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**BREECH PRESENTATION AND DELIVERY IN SINGLETON TERM  
PREGNANCIES IN FINLAND**

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**Academic dissertation**

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## LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following original publications, referred to in the text by their Roman numerals:

- I **Breech presentation at term and associated obstetric risk factors - a nationwide population based cohort study.** Macharey G, Gissler M, Rahkonen L, Ulander VM, Väisänen-Tommiska M, Nuutila M, Heinonen S. Arch Gynecol Obstet. 2017 Apr;295(4):833-838. doi: 10.1007/s00404-016-4283-7. Epub 2017 Feb 7.
- II **Induction of labor in breech presentations at term: a retrospective observational study.** Macharey G, Ulander VM, Heinonen S, Kostev K, Nuutila M, Väisänen-Tommiska M. Arch Gynecol Obstet. 2016 Mar;293(3):549-55. doi: 10.1007/s00404-015-3853-4.
- III **Risk factors and outcomes in "well-selected" vaginal breech deliveries: a retrospective observational study.** Macharey G, Ulander VM, Heinonen S, Kostev K, Nuutila M, Väisänen-Tommiska M. J Perinat Med. 2017 Apr 1;45(3):291-297. doi: 10.1515/jpm-2015-0342.
- IV **Risk factors associated with adverse perinatal outcome in planned vaginal breech labors at term: a retrospective population-based case-control study.** Macharey G, Gissler M, Rahkonen L, Ulander VM, Väisänen-Tommiska M, Nuutila M, Heinonen S, BMC Pregnancy Childbirth 2017 Mar 20;17(1):93-017-1278-8.
- V **Neurodevelopmental outcome at four years according to the mode of delivery in term breech presentation: a nationwide population record linkage study.** Macharey G, Väisänen-Tommiska M, Gissler M, Ulander VM, Rahkonen L, Nuutila M, Heinonen S. J Perinat Med. 2017 Sep 9. pii: /j/jpme.ahead-of-print/jpm-2017-0127/jpm-2017-0127.xml. doi: 10.1515/jpm-2017-0127. [Epub ahead of print]

## **ABBREVIATIONS**

Adjusted odds risk [aOR]

American College of Obstetricians and Gynecologists [ACOG]

Body mass index [BMI]

Confidence interval [CI]

Deutsche Gesellschaft für Gynäkologie und Geburtshilfe [DGGG]

Head circumflex [HC]

International Statistical Classification of Diseases and Related Health Problems 10th Revision [ICD-10]

Magnetic resonance imaging [MRI]

Odds risk [OR]

Planned cesarean section [PCS]

Presentation et Mode d'Accouchement study [PREMODA]

Probability value [p-value]

Relative risk [RR]

Royal College of Obstetricians and Gynaecologists [RCOG]

Society of Obstetricians and Gynaecologists of Canada [SCOG]

Standard deviations [SD]

Trial of vaginal breech labor [TVBL]

## ABSTRACT

The cesarean section rate is increasing worldwide and breech presentation is with approximately 17 % one of the major indications for elective cesarean sections. Cesarean section might be a life-saving procedure for mother and child during labor, but is also a major procedure with possible complications and adverse long-term effects for future pregnancies. Breech presentation occurs in 2-3 % of term pregnancies. The safety of vaginal breech delivery has been questioned for a long time, as a trial of vaginal breech labor is associated with an increased adverse short-term outcome. The randomized Term Breech Trial by Hannah has had a significant effect on the handling of breech labor at term. It showed that vaginal breech labor at term is associated with an increased perinatal mortality and morbidity. However, many questioned the results of the Term Breech Trial as it violated many of its own criteria. More importantly, the Presentation et Mode d'Accouchement-study (PREMODA) showed that a trial of delivery with the fetus in breech presentation at term is safe, if the women are selected carefully and the delivery is managed in a modern obstetric setting. Many organizations like the American College of Obstetricians and Gynecologists [ACOG], the Royal College of Obstetricians and Gynaecologists [RCOG], the Society of Obstetricians and Gynaecologists of Canada [SOGC] and the Deutsche Gesellschaft für Gynäkologie und Geburtshilfe [DGGG] have guidelines for selecting and managing women suitable for vaginal breech labor, but even then adverse outcomes are possible.

Our study was designed to evaluate the potential pathophysiology of breech presentation itself, to look for unidentified risk factors associated with adverse perinatal outcome and to investigate if a trial of vaginal labor at term with the fetus in breech position, is associated with adverse neurodevelopmental outcome in the children at the age of four. Two of our studies (II and III) were conducted in the Department of Obstetrics and Gynecology of the Helsinki University Central Hospital as retrospective observational studies. The study periods were between 2011 and 2013 (II) and 2008 and 2015 (III). The data for these two studies on population characteristics, pregnancy and delivery outcomes were collected from the hospital records. The other three studies (I, IV and V) were conducted as population-based, cohort and record linkage studies, with data received from the National Medical Birth Register and the Hospital Discharge Register, maintained by the National Institute for Health and Welfare.

The study periods were between 2004 and 2014. Study I and IV were conducted as population cohort studies and study V as a population-based, record linkage study.

The main outcome of study I was to show the association of possible obstetric risk factors for adverse outcome with breech presentation at term. In study II the main outcome was perinatal morbidity and mortality after an induction of labor while the fetus was in breech presentation. For study III and IV the main outcomes were risk factors associated with adverse perinatal and early neonatal outcomes in vaginal breech delivery at term. In study V we reviewed the neurological development of children at the age of four years born vaginally or after a trial of vaginal delivery in breech presentation. The key findings of our studies were as follows: The data of study I showed that the breech presentation rate at term in Finland is 2.2 %. Breech presentation is compared with vertex presentation associated with a higher stillbirth rate (odds ratio [OR] 2.12, 95 % confidence interval [CI] 1.98 – 2.28), fetal growth restriction (OR 1.19, 95 % CI 1.07 – 1.32), oligohydramnios (OR 1.42, 95 % CI 1.27 – 1.57), gestational diabetes (OR 1.06, 95 % CI 1.00 – 1.13), congenital fetal abnormalities (OR 2.01, 95 % CI 1.92–2.11) and a previous cesarean section (OR 2.13, 95 % 1.98 – 2.29). Our II study did not show differences in perinatal outcome in induced labors compared to spontaneous breech deliveries. However, a trial of induced breech labor was associated with a higher intrapartum cesarean section rate compared to spontaneous breech labor. The results of study III showed that an active second delivery stage lasting less than 40 minutes protects from adverse perinatal outcome (OR 0.34, 95 % CI 0.15 – 0.79). A higher intrapartum cesarean delivery rate of at least 24 % (OR 0.07, 95 % CI 0.01 – 0.34) was also associated with a lower rate of adverse outcome. Epidural anesthesia, instead, was associated with a higher risk for adverse neonatal outcome (OR 2.88, 95 % CI 1.08 – 7.70). The IV study confirmed fetal growth restriction as a risk factor for adverse perinatal outcome in vaginal breech labor (OR 2.94, 95 % CI, 1.30 – 6.67). In addition we found that oligohydramnios (OR 2.94, 95 % CI, 1.15 – 7.18), a previous cesarean section (OR 2.94, 95 % CI, 1.28 – 6.77), gestational diabetes (OR 2.89, 95 % CI, 1.54 – 5.40), epidural anesthesia (OR 2.20, 95 % CI, 1.29 – 3.75) and nulliparity (OR 1.84, 95 % CI, 1.10 – 3.08) are associated with a higher risk for adverse peri- and neonatal outcome. Our study V did not show any differences in the neurological development of children at the age of four years, which were born after a trial of vaginal labor with the fetus in breech presentation, compared to those born by elective cesarean section with the fetus in breech presentation.

In conclusion our studies showed that breech presentation at term is more often associated with other clinical factors that are per se markers for possible adverse obstetric risks. We showed that an active second delivery stage lasting less than 40 minutes or a higher intrapartum cesarean section rate of at least 25 % have a protective influence on fetal outcome in a trial of vaginal labor with the fetus in breech presentation. Adverse neonatal outcome in vaginal breech delivery was associated with oligohydramnios, fetal growth restriction, gestational diabetes, previous cesarean delivery, epidural anesthesia and nulliparity. An induction of labor while the fetus is in breech presentation is feasible. There were no differences in the neurological development of children born after a trial of vaginal breech labor at term compared to children, who were born by elective cesarean section while the fetus was in breech presentation.



## INTRODUCTION

Breech presentation is defined as a fetus in longitude presentation whose buttocks are adjacent to the maternal pelvis. In breech presentation the presenting part of the fetus may be the buttocks, one or both feet, or one or both knees. Breech presentation is categorized into three different main types. Fifty to seventy percent of fetuses in breech presentation at term are in frank breech presentation (Figure 1). Fetuses in frank breech presentation have flexed both hips while both knees are extended. At term five to ten percent of breech fetuses are in complete breech presentation, in which both the hips and knees are flexed (Figure 2). At term, ten to forty percent of breech fetuses are in incomplete presentation; these fetuses have extended one or both hips. Incomplete breech presentation (Figure 3) is associated with an increased risk of asphyxia, birth related injuries and umbilical cord prolapse in vaginal delivery (1,2).

The incidence of breech presentation at birth is estimated to be between 2-4 %. In preterm delivery the prevalence of breech presentation is much higher: at 28 gestational weeks up to 25 % of all fetuses are in breech presentation, at term less than 4 % of all fetuses are in breech presentation. Therefore, the most common reason for breech presentation in labor is preterm delivery (3-6). Most of the fetuses near term tend to turn spontaneously into vertex position, as in this position the fetus makes the best use of the intrauterine space. If the fetus remains in breech presentation at term, it is most likely that something prevents it from turning into vertex presentation (7). Breech presentation can be caused by a prevention of the fetal rotation (tight nuchal cord, uterus anomalies, cornal-fundal location of the placenta, oligohydramnios), an outstanding fetal rotation (preterm pregnancy), hypermobility of the fetus and disturbed engagement of the fetal head into the maternal pelvis (abnormal maternal pelvis, fetal malformation) (3-6,8-10). The reason for breech presentation at term can only be identified in about 15 % of the cases (11). Many clinical factors besides preterm gestation are frequently associated with breech presentation such as breech presentation in a previous pregnancy, primiparity, congenital fetal anomalies, oligohydramnios, fetal growth restriction, placenta previa, and maternal uterine anomalies (3-6,8-10). Since many of these factors are associated with independent and individual risk for poor obstetric outcome, it is possible that these factors might have an influence on the higher short-term morbidity rate in vaginal breech deliveries, as they can result in a clustering effect in combination with a more stressful

vaginal delivery.

It is commonly accepted that fetuses in breech presentation are at higher risk for birth injuries and birth asphyxia during vaginal delivery than fetuses in vertex presentation. The safety of vaginal breech delivery has been debated regularly over the last decades. The term breech trial by Hannah, which was conducted in 2000 is one of the reasons for this (12), as the trial recommended delivery by cesarean section for all fetuses in breech presentation (12). To minimize the risk of adverse outcomes in vaginal breech delivery, different strategies have evolved to manage fetuses in breech presentation at term.

External cephalic version at or near term is the most frequent strategy to minimize the risks of breech delivery, by reducing the incidence rate of breech presentation at term. The success rate of the external cephalic version varies considerably depending on the skill of the person carrying out the maneuver and certain, identified maternal factors (13-16). The successful rotation of the fetus is followed by vaginal labor but women who had a successful external cephalic version are at increased risk of cesarean section (17). In case of an unsuccessful rotation into vertex presentation a planned cesarean section is the most common way of delivery in many countries (18). However, in case of an unsuccessful external version a trial of vaginal breech labor is also possible, if the women and the fetus are well selected for a trial of vaginal breech labor. A cesarean section should be offered to all high-risk pregnancies and any women that do not wish to attempt a vaginal breech birth. An elective cesarean delivery, without a trial of external version is also an option for women that do not want to have an external version or a trial of vaginal labor. A trial of vaginal labor without a trial of external version is possible, if the woman and the fetus fit the criteria for vaginal breech labor.

Malpresentation of the fetus is one of the main indications for primary cesarean section (18). Cesarean birth is associated with adverse maternal short and long-term outcomes (19-22). Recent studies assume that a cesarean birth affects the immunological development of the infant (23-27) and might be associated with a modestly increased risk in later life of atopic diseases (asthma, allergies and atopic skin disorders), diabetes mellitus type I, obesity and neuropsychological disorders (disorders in the autism spectrum, depressions and Parkinson diseases) (23-27). Various criteria have been developed to minimize the risks for adverse outcome in vaginal breech labor and are well described by many guidelines (28-31) and studies (32-36). Typically these guidelines include the following requirements (28-

31,33,34,37-41): 1. The mother is willing to have a trial of vaginal breech labor. 2. The fetus has no anomalies, which might cause dystocia. 3. The maternal pelvis is confirmed to be sufficient in size. 4. The estimated fetal weight is less than 4000 g evaluated by ultrasound and above 2500g. 5. The fetus is in frank, or complete breech position with the head in flexed position. 6. The mother has not had previous cesarean deliveries. 7. The fetus does not suffer from an intrauterine growth restriction. All breech deliveries should be handled or guided by skilled staff.

Some studies, however, have reported an increased risk of perinatal mortality and morbidity following a trial of vaginal breech labor (12,42-45). Adverse perinatal outcomes in vaginal breech delivery can be caused by complications that are typical for a vaginal breech delivery including umbilical cord prolapse and entrapment of the fetal head, or by prenatal factors like fetal growth restriction, congenital anomalies, and placenta insufficiency (31). These prenatal risk factors for adverse prenatal outcome can sometimes be the cause for breech presentation as they might prevent the fetus from rotation into vertex presentation during pregnancy (7). The present study was designed to investigate the pathophysiology of breech presentation and to investigate the safety of a trial of vaginal breech labor at term. We specifically focused on risk factors that put the fetus at risk for adverse outcome during pregnancy and labor. In addition, we investigated the long-term neurological effects on children born after a trial of vaginal breech labor at term.

**Figure 1:** Frank breech presentation



**Figure 2:** Complete breech presentation



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**Figure 3:** Incomplete breech presentation



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# LITERATURE REVIEW

## Epidemiology

### Prevalence of breech presentation in the population

Breech presentation occurs in 2–4 % of all births (Table 1). In Finland the prevalence of breech presentation in singleton pregnancies at term is between 2.1 % and 3.6 % (42,46). The rate is comparable with the rates in other western, developed countries (4,5,9,10,43,47-49) (Table 1).

