed no major differences between groups. Among women with multiple pelvic fractures (ICD-10 diagnosis S32.7), the proportion of elective CS (17.6%) was higher than with any other diagnosis (Table 4). However, neonatal health was similar in this subgroup when compared to other fracture groups. Perinatal mortality was low with every fracture diagnosis. Vaginal delivery was possible in both fracture groups, and the rates of labor analgesia and modes of delivery were similar when elective cesarean sections were excluded (Table 5).

Discussion

The main finding of this study was the high rate of successful vaginal deliveries, despite the increased rate of CS after pelvic fracture. The rate for preterm deliveries and impaired health of the neonate was also higher after pelvic fracture.

The most important finding was the high rate of successful vaginal deliveries after pelvic fracture. Nevertheless, the proportion of CS was higher after a pelvic fracture, which is further explained by the increased rates of elective CS in the fracture group compared to the no-fracture group. In a country like Finland, where the option of CS is a matter of careful consideration between patient and physician, such a high proportional increase in a patient group is a significant finding. The rate of CS in Finland is one of the lowest in Europe (16–17%), and it has remained stable for the past two decades.[17,18] Even though the rate of elective CS was clearly higher after pelvic fracture in Finland, the rate is still lower than that in other countries. Indeed, in a previous systematic review concerning level-1 trauma centers, the rate of elective CS was over 40% after pelvic fractures[9] which is over 3-fold the rate of elective CS in the fracture group seen in our study. Our results should serve to reduce any doubts women may have regarding vaginal delivery as a mode of delivery after pelvic fracture.

Interestingly, we also found that urgent CS was more frequent in the fracture group. The exact reason for urgent CS remains

Table 1
Background characteristics of deliveries in the fracture group and no-fracture group.

	Fracture-group		No-fracture group	
Total number	1024		1 156 378	
	n	%	n	%
Age at birth (mean SD)	29.0 (5.3)		29.7 (5.4)	
Nulliparous	457	44.6	478 472	41.4
Previous cesarean section	120	11.7	124 235	10.7
Maternal smoking during pregnancy *	237	23.1	169 135	14.6

* Contains women who smoked during only the 1st trimester and/or later trimesters.

Table 2
Perinatal characteristics in the diagnosed fracture group and the no-fracture group.

	Fracture group		No-fracture group	
Total number	1024		1 156 378	
	n	%	n	%
Neonatal sex boy	526	51.4	591 788	51.2
Birth length (cm) (mean; SD)	50.0	2.5	50.1	2.5
Birthweight (grams) (mean; SD)	3474	546	3531	548
LBW <2500 g	36	3.5	34 470	3.0
Preterm <37+0 weeks*	63	6.2	53 117	4.6
Perinatal mortality**	7	0.7	6165	0.5
Neonatal deaths***	5	0.5	2708	0.2
1-minute Apgar score ≤ 6	150	14.6	157 399	13.6
Delivery related asphyxia	26	2.5	34 707	3.0
Phototherapy	65	6.3	68 752	5.9
Neonatal intensive-care unit	138	13.5	115 787	10.0
Neonatal status 7 days postpartum				
at home	956	93.4	1 086 765	94.0
at hospital	68	6.6	69 613	6.0

* Weeks of gestation.
** Includes stillbirths and neonatal deaths occurring during the first seven days.
*** Includes neonates born alive but died during the first seven days.

Table 3
Intended and true mode of delivery, labor analgesia, and procedures related to delivery in trials of labor in the fracture group and the no-fracture group.

	Fracture group		No-fracture group	
Total number	1024		1 156 378	
	n	%	n	%
Intendent mode of delivery				
Elective CS	116	11.3	76,663	6.6
Trial of labor	908	88.7	1,079,715	93.4
Total number (without elective CS *)	908	100	1,079,715	100
Mode of delivery				
spontaneous vaginal delivery	698	76.8	874,824	81.0
breech delivery	4	0.4	7009	0.6
vacuum or forceps delivery	91	10.0	90,840	8.4
urgent CS	115	12.7	107,042	9.9
Labor analgesia				
epidural	455	50.1	469,968	43.5
spinal	154	17.0	123,064	11.4
paracervical	148	16.3	188,597	17.5
amniotomy	446	49.1	533,128	49.4
use of oxytocin	431	47.5	489,282	45.3
episiotomy	214	23.6	278,782	25.8
manual placental removal	12	1.5	16,075	1.5
uterine curettage	6	0.7	9419	0.9

* CS = cesarean section.