The prevalence of breech presentation varies from year to year: in Australia it declined from 3.6 % in 2002 to 2.7 % in 2012 (10) while it increased in Norway between 1967 and 1994 from 2.2 % to 3.4 % (47). The fluctuation in prevalence might be caused by an increase of the risk factors for breech presentation, such as increased maternal age, nulliparity, low gestational age (more premature deliveries) and a low birth weight. Another reason for the fluctuation might be a possible increase in the rate of external vertex versions (10,50).

**Table 1:** Prevalence of breech presentation at birth (4,5,9,42,43,46,47,49,51,52)

	Prevalence of breech presentation	Country	Study period
Kauppila	3.6 %	Finland	1952-1970
Albrechtsen	2.2-3.4 %	Norway	1967-1994
Rayl	2.5 %	USA	1987-1988
Ulander*	2.1 %	Finland	1987-1989
Herbst*	2.8 %	Sweden	1991-1999
Zsirai*	3.3 %	Hungary	1996-2011
Vlemmix*	4.4 %	Netherland	1999-2007
Cammu	4.2 %	Belgium	2001-2010
Bin*	3.6-2.7 %	Australia	2002-2012
Lyons*	2.6 %	Canada	2003-2011

\* At term pregnancy

### **Etiology and pathogenesis of breech presentation**

It is normal for the fetus to be in breech or in any other presentation during pregnancy and it is also normal that the fetus changes its presentation during pregnancy. Most of the fetuses turn spontaneously and remain in vertex position, as it is the most efficient use of intrauterine space. The possibility that the fetus rotates spontaneously from breech into vertex presentation before gestational week 32 is around 70 %, but the chance of a spontaneous rotation decreases with increasing gestational weeks (53,54). Therefore, the most common reason for breech presentation during labor is preterm delivery, as up to 35 % of all preterm fetuses are in breech position (3-6).

If the fetus remains in breech presentation at term, it is likely that there is a reason preventing the rotation of the fetus into vertex presentation (Table 2). The factors that increase the risk of breech presentation are well described, and might be related to an outstanding fetal rotation into vertex presentation, an impediment of fetal rotation or abnormal fetal movements. Preterm gestation is often the cause for an outstanding fetal rotation. Oligohydramnios, a cornual-fundal placenta, uterine abnormalities, an abnormal maternal pelvis or a firmer uterus and abdominal wall like in nulliparous women might cause an impediment to fetal rotation. Reduced fetal movements might also be the cause for breech presentation. Female fetuses, fetuses with congenital anomalies or growth restriction move less than male or healthy fetuses. A study reviewing newborns with myelomeningocele has shown that one quarter is born in breech presentation (55). Reduced fetal movements might also be caused by a short umbilical cord or maternal morbidity or intoxication (diabetes, preeclampsia, smoking). A polyhydramnios on the other hand might cause a hypermobility of the fetus and the fetus might be more comfortable in breech presentation as the intrauterine space is not so limited. Multiparous women might have a less firm abdominal wall and uterus which gives the fetus also more space and comfort to remain in breech presentation. Breech presentation may also occur if the engagement of the fetal head into the maternal pelvis is disturbed. (3-7,9)

**Table 2: Predictive factors for breech presentation in singleton pregnancies**

Predictor	Authors									Possible cause
	Cammu 2014 OR*	Zsirai 2016 OR*	Mostello 2014	Fruscalzo 2014	Sekulić 2013	Ben- Rafael 1991	Albrechtsen 1998	Michalas 1991		
Preterm gestation	1.53-4.13		X	X						Outstanding fetal rotation
Nullipara	1.5			X						Impediment of fetal rotation
Fetal growth restriction	1.18-1.93	1.11	X	X						
Female fetus	1.28	1.20		X						Abnormal fetal movements
Congenital malformations	1.24	1.64	X							Abnormal fetal movements
Maternal age above 30	1.28-1.47	1.04	X	X						Abnormal fetal movements
Oligohydramnios			X							Impediment of fetal rotation
Polyhydramnios										Abnormal fetal movements
Diabetes		1.13	X							Abnormal fetal movements
Prior stillbirth		1.26								
Assisted reproduction		1.19								
Cornual-fundal placenta					X					Impediment of fetal rotation
Hypertension/Preeclampsia		1.11								Abnormal fetal movements
Maternal smoking			X							Abnormal fetal movements
Multiparity										Abnormal fetal movements
Fetal neurologic impairment										Abnormal fetal movements
Short umbilical cord										Abnormal fetal movements
Fetal asphyxia										Abnormal fetal movements
Earlier caesaren delivery		1.44								
Previous breech presentation							X			
Uterine abnormality/ Abnormal maternal pelvis							X		X	Impediment of fetal rotation

\*Odds Ratio (OR) in comparison to vertex presentation at delivery

X predictors for breech presentation

## Signs and diagnosis of breech presentation

Women with a fetus in breech presentation can often feel the head of the fetus in the upper abdomen. They also may sense the kicks of the fetus in their lower abdomen. In outpatient clinics fetal presentation is primarily assessed using a series of abdominal palpation steps called Leopold's maneuvers (59). When the fetus is in breech presentation the fetal cardiac sounds have to be observed in a different place compared to a fetus in vertex presentation. To listen to the cardiac sounds, the transducer is placed on the upper abdominal wall, above the maternal umbilicus. During a vaginal examination, the examiner might feel an empty cavity, as the leading part of the fetus does not put so much pressure on the cervix as the fetal head in vertex presentation. When the membranes are ruptured, the examiner might feel two soft masses separated by a furrow. The furrow is interrupted in the center by the anus. In complete breech presentation the examiner will feel the fetal feet (heel and toes). If any doubts about the fetal presentation remain after the examination, an ultrasound examination should be performed, also during labor.

### **External cephalic version**

Women with a fetus in breech presentation in singleton pregnancies should be offered an external cephalic version (31). The external cephalic version should be performed between gestational weeks 35 to 37, as before 35 gestational weeks a fetus is likely to turn into a cephalic presentation on its own (60-62). During an external cephalic version the fetus is rotated from breech into vertex presentation. External cephalic version is possible with a forward (Figure 4) or a backward (Figure 5) somersault. The procedure improves the possibility of a vaginal delivery but it is contraindicated for women who need to undergo a cesarean section due to some other indication such as placenta previa, two or more previous cesarean sections, multiple gestation or severe oligohydramnios. The risk of breech presentation and the risk of a cesarean section are halved (relative risk [RR] 0.42, 95 % CI 0.29-0.61 RR 0.57, 95 % CI 0.40-0.82) by a succeeded trial of external version (61-63).

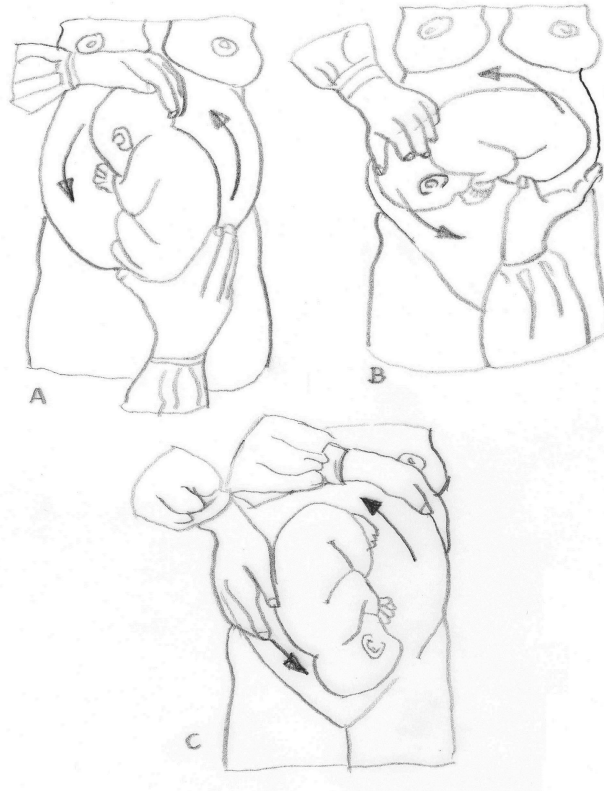
The success rate of an external cephalic version is estimated to be 37 to 66 % (61,62,64,65). A meta-analysis of 84 studies determines that the success rate of an external cephalic version is at 58 % (60). The success rate varies considerably depending on the skill of the health care professional carrying out the maneuver and several maternal factors (13-16). The success rate for multiparous women is higher than for nulliparous women (60,64). Factors associated with a lower success rate include: Nulliparity, anterior placenta, oligohydramnios, low birth weight, maternal obesity, descended buttocks into the maternal pelvis, firm maternal abdominal muscles and tense uterus as well as frank breech presentation (60,65-73).

A systematic review (72) of 37 articles reported that external cephalic version is associated with minor complications: Transient fetal heart rate changes 4.7 %, fetomaternal transfusion 0.9 %, emergency cesarean delivery 0.4 %, vaginal bleeding 0.3 %, rupture of membranes 0.2 %, fetal death 0.2 %, placental abruption 0.2 % and cord prolapse 0.2 % (52). External cephalic version might increase the risk of preterm labor (RR 1.51, 95 % CI 1.03 to 2.21) (61,62). A meta-analysis of three cohort studies and eight case-control studies reported that women with a trial of vaginal labor after successful external cephalic version have an increased risk of emergency cesarean section compared to women with a fetus in spontaneous vertex presentation (OR 2.2, 95 % CI 1.6-3.0) (63). The increased frequency in emergency cesarean delivery is due to dystocia in labor and pathologic fetal heart rate patterns (63). Factors associated primarily with breech presentation like unengaged buttocks, small



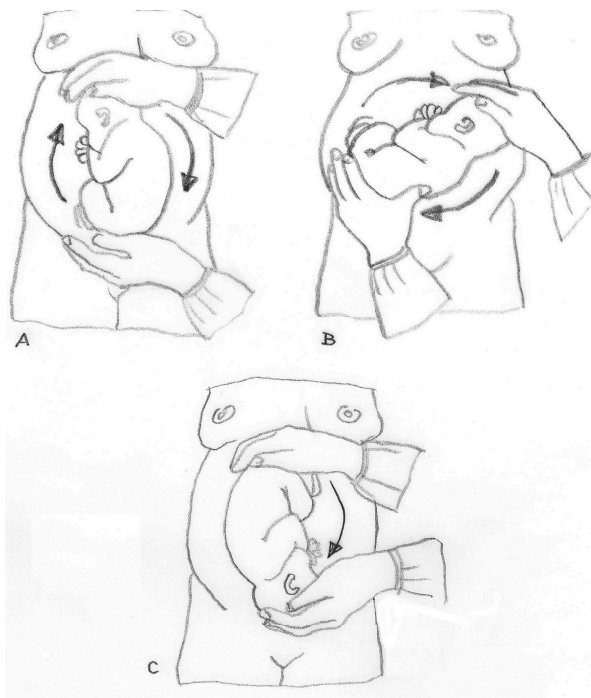
maternal pelvis might be causes for dystocia during vaginal labor after successful external cephalic version (63,74). The increased rate in pathologic fetal heart rates is most likely explainable with the increased rate of fetal growth restriction and oligohydramnios in breech presentation (63,74).

**Figure 4:** External cephalic version: Forward somersault



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**Figure 5:** External cephalic version. Backward somersault



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### **Strategies for delivering singleton fetuses in breech presentation at term**

Women with a singleton fetus in breech presentation at term should be informed that planned vaginal breech delivery is associated with a small increased risk in perinatal mortality compared with planned cesarean section. The perinatal mortality rate in elective cesarean section at gestational week 39+0 is described with 0.5/1000; and in planned vaginal breech labor with approximately 2.0/1000. The perinatal mortality rate in planned vertex labor is described with 1.0/1000 (31). Pregnant women with a fetus in breech presentation should be counseled that the reduced perinatal mortality risk in planned cesarean section is caused by three factors: the prevention of stillbirth after 39 weeks of gestation, the prevention of risks during labor and delivery and the avoidance of risks of vaginal breech birth. The avoidance of risks of vaginal breech birth is the only risk factor that is unique to a breech fetus. The other two factors are also present in each planned vertex labor. (31)

The women and the obstetrician should be aware of the possible complications and economic costs of a cesarean section. A cesarean section is associated with an increased risk of maternal morbidity and mortality, however to a lesser extent than in the past. The increased short-term morbidity and mortality is due to hemorrhages, infections and thromboembolic complications.

Another important fact to be considered by the women is that a history of cesarean section is associated with an increased risk of complications in future pregnancies. Women with earlier cesarean delivery have a higher risk of secondary infertility (75), placental implantation disorder (76), uterine rupture (77) and emergency peripartum hysterectomy (19,21,22,78). The uterine scar increases the risk of maternal and neonatal mortality and morbidity during the following pregnancies. These possible complications place both mother and future offspring at risk.

It is important to find the balance in volume between cesarean sections and vaginal breech deliveries. It is necessary to identify fetuses and mothers with a risk for adverse outcome, as this group will benefit from an elective cesarean section. However, low-risk breech pregnancies should be offered a trial of vaginal delivery, as well-selected pregnancies with adequate intrapartum management are nearly as safe as planned vaginal vertex deliveries (31).

The following strategies are common for delivering breech fetuses at term:

- A trial of external vertex version before labor, with a trial of labor if the version is successful and a cesarean delivery if it is unsuccessful.
- A trial of external vertex version before labor, with a trial of labor if the version is successful. If the version is unsuccessful, a trial of vaginal breech delivery is offered to women that fit the criteria for vaginal breech labor.
- Planned cesarean section without a trial of external vertex version.
- A trial of vaginal breech delivery without a trial of external vertex version (after the onset of labor).

## Criteria for a trial of vaginal breech labor

Many international associations have published guidelines for selecting patients for vaginal breech delivery. The criteria for a trial of labor are shown in Table 3 (28,30,31,41,79).

**Table 3: International guidelines and recommendations for vaginal breech labor at term**

RCOG 2017 <sup>1</sup>	HUCH 2017 <sup>2</sup>	DGGG 2010 <sup>3</sup>	SCOG 2009 <sup>4</sup>	CNGOF 2001 <sup>5</sup>	ACOG 2006 <sup>6</sup>
Ultrasound if possible	Pre- or early labor ultrasound	Pre- or early labor ultrasound	Pre- or early labor ultrasound		The decision regarding the mode of delivery should depend on the experience of the health care provider.
The role of pelvimetry is unclear	Pelvimetry	Normal maternal pelvis	Clinically adequate maternal pelvis	Normal pelvimetry	
Flexed fetal neck on ultrasound	Flexed fetal neck on ultrasound	No disproportion of the fetus (HC > AC)	Flexed fetal neck on ultrasound	Flexed fetal neck	
Estimated fetal weight < 3800 g	Estimated fetal weight < 4000 g	Estimated fetal weight < 3800g	Estimated fetal weight < 4000 g	Estimated fetal weight < 3800g	
Estimated fetal weight above the 10 <sup>th</sup> percentile	Estimated fetal weight above the 10 <sup>th</sup> percentile	Estimated fetal weight above the 10 <sup>th</sup> percentile	Estimated fetal weight above 2500g	Estimated fetal weight above 2500g	
No footling presentation	No footling presentation	No footling presentation	Frank or complete breech	Frank or complete breech	
No evidence of antenatal fetal compromise	Acceptance of the patient	Acceptance of the patient	No cord presentation and no fetal anomaly that are incompatible with vaginal delivery	Acceptance of the patient	
The hospital provides experienced staff in breech delivery.		The hospital provides experienced staff in breech delivery.	The hospital provides experienced staff in breech delivery.	-	
The hospital provides emergency cesarean section facility		The hospital provides emergency cesarean section facility	The hospital provides emergency cesarean section facility	-	

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Society of Obstetricians and Gynaecologists of Canada [SCOG]<sup>4</sup>

Organisme professionnel des médecins exerçant la gynécologie et l'obstétrique en France [CNGOF]<sup>5</sup>

American College of Obstetricians and Gynecologists [ACOG]<sup>6</sup>

These guidelines include many general recommendations for vaginal breech delivery. A pre-labor ultrasound examination gives the possibility to assess the fetal weight, the mode of breech presentation, the fetal neck position, cord presentation and other obstetric risk factors. An adequate maternal pelvis is necessary to safeguard a smooth descent of the fetus as well as a smooth delivery of the fetal head. An extension of the fetal neck may compromise the cervical spine during birth or could lead to an entrapment of the head. It might also be a sign of other risk factors like neurological compromise, nuchal cord, fetal goiter or a sign of an abnormally formed uterus. The fetus should be in frank or complete breech position and the fetus should not be too large to minimize the risk of dystocia and head entrapment. Fetuses with growth restriction are not recommended for vaginal labor, as growth restriction is

associated with placental insufficiency, which is a risk factor for asphyxia. The possibility of an immediate cesarean section and the availability of skilled and experienced staff are essential for a safe trial of vaginal breech labor.

### **Pelvimetry**

The role of pelvimetry on neonatal outcome is unclear. In many countries a pelvimetry is not necessary for vaginal breech labor, but in others it is part of the selection process for vaginal breech labor. In the largest observational vaginal breech delivery study thus far, 82 % of the participating women had a pelvimetry and the study showed a favorable outcome for the neonates and mothers (34). Magnetic resonance imaging [MRI] seems to improve neonatal outcome and reduce the rate of emergency cesarean section (80-83).

MRI pelvimetry is known to reduce the rate of emergency cesarean sections if patients with insufficient results are excluded from a trial of vaginal breech labor at term (80). A recently published study has shown that an interspinous diameter of  $\geq 11$  cm, together with a conjugata vera of  $\geq 12$  cm, may predict successful vaginal breech delivery (82).

## **Labor and delivery while the fetus is in breech presentation**

### **Labor management of breech presentation at term**

Vaginal breech delivery is associated with a higher risk of perinatal mortality and morbidity compared to elective cesarean section. The lower risk in cesarean section is due to three factors: the avoidance of stillbirth after 39 gestational weeks, the avoidance of intrapartum risks and the avoidance of vaginal breech delivery. Only the last mentioned is unique to fetuses in breech presentation (31). The question arises why neonates in breech presentation born vaginally suffer from adverse short-term morbidity. There are two reasons for the fetal hypoxia in vaginal breech delivery: a) When the fetal bottom and the main part of the body are born, the uterus becomes smaller. This size reduction of the uterus results in functional reduction of the blood gas exchange capacity of the placenta, as the placenta is attached to a smaller area of the uterus than before causing respiratory acidosis. b) During vaginal breech delivery the umbilical cord is compressed between the fetal skull and the maternal pelvis as soon as the fetal neck is visible. This results in an acute, predominant respiratory acidosis from which a healthy term newborn easily recovers but not a growth restricted child (84).

The rate of vaginal breech deliveries and the management of vaginal breech deliveries have changed during the past. Obstetric pioneers like Erich Bracht, Werner Bickenbach, Arthur Müller, Jørgen Løvseth, Gustav Veit and William Smellie developed maneuvers and techniques for safer delivery of fetuses in breech presentation (84-87). Bracht's work led to the most significant reduction in breech related neonatal mortality and led to more than 30 trials in Europe and Latin America, showing a dramatic reduction in breech related mortality and morbidity. Due to the development of breech delivery techniques in Europe, the vaginal breech delivery trial rates were as high as 84 to 87 % of all breech deliveries in the 70's (88,89) and 63 to 75 % twenty years later in the 90's (90,91). In Finland the vaginal breech delivery rate has been reported at 89 % in 1952 to 1961 and at 72 % 1963 to 1970. In 1987-89 55 % of all women with a fetus in breech presentation at term underwent a trial of vaginal breech labor (46). In Great Britain and North America vaginal breech delivery became outdated early on and none of the studies performed in non-English speaking countries, were translated into English. At the same time cesarean section became safer, so that by 1978, 60 % (92) of breech neonates in North America and England were born by cesarean section and by 1990 the rate had further increased to 85 % (92,93). In 2000 the Term Breech Trial was

published, a large randomized trial including 121 centers from around the world, reviewing the outcome of vaginal breech delivery at term versus elective cesarean section (12). The trial showed a significantly higher neonatal morbidity rate of 5 % in a trial of vaginal breech labor and only 1.6 % in elective cesarean section (12). After this report, vaginal breech delivery rates dropped dramatically, even in countries with a high previous vaginal breech delivery rate like the Netherlands (from 50 to 20 %) (94) and Finland (from 50 to 20 %) (Figure 12). However, the trial incurred harsh criticism, since its methodology was inconsistent and more recent studies have shown the safety of breech birth when patients are well-selected and deliveries well-managed (34,95).

Several national societies and organizations have published guidelines for the labor and delivery management of the fetus in breech presentation (Table 4) (28,30,31,41,79). A vaginal examination and an ultrasound should be performed on admission to determine whether the fetus is in frank/complete breech (hips are flexed) or in incomplete breech position (extended legs). The cervical status should be evaluated to monitor the progress of labor. In general, the amniotic membranes should be left intact, since the risk of cord prolapse otherwise increases (96). On the other hand cord prolapse has also been associated with spontaneous rupture of membranes (97).

An amniotomy is not contraindicated and might be used to treat hypocontractile uterine activity. In case of spontaneous membrane rupture a vaginal examination should be done to exclude a cord prolapse (41). The use of cardiotocography (external or fetal scalp electrode) is, as in other high-risk deliveries, recommended (98,99). The progress of labor should be monitored continuously, similarly as it is performed when the fetus is in vertex presentation. The use of epidural analgesia is common (41,100), even though it is still unknown if epidural analgesia has a negative effect on neonatal outcome (101,101-103). The use of oxytocin is not contraindicated; it might be used after epidural analgesia or in the latent phase of the delivery (41,103-105).

In case of inadequate progress during the active phase of labor, a cesarean delivery should be performed. The passive second stage as of the fully dilated cervix up to the active pushing phase should not last longer than 90 minutes (41). The active pushing phase should not last longer than 60 minutes (34,41). Otherwise it is recommended to perform a cesarean section.

**Table 4: Recommendations for labor management in vaginal breech delivery**

RCOG 2017 <sup>1</sup>	HUCH 2017 <sup>2</sup>	DGGG 2010 <sup>3</sup>	SCOG 2009 <sup>4</sup>
Induction of labor is not usually recommended	Induction of labor is possible	-	Induction of labor is not recommended
Augmentation only in the presence of epidural analgesia	Augmentation is possible	-	Augmentation only in the presence of epidural analgesia
Adequate descent of the breech in the passive second stage	Adequate descent of the breech in the passive second stage Active second stage <60 min	-	Passive second stage < 90 min Active second stage <60 min
Assistance, without traction	Spontaneous or assisted breech delivery is acceptable.	-	Spontaneous or assisted breech delivery is acceptable.
Epidural analgesia is likely to increase the risk of intervention	Epidural analgesia is permitted	Epidural analgesia is recommended	Epidural analgesia is permitted
Continuous electronic fetal heart monitoring is recommended	Continuous electronic fetal heart monitoring	Continuous electronic fetal heart monitoring	Continuous electronic fetal heart monitoring
-	At the time of delivery of the after-coming head, suprapubic pressure should be applied	-	At the time of delivery of the after-coming head, suprapubic pressure should be applied

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### **Delivery of the term breech fetus**

The delivery of a term singleton breech fetus can be spontaneous or assisted, however extraction should be avoided (29,31,41,84,85). In a breech delivery it is recommended to wait with assistance until the fetal umbilicus is expelled (29,31,41,85).

After the fetal umbilicus is delivered, the obstetrician may complete the delivery of the legs by applying pressure to the inner aspect of the knee away from the midline, so that the lower extremity can be swept laterally out of the vagina (Figure 6).



**Figure 6:** Extraction of the fetal legs



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If the fetal trunk does not rotate spontaneously, the obstetrician should assist the delivery by rotating the fetal trunk. Traction on the trunk is still contraindicated as it can complicate the delivery. The Bracht maneuver can be used to assist the delivery of a fetus in breech position. When the fetus's umbilicus becomes visible the obstetrician delivers the fetus by lifting the fetal legs and body over the maternal symphysis pubis, in addition an assistant has to push the fetal head into the maternal pelvis during the whole maneuver. No traction should be applied during the Bracht maneuver, as traction might lead to complications like nuchal arms. If the fetal arms are not delivered spontaneously, intervention is required. Common maneuvers for delivering the fetal arms are the Müller's, Bickenbach's, Classic's and Løvset's maneuvers. In Helsinki University Central Hospital one of the most common maneuvers used for the extraction of the fetal arms is the Løvset's maneuver (Figure 7).

**Figure 7: Løvset's maneuver**



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The fetus is held at the hips or the buttocks (caution: if the fetus is held too high at the abdomen an injury of the kidneys or adrenals is likely). The first shoulder is delivered by rotating the fetus by 180 degrees, afterwards the fetus is rotated in the opposite direction by another 180 degrees to deliver the other shoulder and arm. If after the maneuver the arms are still not delivered being trapped under the symphysis pubis, an index finger should be introduced into the antecubital fossa along the fetal scapula and over the shoulder. The operator swaps the arm down, across the fetal face and downward to the chest, at which point the arm can be delivered (Figure 8). (106)

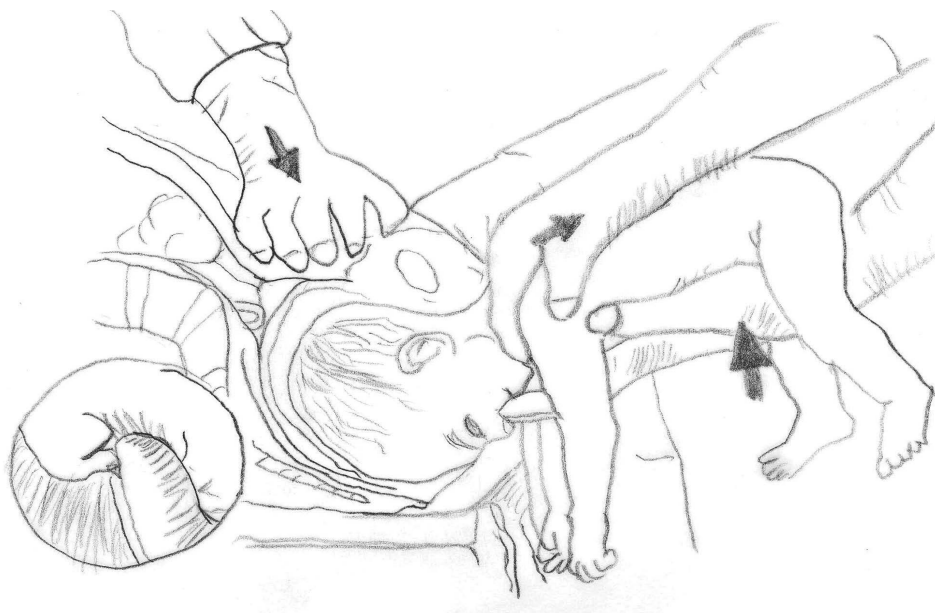
**Figure 8:** Delivery of the entrapped arm



The procedure can be repeated for the other arm. In the rare case that the arms are still undelivered, the fetus should be rotated so that the fetal chest faces upward towards the pubic symphysis. This can help to extract the arms as the elbow can be moved downwards and then extracted. (86,106)

In the end pressure is applied to the lower abdomen above the pubic symphysis to support the flexion and descent of the head (82,106). Once the hairline of the fetus is visible, the head is delivered, either spontaneously or with assistance. The Mauriceau-Smellie-Veit maneuver is one of the most common maneuvers for the delivery of the head in breech presentation (Figure 9) (87).