Table 4
Absolute numbers, percentages, univariable and adjusted Odds ratios (OR) with 95% confidence intervals (CI) for the main outcomes. The models were adjusted using the following variables: Maternal smoking during pregnancy, maternal diabetes during pregnancy, previous cesarean section, and preterm delivery. Each of the adjusting variables were reported in the MBR during pregnancy.

Total number	Fracture group		No fracture-group		Univariable	Adjusted
	n	%	n	%	OR (95% CI)	OR (95% CI)
Preterm delivery	63	6.2	53 117	4.6	1.36 (1.04–1.74)	1.32 (1.01–1.69) **
Cesarean section *	231	22.6	183 705	15.9	1.54 (1.33–1.78)	1.55 (1.32–1.80) ***
Neonatal intensive care	138	13.5	115 787	10.0	1.40 (1.17–1.67)	1.31 (1.07–1.58) ****

* All cesarean sections, including elective CS.
** Adjusted with maternal smoking during pregnancy and maternal diabetes during pregnancy.
*** Adjusted with maternal smoking during pregnancy, maternal diabetes during pregnancy, and previous CS.
**** Adjusted with maternal smoking during pregnancy, maternal diabetes, diabetes during pregnancy, and preterm delivery.

unclear, as this information is not recorded to the register. The previous pelvic fracture may have complicated the delivery and the higher rate of urgent CS might be due to complications caused by pelvic fractures. Also, the awareness of a previous pelvic fracture may have lowered the threshold for the obstetrician to convert the trial of labor to urgent CS. Additionally, some women with a recorded urgent CS may already have planned an elective CS, but because the labor began early, the planned elective CS was recorded as an urgent CS. In the subgroup analysis, women with multiple pelvic fractures had notably higher rates of elective and urgent CS than women with other fracture diagnoses and women in the no-fracture group. The total rate of CS (including elective and urgent CS) was 32.1% in the group of women with multiple fractures.

Overall, the perinatal mortality rate was low, and no increase was observed among patients in the fracture group. However, the need for neonatal intensive care was higher in the fracture group, which can be explained by the higher CS rate. The higher rate of preterm deliveries can partly be explained by the higher rate of smoking among women with previous pelvic fracture, as smoking is known to increase risk for preterm deliveries.[19] In previous studies, no increase in rates of miscarriage or infertility after pelvic trauma has been reported either. However, the number of patients included in these studies was quite low, and the health of neonates was not reported.[5,8,10]

CS procedures were more common in the fracture group, but in majority of cases vaginal delivery was successful, and the health of the neonate was not affected. CS is linked to a decrease in mortality of neonates and parturients in selected cases. However, the downsides of CS for the neonate are the increased risk for asthma, obesity, and poorer cardiorespiratory health in later life than those born vaginally.[20,21] Additionally, breastfeeding duration is shorter after elective CS.[22] For women, CS may cause pregnancy-related complications in future pregnancies.[23] According to the results of this study, vaginal delivery is the primary mode of delivery even after multiple pelvic fractures or operated pelvic trauma. Interestingly, our results show that the incidence of pelvic fractures among fertile-aged women is increasing in Finland, and similar findings have been reported in Sweden.[1] Consequently, there may be an increase in deliveries after pelvic fracture in future. The results of our study should also be considered when obstetricians and women who have had a pelvic fracture discuss the delivery method during pregnancy, as vaginal delivery for these women appears to be safe and could be attempted.

The strength of our study is the large, nationwide study population with long study period which enabled the analysis of these relatively rare events. The data for the registers used in this study are routinely collected using structured forms with nationwide instructions, which ensures the registers have good coverage and

Table 5
Perinatal characteristics and outcomes in the subgroups based on the type of fracture diagnosis among fracture patients.