**Figure 9:** Mauriceau-Smellie-Veit maneuver in breech delivery



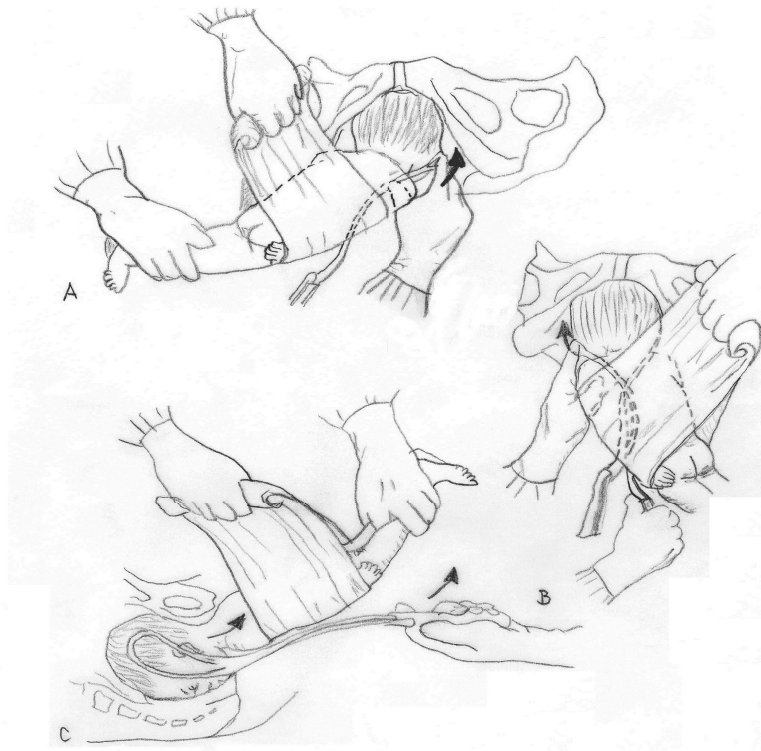
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The maneuver starts with the fetus resting on the operator's forearm, after which the first and the second finger of the hand are placed on the maxilla to flex and promote the descent of the fetal head. The fingers of the other hand are placed around the shoulder. Then the fetal head is pulled downward gently until the hairline becomes visible. The fetus is raised, still astride the arm, until the mouth and nose are visible. The fetus is delivered in an arc rotation on top of the maternal abdomen, reflecting the pelvic curve. Suprapubic pressure should be applied as the fetal head is delivered. (82,106)

The use of forceps to support the delivery of the after-coming head is another option in breech deliveries and a warrant in an emergency situation (Figure 10). An emergency is identified as a failure to accomplish the delivery of the fetal head within two minutes. When supporting the delivery of a breech fetus by forceps, the baby is lifted with the help of a towel. The left forceps blade is applied first: it is held by the operator's left hand and inserted horizontally into the vagina on the left side. The right hand is used to protect the soft tissue and to guide the blade. The right blade is held by the operator's right hand and inserted horizontally to the right maternal side while the left hand is used to protect the vaginal soft tissue and to guide the blade. The handles should lock easily without force, otherwise they

have to be removed and reapplied. The forceps are first drawn downwards to support the descent of the fetal head after which they are lifted upward to follow the pelvic curve and to deliver the fetal head.

**Figure 10: Piper-forceps breech delivery**



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An episiotomy should only be performed in a breech delivery if required to facilitate the birth, but many clinicians perform routine episiotomy in breech delivery (107).

In case of head entrapment, uterine relaxants should be applied (terbutoline or nitroglycerin). A symphysiotomy might be helpful in delivering the entrapped head, but is associated with a significant risk for the mother (41,108). The Zavanelli maneuver (replacement of the fetal body back in the uterus) might be a last option to save the fetus (109-112), but the procedure is associated with a high fetal morbidity and mortality rate especially in cephalic presentation (113).

### **Upright position of the women during vaginal breech delivery**

In an upright position the mother kneels and is leaning on the head of the bed, or she is on all fours, or she stands upright. An upright position of the mother during labor seems to be associated with fewer interventions (114,115), fewer maternal morbidity (114,115), a shorter second stage of labor (115) and fewer neonatal injuries (115), but more research regarding the upright position of the mother during vaginal breech labor is needed.

### **Failure of the fetal trunk to rotate**

If the fetal trunk fails to rotate and the fetus ends up with its head in an occiposterior position, the fetal trunk and head have to be rotated to bring them into anterior position. Sometimes it is enough to put pressure to the bottom of the fetus to stop the descent during labor and the fetus will rotate itself. If the fetus does not rotate itself the fetal trunk has to be grasped at the pelvis to rotate the fetus by 180 degrees. If the fetal head remains facing the pubis it has to be delivered by reversed malar flexion and traction of the shoulder with the Prague maneuver (Figure 11) (7).

**Figure 11:** Prague maneuver



### **Induction of labor while the fetus is in breech presentation**

The induction of labor is a common obstetric procedure. Up to 30 % of all pregnancies in developed countries are induced (116-119). An induction is normally performed for prolonged pregnancies (>42 weeks of gestation), maternal medical diseases like diabetes or preeclampsia, fetal reasons (IUGR) and rupture membranes without evidence of labor. It is important to induce pregnancies only for medical causes, as induction of labor is associated with an increased cesarean section rate (up to 50 % of induced nulliparous women have a cesarean section) (116-122). The induction of labor while the fetus is in breech presentation is controversial. Some older studies based on small sample size (123-125) did not detect unfeasible maternal or neonatal outcomes after the induction of labor. Recently several newer studies have also shown that an induction of labor in term breech presentation is not associated with an adverse maternal or perinatal outcome (126-129).

National guidelines are indifferent regarding the induction of labor in pregnancies with the fetus in breech presentation. The National Institute for Health and Care Excellence UK states that an induction of labor while the fetus is in breech presentation should not be offered generally, but might be considered after the risks of it have been discussed with the mother. The Canadian guidelines do not recommend an induction of labor while the fetus is in breech presentation (41), but the authors of the guidelines do not see breech presentation as an absolute contraindication any longer and believe an induction might be feasible after a risk assessment (personal communication Andrew Kotaska 06/2014). The ACOG (40), French (28) and the German guidelines (30) make no recommendations regarding an induction of labor while the fetus is in breech presentation. No research has been published comparing the different methods of induction of labor while the fetus is in breech presentation.

## **Outcome of pregnancies with children born in breech presentation at term**

### **Children's short-term outcome**

Vaginal breech labor at term is controversial (Table 5). Fetuses in breech presentation at term are at higher risk for birth asphyxia and perinatal mortality during vaginal delivery than fetuses in vertex presentation (12,31,42,91). It is also commonly accepted that a planned cesarean section for the breech fetus is associated with a lower risk for adverse neonatal outcome compared to planned vaginal breech delivery (12,130). The following three factors, (31) are the reasons for the lower risk for adverse neonatal outcome in elective cesarean section:

1. Planned cesarean section protects from the occurrence of stillbirth after 39 weeks of gestation, as it is normally performed in week 39 of gestation.
2. Planned cesarean section avoids the risk of complications during labor.
3. Planned cesarean section avoids the risks of vaginal breech delivery.

Only the last reason applies to a fetus in breech presentation uniquely (31). The main risk in vaginal breech delivery is that the fetus suffers from respiratory acidosis, caused by the reduced capacity of the placenta to maintain blood exchange with the uterus after body of the fetus are born. The second reason for respiratory acidosis the compression of the umbilical cord between fetal head and maternal pelvis once the fetal neck is delivered (84). These complications are also most likely the reasons why decreased variability and late deceleration have been observed to be more prevalent in fetal cardiotocography during vaginal breech delivery compared to vertex delivery (99).

In many countries most breech fetuses at term are born by planned cesarean section (18). The main reason for this is the term breech trial by Hannah (12). This trial, published in 2000 was a large, randomized multicenter study. It changed worldwide the management of breech labor overnight, including Finland (Figure 12). However, the results of the term breech trial have been questioned (34,41,95,131-133), as the study had major deficits. The major limitations of it were the inadequate selection of the women and fetuses eligible for a trial of vaginal breech



delivery, incomparable birth centers were included in the study and perinatal short-term morbidity was used as a surrogate marker for long-term neurological impairment (41,95).

The PREMODA study has shown that vaginal breech labor might be safe for well-selected deliveries treated with caution and in a modern obstetric unit (32,34-36,46,105,134-137). The perinatal mortality and severe morbidity did not differ for planned cesarean section compared to vaginal breech labor in the PREMODA study (34). In addition two Finnish publications from the last decade demonstrate that vaginal breech delivery is feasible in well selected pregnant women (35,36).

To minimize the risk of adverse neonatal outcome patients suitable for a trial of vaginal breech labor should be carefully selected. Patient and provider values, experience and preferences should also guide the choice of delivery route.

**Table 5: Possible risk of adverse short-term outcome in neonates after a trial of vaginal breech labor compared to neonates born by planned cesarean section (12,34,136):**

	Hannah 2000 (12)	Goffinet 2008 (34)	Vistad 2013 (136)
	OR (95 % CI)	OR (95 % CI)	OR (95 % CI)
Perinatal / neonatal death	4.33 (1.23-15.25)	-	2.11 (0.63–7.01)
Birth trauma	2.33 (0.89-6.09)	3.90 (82.40-6.34)	
Seizures	7.00 (0.86-57.00)	1.27 (0.37-4.33)	
Hypertonia	9.00 (2.08-38.89)		
Abnormal level of consciousness	2.67 (1.04-6.84)		
Apgar <7 at 5 min	3.88 (1.77-8.47)	3.20 (1.93-5.30)	7.10 (5.04–10.88)
Apgar <4 at 5 min	9.00 (1.14-71.17)	8.92 (1.00-79.8)	4.30 (2.35–7.93)
Cord-blood base deficit ≥15 mmol/L	3.30 (1.07-10.20)		
Cord-blood pH <7.0	6.59 (1.47-29.35)		
Intubation and ventilation >24 h	4.00 (0.44-35.85)	1.06 (0.50-2.26)	
Tube feeding >4 days	3.00 (0.60-14.90)	1.04 (0.56-1.93)	
Care in neonatal ICU >4 days	1.50 (0.42-5.33)	0.97 (0.59-1.58)	1.80 (1.51–2.17)
Neonatal mortality and serious neonatal morbidity	3.06 (1.75-5.33)	1.10 (0.75-1.61)	

ICU intensive care unit

**Figure 12:** Numbers of vaginal breech deliveries in Finland and HUCH during 1998 -2014



HUCH Helsinki University Central Hospital

### **Long-term outcome of children**

The question of the effect of planned vaginal breech labor on the long-term outcome of children is unresolved. The follow up study of the Hannah's term breech trial did not show significant changes in the long-term outcome of the children, except for the fact that infants born by planned cesarean delivery reported more medical problems at the age of two years. The study reported that the combined risk of death and neurodevelopmental delay was similar in the children of both groups at the age of two (138).

However, some studies have shown an association between a planned vaginal breech delivery and adverse neurodevelopmental outcome. Vaginal breech delivery has been associated with epilepsy or cerebral palsy (139-142). On the other hand, it has been shown that adverse neurodevelopmental long-term outcome in children born in breech presentation was not related to intrapartum events (Table 6) (45,52,143-146), but to obstetric risk factors associated with breech presentation (144-146). In general cesarean section improves the

outcome of infants, as it protects them from most adverse intrapartum events (31). One study even claims that elective cesarean section protects the fetus from cerebral palsy (141).

While considering long-term outcomes, it should be kept in mind that a recent study assumes that children born by cesarean section have a lower performance at school (147). In addition birth by cesarean section is suspected to affect the immunological development of infants (23-27,148) and is associated with a modest increase of atopic diseases (asthma, allergies and atopic skin disorders), diabetes mellitus type I, obesity and neuropsychological disorders (disorders in the autism spectrum, depressions and Parkinson’s disease) (23-27). Birth by cesarean section has also been associated with early breast-feeding problems like cessation of breastfeeding (149).

**Table 6: Possible risk of adverse neurodevelopmental long-term outcome in children born vaginal in breech presentation compared to children born by planned cesarean section**

	Whyte 2004 (138)	Danielian 1996 (143)	Bin 2016 (52)	Bjellmo 2017 (45)	Andersen 2009 (142)	Thorngren-Jerneck 2006 (141)
	OR (95 % CI)	OR (95 % CI)	RR (95 % CI)	OR (95 % CI)	OR (95 % CI)	OR (95 % CI)
Neurodevelopmental delay	1.09 (0.71-1.66)	-	-	-	-	-
Abnormal speech/communication	1.24 (0.54-2.83)	0.83 (0.20-0.52)	-	-	-	-
Abnormal gross motor	1.72 (0.63-4.69)	0.18 (0.02-1.70)	-	-	-	-
Abnormal fine motor	1.03 (0.51-2.08)	-	-	-	-	-
Abnormal problem-solving	0.71 (0.33-1.51)	-	-	-	-	-
Abnormal personal-social	1.38 (0.71-2.65)	-	-	-	-	-
Abnormal auditory	1.03 (0.06-16.44)	1.25 (0.71-2.20)	-	-	-	-
Abnormal visually	-	0.74 (0.40-1.36)	-	-	-	-
Convulsions	-	0.45 (0.21-0.96)	-	-	-	-
Psychiatric problems	-	0.69 (0.33-1.43)	-	-	-	-
Severe handicap	-	0.49 (0.23-1.05)	-	-	-	-
Cerebral palsy	-	-	-	0.93 (0.40-2.15)	3.9 (1.6 – 9.7)*	3.0 (2.4 – 3.7)*
Developmentally vulnerable	-	-	1.22 (0.88–1.69)	-	-	-
Special needs	-	-	0.95 (0.48–1.88)	-	-	-
Low reading score	-	-	1.10 (0.87–1.40)	-	-	-
Low numeracy score	-	-	1.04 (0.81–1.34)	-	-	-

[OR] Odds ratio

[RR] Relative risk

\* Significant findings

### Maternal outcome and future pregnancies

The maternal experience of vaginal breech delivery seems to be as positive as the experience of women with a vaginal delivery with the fetus in vertex presentation (150). The results of the term breech trial of Hannah et al. did not show that planned cesarean section versus planned vaginal birth for breech presentation at term had an effect on the long-term maternal outcomes at two years (151). However, planned cesarean section was associated with a

higher maternal short-term morbidity, including hemorrhage, need for transfusions and infection (151). In addition, it carries a higher risk of postpartum depression (152) and women recovering from a cesarean section are reported to have a lower ability to bond with their children (153).

The most important consequence of a cesarean section for the mother is its association with an increased risk of complications in future life. A preceding cesarean delivery is associated with anatomical-pathological changes of the uterus (154). Women with a cesarean scar suffer more often from menorrhagia, metrorrhagia and dysmenorrhagia (155). Pregnancy complications related to the uterine scar are common. A possible complication in next pregnancy might be a cesarean scar pregnancy (156). The symptoms of a cesarean scar pregnancy are typically vaginal bleedings and abdominal pain, but up to one third of all women are without any kind of symptoms (156). Other possible complications in later pregnancy and during labor are placental implantation disorders like placenta previa (157), placenta accreta, increta and percreta (76), and uterine rupture (77). Placental implantation disorders are significantly increased after cesarean section and might be associated with severe hemorrhage and surgical complications. A uterine rupture is one of the most feared complications during pregnancy and labor, as it is associated with increased perinatal and maternal morbidity and mortality. The uterine rupture risk for a woman with a scar is 4-7/1000 deliveries, which is three times higher, compared to women without a scar (158). Placental implantation disorder and uterine rupture are predictors for peripartum hemorrhage and emergency peripartum hysterectomy (19-22,78). A cesarean scar might affect also the blood flow in the gravid uterus, which might have an effect on the pregnancy (161). Due to these possible complications the uterine scar increases the risk of maternal and neonatal mortality and morbidity during the following pregnancies (159,160). A cesarean section may also lead to reduced fertility (162). Women with a history of cesarean section have a lower subsequent pregnancy rate and a lower birth rate (162). They are more likely to suffer from secondary infertility (75). The most likely reason for this might be related to the scar tissue of the cesarean section (163). Women suffering from secondary infertility often benefit from a treatment of the uterine isthmocele caused by a cesarean section. The treatment of the isthmocele results in a spontaneous pregnancy rate of 89 % (163).

## **AIMS OF THE STUDY**

The present study was carried out to investigate the pathophysiology of breech presentation itself and to investigate under which circumstances a trial of vaginal breech labor at term is safe. The specific aims were:

1. To evaluate if breech presentation itself is associated with earlier known obstetric risk factors.
2. To evaluate delivery outcomes in pregnancies with the fetus in breech position at term undergoing an induction of labor.
3. To assess clinical factors associated with adverse perinatal outcomes in women undergoing a trial of vaginal breech labor at term.
4. To investigate the neurodevelopmental long-term outcome in children at the age of four years born vaginally or after a trial of vaginal labor in breech presentation.

## **PATIENTS AND METHODS**

### **Study data and design**

The data for study I, IV and V were collected from the National Medical Birth Register and the Hospital Discharge Register, maintained by the National Institute for Health and Welfare. Reporting to the national registers is mandatory for all Finnish hospitals. Completeness and accuracy of the data varies from satisfactory to very good (164). The registers have a good nationwide coverage (164). The National Medical Birth Register contains information about all births (live births and stillbirths) with a birth weight of 500 g or more or with a gestational age of 22 weeks and beyond. The Hospital Discharge Register includes data on all inpatient periods in all Finnish hospitals and all outpatient visits recorded in the public sector (164). The registers contain demographic data, maternal information before and after the delivery, intrapartum procedures and complications, as well as neonatal outcome. The data collected in the registers is coded according to the International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10). (164)

Study I was designed as a retrospective, population-based cohort. Study IV was designed as a retrospective population-based, case control study and the fifth study as a retrospective, population-based record linkage study. The National Institute of Health and Welfare authorized the use of the data as required by the national data protection law in Finland (Reference number THL/1200/5.05.00/2012).

The data for studies II and III was collected in the Department of Obstetrics and Gynecology of Helsinki University Hospital. The Department of Obstetrics and Gynecology of the Helsinki University Hospital includes three different delivery departments with annually 16.000 deliveries. The studies were conducted as retrospective, observational cohort studies. The regional research committee of the medical faculty of Helsinki University approved the study protocols. A description of the studies is presented in Table 7.

**Table 7: Summary of the study**

	<b>Study I</b>	<b>Study II</b>	<b>Study III</b>	<b>Study IV</b>	<b>Study V</b>
N <sup>a</sup>	13058	268	776	10 057	8374
Design	Retrospective population-based cohort study	Retrospective observational cohort study	Retrospective observational cohort study	Retrospective population-based case control study	Retrospective population-based record linkage study
Study period	01/2005 – 12/2014	10/2011 – 12/2013	01/2008 – 04/2015	01/2005 – 12/2014	01/2004 – 12/2010
Data source	National Medical Birth Register	Helsinki University Central Hospital	Helsinki University Central Hospital	National Medical Birth Register	National Medical Birth Register
Main research question	Is breech presentation at term associated with obstetric risk factors for adverse perinatal outcome?	Delivery outcomes in induced breech labors versus spontaneous breech labors	To assess risk factors for adverse perinatal outcome in a trial of vaginal breech labor at term	To assess risk factors for adverse perinatal outcome in a trial of vaginal breech labor at term	Is a trial of vaginal breech labor at term associated with adverse long-term outcome among offspring?
Outcome	Obstetric risk factors in breech presentation	Perinatal outcome and cesarean section rate	Factors associated with adverse perinatal outcome	Factors associated with adverse perinatal outcome	Neurodevelopment outcome of children born in breech presentation at the age of four years

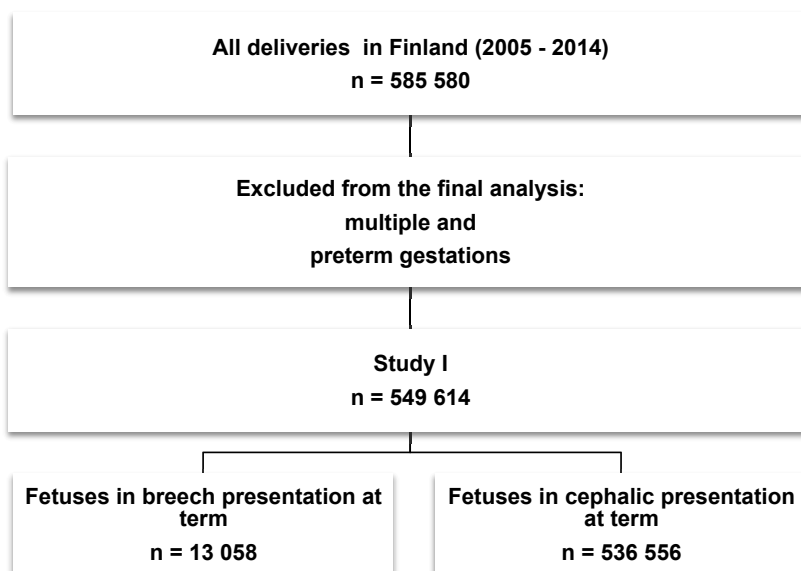
<sup>a</sup>N = number of studied women

## The study populations

### Study I

We identified all pregnancies with a fetus in breech presentation at term from the National Medical Birth Register and the Hospital Discharge Register. These pregnancies were compared with all singleton pregnancies with the fetus in vertex presentation at term. All women with multiple gestation or a preterm pregnancy (< 37+0 gestational week) were excluded. The study period was from 2005 to 2014. (Figure 13)

**Figure 13.** Flow chart of the patient selection process in study I

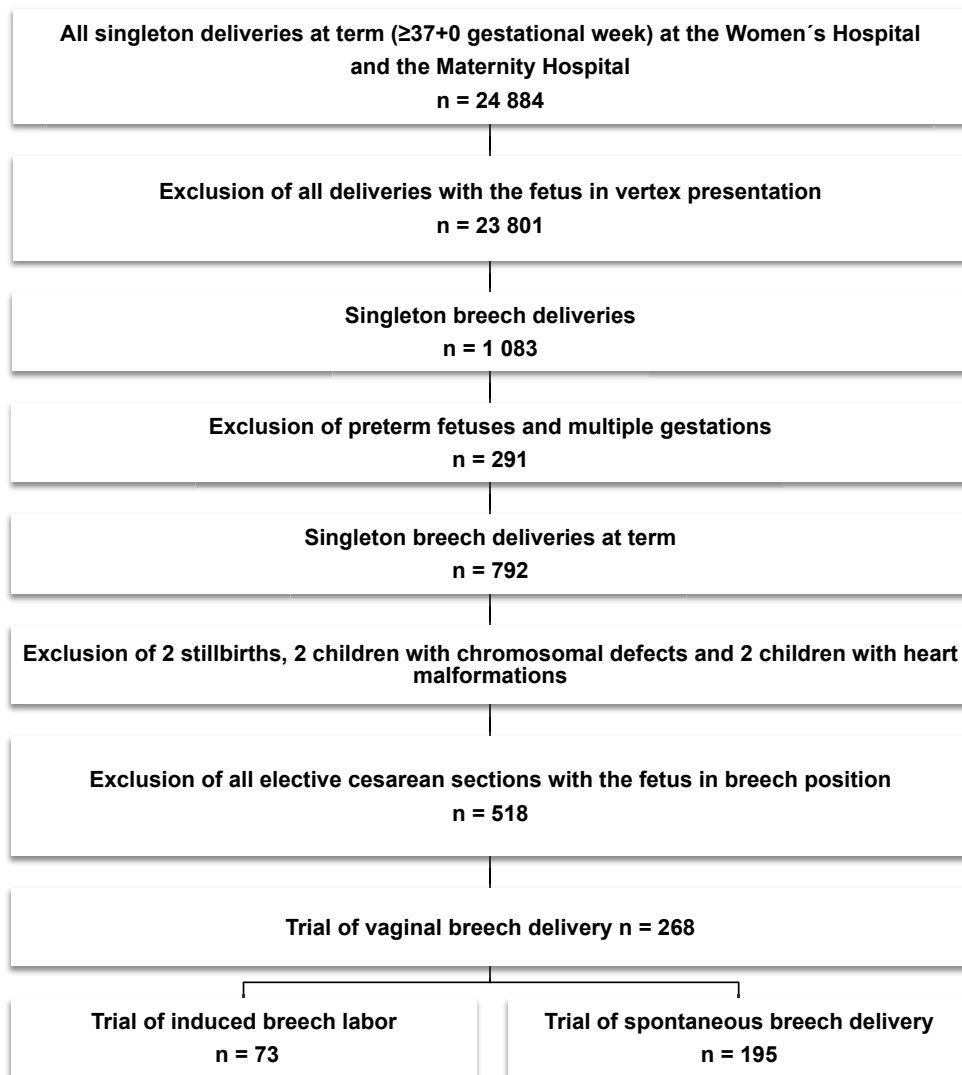




## Study II

We identified all women with an induced labor with a singleton fetus in breech presentation at term. These deliveries were compared with all spontaneous vaginal breech labors with a singleton fetus at term. The data was collected from the maternal records of the Helsinki University Central Hospital (Women's Hospital and Maternity Hospital). The study period was from 10/2011 to 12/2013. (Figure 14)

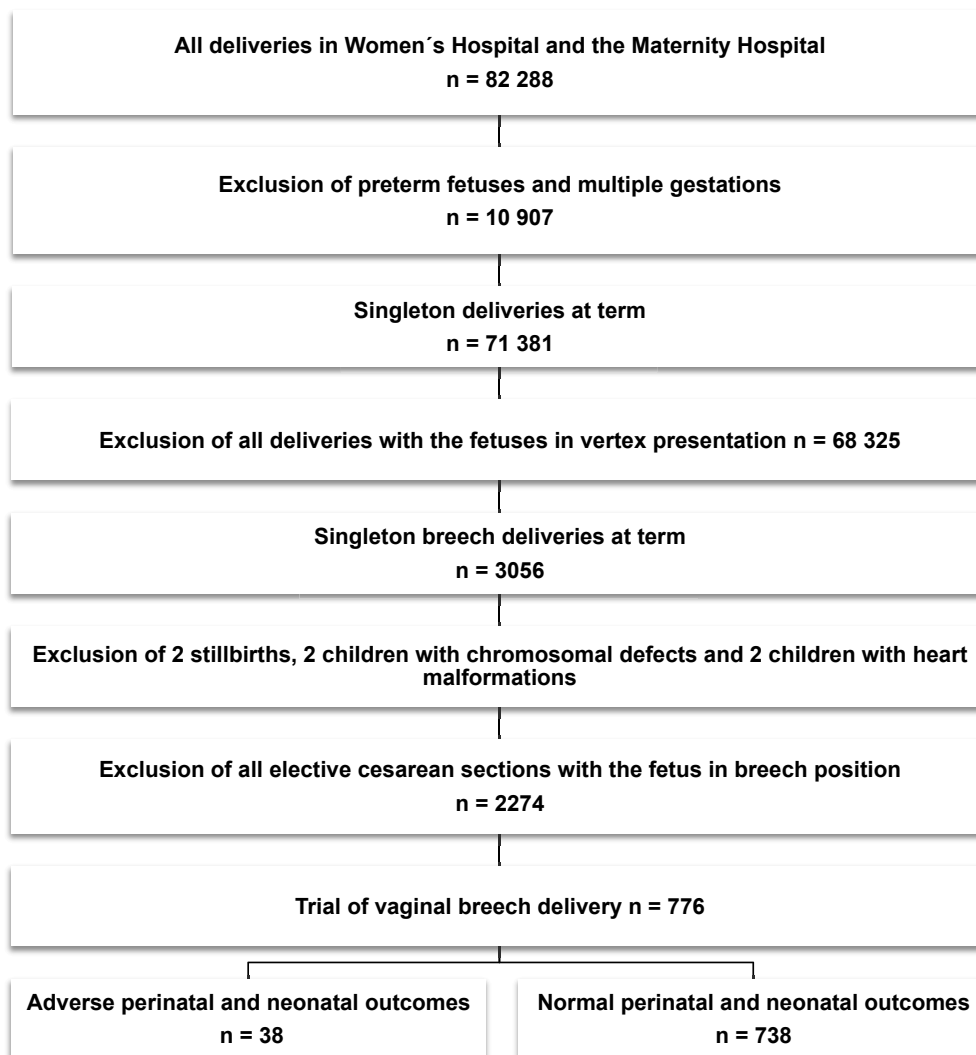
**Figure 14.** Flow chart of the patient selection process in study II



### Study III

We identified all women with a trial of labor with a singleton fetus in breech presentation at term. The data was collected retrospectively from the maternal records of the Helsinki University Central Hospital (Women's Hospital and Maternity Hospital). Preterm deliveries, multiple gestations, congenital malformations, placenta previa and prelabor stillbirths were excluded from the study. All deliveries with a normal neonatal outcome were compared with all deliveries with an adverse neonatal outcome. The study period was from 2008 to 4/2015. (Figure 15)