Type of fracture	Sacrum (S321)		Ilium (S323)		Acetabulum (S324)		Pubis (S325)		Multiple fractures (S327)		Other or undefined (S328)	
Total number	179		92		128		214		262		149	
	n	%	n	%	n	%	n	%	n	%	n	%
Intended mode of delivery												
Elective CS*	25	13.9	3	3.3	14	10.9	16	7.5	46	17.6	12	8.1
Trial of labor	154	86.1	89	96.7	114	89.1	198	92.5	216	82.4	137	91.9
Preterm <37+0 weeks**	17	9.5	4	4.3	11	8.6	6	2.8	14	5.3	11	7.4
1 min Apgar score ≤ 6	27	15.1	13	14.1	21	16.4	27	12.6	42	9.2	20	13.4
Neonatal intensive care unit	25	14.0	12	13.0	21	16.4	33	15.4	27	10.3	20	13.4
Neonatal status 7 days postpartum												
at home	164	91.6	85	92.4	115	89.8	201	93.9	247	94.3	138	92.6
at hospital	15	8.4	7	7.6	13	10.2	13	6.1	15	5.7	11	7.4

* CS = cesarean section.
** Weeks of gestation.

Table 6
Proportions of selected obstetric variables in attempted vaginal deliveries in the subgroups based on the type of fracture diagnosis among fracture patients.

Fracture diagnosis (ICD-10)	Sacrum (S321)		Ilium (S323)		Acetabulum (S324)		Pubis (S325)		Multiple fractures (S327)		Other or undefined (S328)	
Total number	154		89		114		198		216		137	
	n	%	n	%	n	%	n	%	n	%	n	%
Mode of delivery												
spontaneous vaginal delivery	126	81.8	73	82.0	90	78.9	153	77.3	151	69.9	105	76.6
breech, vacuum, or forceps delivery*	7	4.5	13	14.6	11	9.6	22	11.1	27	12.5	15	10.9
urgent CS **	21	13.6	3	3.4	13	11.4	23	11.6	38	17.6	17	12.4
Labor analgesia												
epidural	75	48.7	47	52.8	60	52.6	99	50.0	105	48.6	69	50.4
spinal	29	18.8	12	13.5	16	14.0	40	20.2	36	16.7	21	15.3
paracervical	16	10.4	16	18.0	24	21.1	33	16.7	33	15.3	26	19.0

* Due to the low number of breech and forceps deliveries, they were combined because Finnish legislation prevents the reporting of the exact event rate if the rate is lower than three.
** CS = cesarean section.

reduces possible reporting and selection bias.[24] Therefore, the coverage and validity of both registers included in this study are high.[25] The advantage of our study compared to previous studies is the large national research material in a country with uniform delivery-related guidelines and attitudes. Furthermore, another advantage compared to multinational studies is that in multinational studies, CS standards may differ between countries (for example, attitudes towards CS and threshold for elective CS), which could result in inaccuracies in the results and make these studies vulnerable to bias.

The main limitation of our study is the missing clinical information on fractures (for example, radiological findings or pelvimetric examination results). As this information is not recorded to the registers, we could only use ICD-10 coding. Further, the contents of the birth register were updated in 2004 and 2017, and ICD-codes concerning chronic diseases of the mother, pregnancy, and delivery, 5-minute Apgar scores, and durations of labor stages were only included after 2004. Therefore, these were not analyzed in our study. Furthermore, since cases of CS were classified as elective or urgent prior to 2004, we have used the same classification in the present study instead of the elective, urgent, and emergency classifications.

Conclusion:

Based on our findings, the proportion of CS was higher after pelvic fracture when compared to the no-fracture group without previous pelvic fractures. However, the rate of preterm deliveries and neonates with health problems born to women with previous pelvic fracture was affected less by previous pelvic fracture when compared to the no-fracture group. Thus, our results advocate vaginal delivery as safe for women after fractures of the pelvis or operated pelvic trauma. These findings could further encourage obstetricians and women with a previous pelvic fracture to consider the possibility of vaginal delivery.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ejogrb.2022.01.008.

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