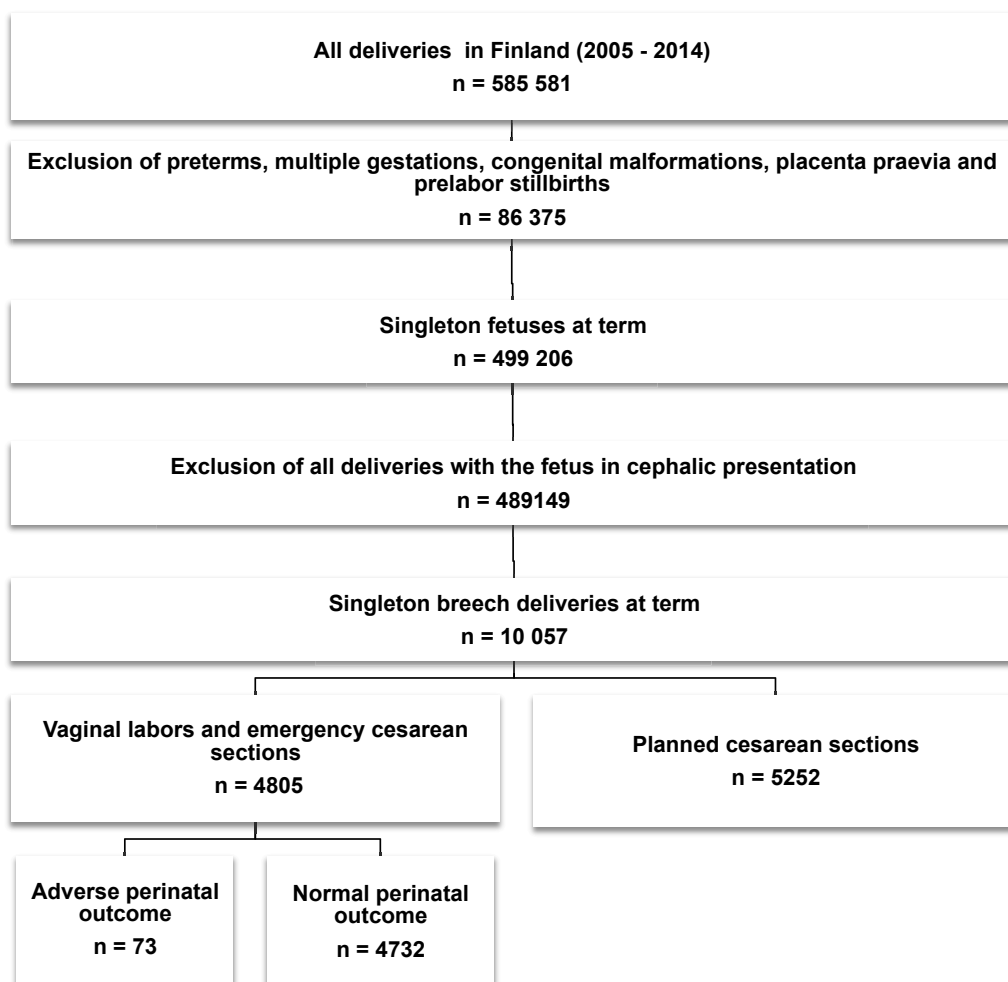
**Figure 15.** Flow chart of the patient selection process in study III



## Study IV

We identified all women with a trial of labor with a singleton fetus in breech presentation at term in Finland. Preterm deliveries, multiple gestations, congenital malformations, placenta previa and prelabor stillbirths were excluded from the study. All deliveries with a normal neonatal outcome were compared with all deliveries with an adverse neonatal outcome. The data was collected from the National Medical Birth Register. The study period was from 2005 to 2014. (Figure 16)

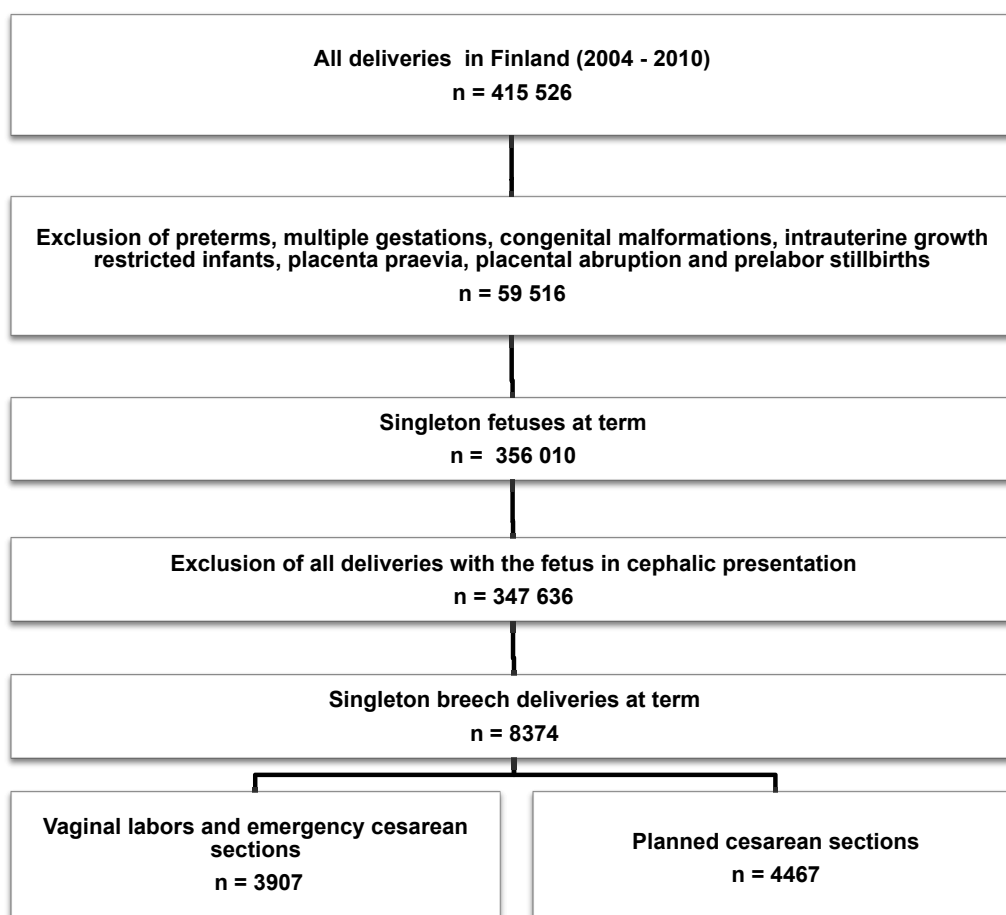
**Figure 16.** Flow chart of patient selection process in study IV



## Study V

We identified all singleton neonates born at term in breech presentation in Finland. Preterm deliveries, multiple gestations, congenital malformations, placenta previa and prelabor stillbirths were excluded from the study. All neonates that underwent a trial of vaginal breech labor were compared with all neonates born by elective cesarean section with the fetus in breech presentation. The data was collected from the National Medical Birth Register. The study period was from 2004 to 2010. (Figure 17)

**Figure 17.** Flow chart of the patient selection process in study V



## **Characteristics and outcomes of the studies**

In study I the possible risk factors for adverse outcome were studied in singleton pregnancies with the fetus in breech presentation at term. These factors were chosen based on previous literature and included: maternal age, parity, maternal smoking during pregnancy, the maternal body mass index [BMI]  $> 30 \text{ kg/m}^2$ , diabetes mellitus type I, gestational diabetes, maternal history of cesarean section, maternal history of infertility, preeclampsia, oligohydramnios, placenta previa, birth weight below the two standard deviations [SD], fetal sex (male), birth weight in grams and congenital malformations of the fetus (2,33,42,46,100,115-117). (Table 8)

In study II we studied the induction of labor while the fetus was in breech presentation. An induction of labor was defined as cervical ripening with a balloon or prostaglandin  $E_1$ , an induction with oxytocin infusion or amniotomy. In pregnancies with an unripe cervix (Bishop scores  $< 6$ ): labor was induced either a) with prostaglandin  $E_1$  and if necessary combined with an oxytocin infusion or b) a balloon catheter was used in combination with an oxytocin infusion if necessary. An amniotomy was performed for augmentation if necessary. Women with Bishop scores  $\geq 6$  underwent amniotomy or were induced with an oxytocin infusion, alone or in combination with each other. We reviewed the following characteristics: maternal age, nulliparity, gestational age at delivery, maternal weight and height, history of earlier cesarean section, maternal diabetes, epidural anesthesia, duration of the II delivery stage, intrapartum cesarean section, fetal sex (male) and birth weight in grams. (Table 8)

Vaginal delivery was chosen for primary outcome. Adverse maternal and neonatal morbidity and mortality were chosen as secondary outcomes. (Table 9)

In studies III and IV we evaluated risk factors for adverse outcome in vaginal breech labor. The following characteristics were studied: maternal age, nulliparity, gestational age at delivery, maternal smoking during pregnancy (study IV), the maternal BMI  $\geq 30 \text{ kg/m}^2$  (study IV), gestational diabetes (study IV), maternal diabetes (study III), diabetes mellitus type I (study IV), diabetes mellitus type II (study IV), the maternal history of cesarean section, the maternal history of infertility (study IV), maternal hypertonia or preeclampsia, oligohydramnios (study IV), post term pregnancies (study IV), epidural anesthesia, uterine rupture (study IV), gender of fetus, neonatal birth weight in grams, birth weight below the  $< 2\text{SD}$  (study IV) and above 4500g (study IV). (Table 8)

Adverse neonatal outcome in planned vaginal breech labor at term was defined as a composite index of neonatal mortality and neonatal morbidity. In study III the criteria included: birth trauma, seizures occurring < 24 h of neonatal age or requiring two or more drugs to control them, 5 min Apgar score < 4, umbilical arterial pH < 7.00, umbilical arterial base deficit of < -12 mmol/L, hypotonia for at least 2 h, stupor, decreased response to pain, neonatal coma, intubation or ventilation for at least 24h, tube feeding for > 4 days, need for neonatal intensive care unit [NICU] for  $\geq 4$  days.

In study IV the adverse neonatal criteria included: neonatal mortality, umbilical arterial pH < 7.00, 5 min Apgar score < 4). (Table 9) This composite index included the criteria for severe neonatal outcome from the term breech trial and from other former studies (12,165,166).

In study V we evaluated adverse neurodevelopmental outcome in children at the age of four years according to mode of delivery in breech presentation at term. We studied the following characteristics: maternal age, nulliparity, smoking, maternal body mass index [BMI] > 30 kg/m<sup>2</sup>, diabetes mellitus type I, gestational diabetes, maternal history of cesarean section, history of assisted reproduction technology, preeclampsia, oligohydramnios, needs for emergency cesarean section, gestational age at delivery, gender of neonate and birth weight in grams. (Table 8)

The following neurodevelopmental outcomes were included: cerebral palsy, epilepsy, intellectual disability, and sensor-neural defects including visual impairment and deafness, speech or language problems and hyperactivity. The data was received from the Hospital Discharge Register using the ICD-10 codes for neurologic diagnoses (Table 9). Diagnoses were made based on medical history, ultrasonography, and MRI data as required, and multidisciplinary evaluations in secondary or tertiary pediatric neurology units. The age of four was chosen because cerebral palsy is usually diagnosed within the first two years and practically always by the age of three to four years (167). The ICD-10 code of cerebral palsy is reported to the Hospital Discharge Register immediately after diagnosis. All Finnish children undergo mandatory physical examinations during their childhood at state child health clinics; thus, neurological disorders are consistently recognized by the age of four (168). Maternal, pregnancy related, fetal and neonatal factors and characteristics were reviewed in relation with adverse neurodevelopmental outcome among children (Table 8).

**Table 8: Reviewed exposures and objects of the studies**

Study I	Study II	Study III	Study IV	Study V
Maternal age	Maternal age	Maternal age	Maternal age	Maternal age
Parity	Nulliparity	Nulliparity	Nulliparity	Nulliparity
Smoking	Gestational age at delivery	Gestational age at delivery	Gestational age at delivery	Smoking
BMI $\geq 30$ kg/m <sup>2</sup>	Maternal height	BMI $\geq 30$ kg/m <sup>2</sup>	Maternal smoking	BMI $\geq 30$ kg/m <sup>2</sup>
Diabetes mellitus type I	Maternal diabetes	Maternal height	BMI $\geq 30$ kg/m <sup>2</sup>	Diabetes mellitus type I
Gestational diabetes	II delivery stage duration	Gestational diabetes	Diabetes mellitus type I	Gestational diabetes
History of cesarean section	History of cesarean section	History of cesarean section	Gestational diabetes	History of cesarean section
History of infertility	Maternal hypertonia	Maternal hypertonia	Diabetes mellitus type II	History of infertility
Preeclampsia	Induction of labor	Pelvimetry	History of cesarean section	Preeclampsia
Oligohydramnios	Intrapartum cesarean section	Epidural anesthesia	History of assisted reproduction technology	Oligohydramnios
Placenta previa	Neonatal gender (male)	Augmentation	Preeclampsia	Emergency cesarean section
Fetal growth restriction <sup>^</sup>	Birth weight in grams	II delivery stage duration	Oligohydramnios	Gestational age at delivery
Fetal sex (male)		Neonatal gender (male)	Post term pregnancies > 40 gws	Neonatal gender (male)
Birth weight in grams		Birth weight in grams	Epidural anesthesia	Birth weight in grams
Congenital malformations		Birth weight <2500g	Uterus rupture	
Stillbirth before labor		Birth weight 2500-4000g	Fetal growth restriction <sup>^</sup>	
		Birth weight >4000g	Neonatal gender (male)	
			Birth weight in grams	
			Macrosomia (>4500 grams)	

<sup>^</sup> (Birth weight < 2SD)

<sup>†</sup>BMI = Body mass index

gws = gestational week

**Table 9: Maternal, perinatal and children's neurodevelopmental outcomes**

Study I	Study II	Study III	Study IV	Study V
Breech presentation	Umbilical arterial pH < 7.00	Birth trauma	Neonatal mortality < 7 d	Umbilical arterial pH <7.00
	Umbilical arterial BE $\leq$ -12 mmol/L	Subdural hematoma	Umbilical arterial pH < 7.00	5 min Apgar score <7
	5 min Apgar score <7	Seizures occurring at < 24 h	5 min Apgar score < 4	Cerebral palsy
	NICU >24 hours	Apgar score < 4 at 5 min		Epilepsy
	Metabolic acidosis	Umbilical arterial pH <7.00		Intellectual disability
	Neonatal encephalopathy	Umbilical arterial BE $\leq$ -12 mmol/L		Autism
	Intrapartum stillbirths	Umbilical arterial BE $\leq$ -15 mmol/L		Speech/ language problems
	Birth trauma	Neonatal mortality		Visual defects
	Umbilical arterial pH	Fetal mortality		Auditory defects
	Neonatal mortality	Tube feeding $\geq$ 4 days		Hyperactivity
	Hospital stay post partum (d)	NICU $\geq$ 4 days		
	Cesarean section	Hypotonia $\geq$ 2 hours		
	Intrapartum cesarean section rate	Stupor		
	Maternal blood loss (ml)	Decreased response to pain		
		Coma		
		Intubation $\geq$ 24 hours		
		Ischemic encephalopathy		

Hours = h

Minutes = min

Potential of hydrogen = pH

Base excess = BE

Days = d

Milliliter = ml

## Statistical analysis

In study I, IV and V statistical analyses were undertaken using the Statistical Package for the Social Science Versions 17, 21 and 23, (SPSS Inc. Chicago, IL, USA). Qualitative variables were reported by using percentages. Continuous variables were reported by using medians, ranges and means. Categorical data was analyzed by Chi-square test when appropriate; Fisher's exact probability test was employed if the sample size was too small for the Chi-square test. To compare continuous variables, Student's t-test was applied for normal distributions and Mann-Whitney U-test for other type of distributions. Only valid percentages were calculated. A probability value (p-value) < 0.05 was considered statistically significant. In study I, IV and V a multivariate logistic regression analysis was performed to adjust outcome variables for potential confounding factors.

In study II and III statistical analyses were undertaken using SAS 9.2. (SAS-Institute, Cary, USA). For study II categorical variables were compared using the Chi-square test. The Wilcoxon signed rank test was used to compare continuous variables. A *p* value of 0.05 was considered significant. In study III continuous variables were reported by using medians, ranges and means. Categorical data was analyzed by Chi-square test or Fisher's exact probability test. To compare continuous variables, Student's t-test was applied for normal distributions and Mann-Whitney U-test for other type of distributions. Only valid percentages were calculated. A probability value (p-value) < 0.05 was considered statistically significant. For study II and III a stepwise regression model was used for adjustment. In study I, IV and V multivariate logistic regression analysis and 95 % CIs were used to evaluate the factors associated with adverse outcomes.



## RESULTS

### **Breech presentation and obstetric risk factors**

The prevalence of breech presentation of the fetus at term was 2.2 % in this study. Women with a fetus in breech presentation at term were significantly more often nulliparous [aOR] 2.68 (2.58 – 2.79)]. The percentage of women with a BMI greater than 30 kg/m<sup>2</sup> was lower in women with a fetus in breech presentation compared to women with a fetus in vertex presentation (10.3 % versus 11.5 %). The age of women with a fetus in breech presentation at term was higher (mean age 30.4 years) compared to women with a fetus in vertex presentation (mean age 30.1 years).

In addition, women with a fetus in breech presentation had, compared to women with a fetus in cephalic presentation; more often a preceding cesarean delivery [aOR 2.13 (95 % CI 1.98 – 2.29)] and suffered from gestational diabetes in the ongoing pregnancy [aOR 1.06 (95 % CI 1.00 – 1.13)]. The fetuses in breech presentation compared to fetuses in cephalic presentation had significantly more congenital anomalies [aOR 2.01 (95 % CI 1.92 – 2.11)], were suffering more often from intrauterine stillbirth [OR 2.12 (95 % CI 1.98–2.28)], were more often female [aOR 0.78 (95 % CI 0.75–0.81)], had growth restriction [aOR 1.19 (95 % CI 1.07 – 1.32)] and oligohydramnios [aOR 1.42 (95 % CI 1.27 – 1.57)]. (Table 10)

### **Maternal and neonatal outcome in induced breech labors at term**

In study II 73 women with a fetus in breech presentation at term were induced and 195 women attempted a spontaneous vaginal breech delivery. Induction of labor was associated with an increased intrapartum cesarean section rate compared to deliveries with a spontaneous onset of labor (36 % versus 20 %,  $P < 0.01$ ). However, an induction of labor in breech presentation was not associated with an increased adverse perinatal or maternal outcome when compared to the outcome of patients with a trial of spontaneous vaginal breech labor (Table 11).

Labor induction was also associated with a longer active second delivery stage (means 34 versus 18 minutes  $P < 0.01$ ), higher gestational weeks at delivery (means 39.9 versus 39.6 weeks,  $P < 0.05$ ) and the gestational duration equal to or higher than 41 gestational weeks (36

% versus 12 %,  $P < 0.01$ ). Women with induced labor were more often suffering from hypertension (11 % versus 3.6 %,  $P < 0.05$ ).

### **Risk factors for adverse outcome in vaginal breech labor at term**

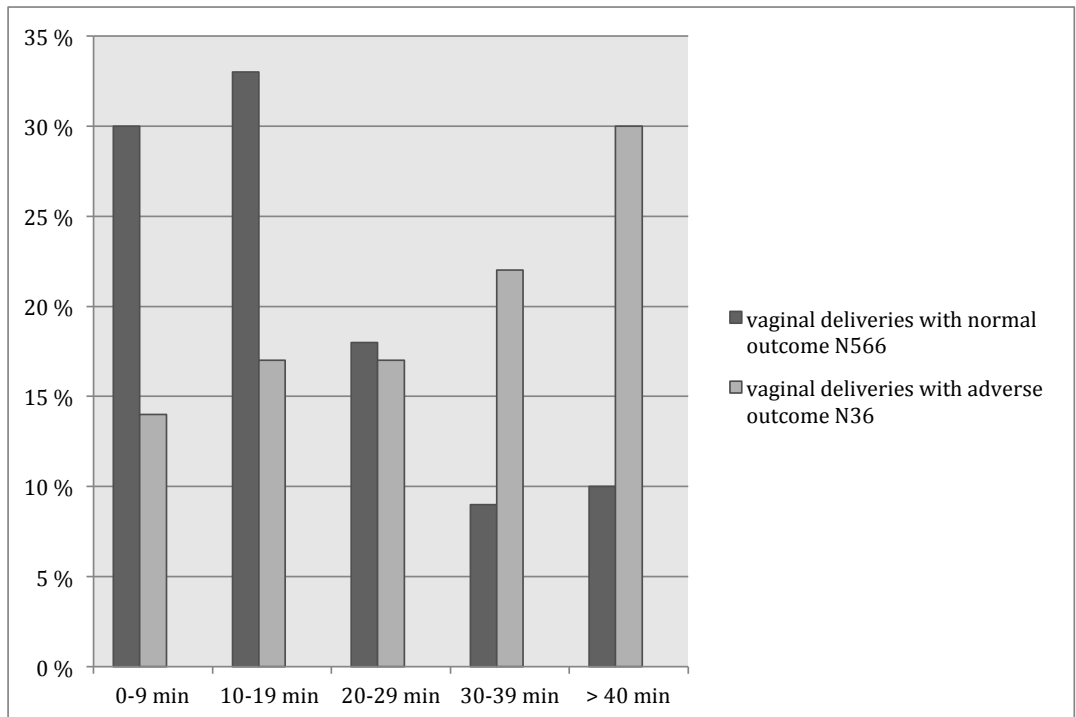
In study III we included 776 women that attempted a vaginal breech delivery. In total 38 neonates (4.9 %) born out of these attempted vaginal breech deliveries had an adverse perinatal or neonatal outcome, whereas 738 neonates did not have an adverse outcome. One intrapartum death occurred. The perinatal mortality rate in women undergoing a trial of vaginal breech delivery at term was 0.13 %. The labor of the deceased child was induced in gestational week 41+0. The mother delivered a stillborn baby during an emergency cesarean section in the first phase of labor. The fetus suffered from nuchal cord complications.

Three intrapartum risk factors for adverse peri- and neonatal outcome were found. A second delivery stage (active) lasting less than 40 minutes (Figure 18) [aOR 0.34 (0.15 - 0.79)] and a higher intrapartum cesarean section rate [aOR 0.07 (0.01 - 0.34)] had protective characteristics. The cesarean section rate was lower in the group of neonates with adverse outcome (5.3 %), compared to the cesarean section rate in the group of neonates born without an adverse outcome (24.3 %). The application of epidural anesthesia was associated with a higher adverse outcome rate in vaginal breech delivery [aOR 2.88 (1.08 - 7.70)].

During study IV 10 057 women delivered a singleton fetus in breech presentation at term. Out of these 4805 women attempted a vaginal breech labor at term, 35 % delivering by cesarean section and 65 % vaginally. 73 (1.5 %) children born after a trial of vaginal delivery had a severe adverse perinatal outcome (Table 11).

In study IV adverse perinatal outcome was related to fetal growth restriction (aOR, 2.94; 95 % CI 1.30 - 6.67), gestational diabetes (aOR, 2.89; 95 % CI 1.54 - 5.40), a history of cesarean section (aOR, 2.94; 95 % CI 1.28 - 6.77), oligohydramnios (aOR, 2.94; 95 % CI 1.15 - 7.81), epidural anesthesia (aOR, 2.20; 95 % CI 1.29 - 3.75) and nulliparity (aOR, 1.84; 95 % CI 1.10 - 3.08). To our surprise no correlation was found to macrosomia, higher maternal age, maternal BMI  $> 30 \text{ kg/m}^2$ , diabetes mellitus type I/II, maternal smoking, higher gestational age, neonatal sex, preeclampsia, birth weight, assisted reproduction technology and post term pregnancies (Table 10).

**Figure 18.** Relation of the duration of the active II delivery stage in minutes compared to normal and abnormal neonatal outcome in percent



**Table 10:** Associated factors with breech presentation and associated risk factors for adverse neonatal outcome in a trial of vaginal breech delivery

Exposures/characteristics	Study I	Study III	Study IV
	aOR (95 % CI)	aOR (95 % CI)	aOR (95 % CI)
Maternal increased age (mean age in years)	1.03 (1.03 – 1.04)	-	-
Maternal height	NA	-	NA
Nulliparity	2.68 (2.58 – 2.79)	-	1.84 (1.10 - 3.08)
BMI > 30 kg/m <sup>2</sup>	0.89 (0.84 – 0.95)	NA	-
Smoking during pregnancy	-	NA	-
Gestational age at delivery (weeks)	NA	-	-
Assisted reproduction technology	-	NA	-
History of cesarean section	2.13 (1.98 – 2.29)	-	2.94 (1.28 - 6.77)
Diabetes mellitus type I	-	NA	-
Diabetes mellitus type II	NA	NA	-
Gestational diabetes	1.06 (1.00 – 1.13)	-	2.89 (1.54 - 5.40)
Congenital malformations	2.01 (1.92 – 2.11)	NA	NA
Stillbirth	2.12 (1.98 – 2.28) <sup>*</sup>	-	NA
Pelvimetry	NA	-	-
Attempted vertex version	NA	-	NA
Preeclampsia/Hypertension	-	-	-
Oligohydramnios	1.42 (1.27 – 1.57)	- <sup>#</sup>	2.94 (1.15 - 7.81)
Polyhydramnios	- <sup>#</sup>	- <sup>#</sup>	- <sup>#</sup>
Fetal growth restriction	1.19 (1.07 – 1.32) <sup>**</sup>	- <sup>***</sup>	2.94 (1.30 - 6.67) <sup>**</sup>
Fetal/neonatal gender (male)	0.78 (0.75 – 0.81)	-	-
Birth weight in grams	NA	-	-
Macrosomia (>4500g)	NA	NA	NA
Placenta previa	-	NA	NA
Epidural anesthesia	NA	2.88 (1.08 – 7.70)	2.20 (1.29 - 3.75)
Intrapartum cesarean section	NA	0.07 (0.01 – 0.34)	NA
II delivery stage < 40min	NA	0.34 (0.15 - 0.79)	NA
Augmentation	NA	-	NA
Post term pregnancies > 40 week	NA	NA	-
Uterus rupture	NA	NA	-
Induction of labor	NA	-	NA

- not significant

NA nota applicable

<sup>\*</sup>unadjusted OR

<sup>\*\*</sup> defined as < -2SD

<sup>\*\*\*</sup> defined as ≤10<sup>th</sup> percentile

<sup>#</sup>Not publicized information

## Long-term outcome of children at the age of four according to the mode of birth

During the study V 8374 children were delivered in breech position at term in Finland. Among them 4467 (53.3 %) infants were delivered by planned cesarean section and 3907 (46.7 %) underwent a trial of vaginal labor.

Out of all infants born in breech presentation a total of 275 (3.3 %) suffered from an abnormal neurodevelopment at the age of four. From the infants born after an attempted vaginal breech delivery 133 (3.4 %) suffered from an abnormal neurodevelopment at the age of four compared to 142 (3.2 %) infants delivered by planned cesarean section [OR 1.06; 95 % CI 0.74-1.52]. The neurological outcome is summarized in Table 11. Five of the infants born by attempted vaginal breech delivery suffered from cerebral palsy, compared to six in the planned cesarean group [OR 1.31; 95 % CI 0.28-6.07]. Epilepsy was diagnosed in 23 children in the planned vaginal labor group (0.59 %) and in 23 in the planned cesarean section group (0.51 %) [OR 1.39; 95 % CI 0.62-3.14]. No significant differences were found when comparing the trial of vaginal breech labor group to the planned cesarean section group for the other variables of adverse neurodevelopment. (Table 11) A trial of vaginal breech labor was associated with an increased adverse short-term outcome including a significantly lower umbilical artery pH and a lower 5 min Apgar score (Table 11).

**Table 11: Short and long-term neonatal outcomes after a trial of vaginal breech labor (TVBL)**

	Study II		Study III	Study IV	Study V		
	Induced TVBL	Spontaneous TVBL	TVBL	TVBL	TVBL	PCS	OR (95 % CI)
	%	%	%	%	%	%	
<b>Umbilical artery pH &lt; 7.00</b>	0	2.6	1.8	0.9	1.2	0.1	8.9 (3.13 - 25.08)
<b>5 min Apgar score ≤ 6</b>	1.4	1.5	2.7*	-	3.1	1.2	2.61 (1.86 - 3.65)
<b>5 min Apgar score &lt; 4</b>	-	-	1.02	0.6	-	-	-
<b>Neonatal mortality 0-28 days</b>	1.4	0	0.13	0.1	0.08	0	0.95 (0.29 - 3.12)
<b>Cerebral palsy</b>	-	-	-	-	0.13	0.13	1.31 (0.28 - 6.07)
<b>Epilepsy</b>	-	-	-	-	0.59	0.51	1.39 (0.62 - 3.14)
<b>Intellectual disability</b>	-	-	-	-	0.28	0.13	1.26 (0.45 - 3.56)
<b>Autism</b>	-	-	-	-	0.13	0.22	0.20 (0.02-1.60)
<b>Speech or language problems</b>	-	-	-	-	1.07	1.03	1.21 (0.73-2.00)
<b>Visual defects</b>	-	-	-	-	1.10	1.35	0.68 (0.36-1.29)
<b>Auditory defects</b>	-	-	-	-	0.33	0.25	1.52 (0.59-3.90)
<b>Hyperactivity</b>	-	-	-	-	0.08	0.13	1.03 (0.19-5.55)

[TVBL] Trial of vaginal breech labor

[PCS] Planned cesarean section

\*Not publicized information

## DISCUSSION

### **Main findings**

Our study showed that the prevalence of breech presentation was 2.2 % for all singleton pregnancies at term in Finland. We found that breech presentation was associated with various well-known obstetric risk factors for adverse peri- and neonatal outcome such as nulliparity, previous cesarean section and congenital anomaly, fetal growth restriction, gestational diabetes, increased maternal age and oligohydramnios. Equally importantly, our results showed that breech presentation before the onset of labor was associated with an increased antepartum stillbirth rate.

We found that an induction of breech labor in well-selected pregnant term women was not associated with a higher rate of neonatal morbidity or mortality and that the induced breech labor for selected women at term had the same favorable neonatal outcomes compared to spontaneous vaginal breech deliveries. In other words, an induction of labor while the fetus is in breech presentation is feasible for a well-selected population. Induction of labor was, however, associated with an increased intrapartum cesarean section rate in addition to a longer second stage of delivery.

With our results from the Helsinki University Central Hospital database (Study III), we demonstrated that an adverse neonatal outcome was associated with intrapartum risk factors such as a prolonged active second delivery stage, epidural anesthesia and a low intrapartum cesarean section rate. The analysis of the Finnish national birth register confirmed that the use of epidural anesthesia during breech vaginal trial was associated with a higher risk of adverse neonatal outcome (Study IV). This database includes all pregnant women who had a vaginal breech trial at term. In addition, the results showed that adverse neonatal outcome in vaginal breech labor at term is correlated with pre-partum risk factors like nulliparity, cesarean section in a previous pregnancy, oligohydramnios, fetal growth restriction and gestational diabetes. These results show how important the selection process of the women for vaginal breech delivery is.

Finally, our results from study V showed that the long-term neurological outcome of children at the age of four, born after a trial of vaginal breech labor at term, was not different from the

children born by planned cesarean section. Children with growth restriction and congenital anomalies were excluded from the study.

### **Strengths and limitations of the study**

The strengths of our studies include the well-characterized study cohorts. Our studies were performed in Finland, a country with a homogenous population, where health care insurance covers all citizens. Furthermore, our study population consisted of the entire nation or a solid reflection of it. The maternity clinics reach 99.7 % of all pregnant women (169). In Finland, pregnant women have approximately between 11 and 15 appointments with a health care professional (nurse, midwife or doctor) during pregnancy. A first trimester screening for chromosomal abnormalities and pregnancy dating is offered to all women as well as second trimester fetal organs scan with a screening for growth deficiency. Attending the appointments is mandatory to be eligible for maternity benefits and 90 % of all women participate in the voluntary screening program. Women with a fetus in breech presentation are offered an external version at 35-36 gestational weeks. After delivery the children's health and development is followed up in child health clinics up to school age.

Nearly all deliveries (99.7 %) in Finland take place in a hospital (46). All delivery hospitals have the facilities for cardiotocography and fetal ultrasound examination and all of them have a 24/7 service for anesthesia, pediatrics and obstetrics. Obstetricians are trained over a five-year period in the five university hospitals of Finland and follow similar guidelines, which are provided by the National Gynecologic Society and the medical authorities (164). Finnish national registers have good coverage (164). The data of less than 0.1 % of all newborns is missing in the National Medical Birth Register and missing data is obtained from the Central Population Register and the Cause of Death Register (168). The Hospital Discharge Register was used to collect data on diagnoses related to pregnancy, delivery and the neurodevelopment of the children born in breech presentation. Reporting to the register is mandatory for all public and private clinics. The validity of the study results is good as the care of pregnant women is equal nationwide and happens in a modern obstetric setting.

The major limitations of our studies are their retrospective design. Some might claim that the small number of patients enrolled to the case groups of study II and III are limitations, but

taking into account that breech delivery and induction of labor while the fetus is in breech presentation are rare, our case groups are quite reasonable in size. Further limitations for study I, IV and V were that variables were restricted to databank availability. Because of the restricted data availability register studies like ours are not able to evaluate all delivery aspects, for example more specified maternal complications like postpartum infections, vaginal lacerations and long-term complications including urinary incontinence or complications for future pregnancies.

## **Interpretation of the study**

### **Breech presentation of the fetus at term**

We showed in study I that fetuses in breech presentation have a twice as high risk of suffering an intrauterine stillbirth. This is not surprising based on our demonstration that breech presentation at term is associated with known obstetric risk factors.

Nulliparous women had a 2.7-times higher risk of having a fetus in breech presentation and women with a history of cesarean section have a 2.1-times higher risk of having a fetus in breech position. Fetuses in breech presentation had a two times higher risk of being diagnosed with a congenital anomaly, a 1.4 times higher risk of suffering from oligohydramnios and a 1.2-times higher risk of being growth restricted.

Our data supports earlier studies that have shown an increased antepartum stillbirth rate in breech presentation at term compared to the rate in pregnancies with the fetus in vertex presentation (9,48). We were able to confirm that nulliparity is a risk factor for breech presentation (4,9). Most likely the reason for this is a firm abdominal and uterine wall, due to which the fetus is more restricted in its movements (4). Nulliparity is further associated with a prolonged second stage of labor (170) and with adverse neonatal outcome (171) as detected in Study III and IV. Our study showed that a history of cesarean section is also associated with breech presentation in a succeeding term pregnancy. Preceding cesarean delivery is a risk factor for uterine rupture, emergency peripartum hysterectomy and placental abnormalities (22,172) and is therefore a risk factor for adverse neonatal and maternal outcome (22,172,173). However, our results only showed an association between breech presentation of the fetus and preceding cesarean delivery, not an association between adverse neonatal outcome and the common complications of an earlier cesarean delivery.



We were able to confirm that breech presentation at term is more often associated with congenital fetal anomalies than in cephalic presentation (58,174). Fetuses with congenital anomalies most likely suffer from underlying problems in fetal morphogenesis (they might fit better into the uterine cavity in breech presentation) and/or neuromuscular functional problems (58,174).

Our results demonstrated that breech presentation at term is associated with oligohydramnios and fetal growth restriction. Oligohydramnios is a known risk factor for breech presentation at term (175,176), most likely caused by an impediment of the fetal rotation. Oligohydramnios is a known obstetric risk factor as it might indicate placental insufficiency (177). Growth restricted fetuses might suffer from lower neurologic and muscular control, as fetal growth restriction is associated with a lower rate of fetal movement (178-180). This reduced amount of movement may impede the fetus from rotating into vertex presentation. Reduced fetal movements are a known risk or associated factors for adverse peri- and neonatal outcome (180,181), but reduced fetal movements may also suggest that the fetus is suffering while still in the womb.

In our study gestational diabetes was found to be associated with a slightly increased risk for breech presentation at term, as shown before (182). It is a known risk factor for adverse perinatal outcome, like macrosomia, jaundice preeclampsia and postnatal hypoglycemia (173,183,184). However, the association between gestational diabetes and breech presentation at term might be due to fetal macrosomia caused by gestational diabetes, as macrosomic fetuses might be less capable of moving within the uterus. Polyhydramnios is often claimed as a risk factor for breech presentation of the fetus at term, as it might increase abnormal fetal movements; however this association could not be confirmed in reasoned published papers (4-6,8,9,47,58); also our results could not confirm it as a risk factor for breech presentation.

### **Induction of labor while the fetus is in breech presentation at term**

We demonstrated that an induction of labor while the fetus is in breech position is feasible. The rate of successful vaginal deliveries was slightly lower in induced labor compared to spontaneous breech labor. However, induced vaginal breech delivery has the same favorable

neonatal outcomes as spontaneous breech delivery at term. Our findings regarding the induction of breech labor are consistent with earlier and recently performed studies (123-129).

Despite the clear results of all recent studies the guidelines of the Royal College of Obstetricians and Gynaecologists (31) and the Society of Obstetricians and Gynaecologists (41) do not recommend induction of labor while the fetus is in breech presentation. The guidelines of the American College of Obstetricians and Gynecologists, the Deutsche Gesellschaft für Gynäkologie und Geburtshilfe and the Organisme professionnel des médecins exerçant la gynécologie et l'obstétrique en France make no recommendation at all on the topic (28,30,79).

### **Pre- and intrapartum criteria for a safe vaginal breech labor**

In our studies we showed both new and old antenatal (nulliparity, a previous cesarean delivery, gestational diabetes, fetal growth restriction and oligohydramnios) and intrapartum (epidural anesthesia, an active second delivery stage lasting more than 40 minutes and a low intrapartum cesarean section rate) risk factors for adverse outcome in a trial of vaginal labor.

Nulliparity was associated with an increased adverse peri- and neonatal outcome. The results showed that pregnant women, who are expecting their first child have a 1.8 times higher risk for adverse peri- and neonatal outcome compared to multiparous women. Nulliparity is a known risk factor for breech presentation and is also known to be associated with adverse pregnancy outcomes like hypertension, preeclampsia, preterm delivery, smallness for gestational age and a prolonged second delivery stage (170,185-196). Fetuses born of pregnancies with preeclampsia, maternal hypertension or a fetus that is small for gestational age might not have the reserves to cope with a trial of vaginal breech delivery.

The risk for adverse outcome was nearly three times higher, if the woman had a history of preceding cesarean deliveries. A previous cesarean delivery is a known risk factor for adverse outcome as it is associated with a higher perinatal mortality, birth asphyxia and sepsis, uterine rupture and a prolonged labor (22,172,197-201). A previous cesarean delivery is a risk factor for adverse neonatal outcome, no matter what the fetal presentation (breech or cephalic) is.

Our results showed that gestational diabetes was associated with a three times higher risk for adverse neonatal outcome in breech presentation. Gestational diabetes is a known risk factor for increased perinatal mortality, fetal macrosomia and preeclampsia (173,183,184). The placenta might changes in structure and function through hyperglycemia. These changes include villous immaturity, villous fibrinoid necrosis, chorangiomas, and increased angiogenesis. Earlier research suggests that diabetic placental changes are associated with inflammation and oxidative stress that can lead to chronic fetal hypoxia. (202-205). Fetuses that suffer from hypoxia in the womb will most likely not endure a trial of vaginal breech delivery.

The risk for adverse neonatal outcome was nearly three times higher if the fetus suffered from growth restriction. Fetal growth restriction is one of the most common reasons for antepartum stillbirths and adverse perinatal outcome as shown by the ACOG guidelines and others (177,179,181,206-211).

Oligohydramnios was associated with a nearly three times higher risk for adverse neonatal outcome including low Apgar points and low umbilical arterial pH <7.00 as shown by a meta-analysis (211). Oligohydramnios might cause a higher risk for adverse outcome based on placental insufficiency or umbilical cord compression (177,212). Fetal growth restriction like oligohydramnios could be a sign of a compromised fetus, which should not be eligible for a trial of vaginal breech labor.

We were able to identify epidural anesthesia, an active second delivery stage lasting more than 40 minutes and a low intrapartum cesarean section rate as intrapartum risk factors for adverse peri- and neonatal outcomes. Epidural anesthesia increased the risk for adverse neonatal outcome [aOR 2.2 (study III) and aOR 2.9 (study IV)]. Epidural anesthesia is associated with a prolonged second delivery stage and with temperature elevation, which has been associated with adverse outcome in neonates in term pregnancies (100-102,195), but it has to be considered, that epidural anesthesia is only a sign of a slowly progressing labor, not the reason for adverse outcome.

In study III we demonstrated that a prolonged second delivery stage, epidural anesthesia and a low intrapartum cesarean section rate are intrapartum risk factors for adverse peri- and neonatal outcome in trial of breech delivery. Earlier studies have shown that the duration of the active second delivery stage lasting more than 60 minutes increases the risk for adverse neonatal outcome (12,213). The most common reason for a prolongation of the active second delivery stage are inadequate uterine contractions (214). Another reason for the delay in labor is the insufficient descent of the fetus due to fetal-maternal disproportion or umbilical cord complications (like nuchal cord). The guidelines for breech delivery in Canada recommend a cesarean section if vaginal labor is not imminent after on hour of active pushing (41), whereas our data suggests that a second delivery stage of less than 40 minutes or even less than 30 minutes has a protective effect for normal neonatal outcome. A prolonged labor might cause more fetal head entrapment. The delayed delivery of the fetal head and the maneuvers needed to treat it are most likely the cause of the increased fetal morbidity.

To our surprise we found a lower intrapartum cesarean section rate in the group with adverse perinatal outcome, as secondary cesarean section is a common risk factor for adverse fetal outcomes (214). The emergency cesarean section rate in the group with adverse outcome was low (5.3 %). This rate seems too low, as unfavorable vaginal breech labors (CTG changes, slow progress in labor) should be converted into cesarean section to safeguard the health of the neonates. A cesarean section rate of 20 to 30 % when attempting vaginal breech delivery seems to be normal (215,216). However, the PREMODA study by Goffinet showed that selecting and managing vaginal deliveries carefully could safeguard a normal neonatal outcome, even though the cesarean section rates varied significantly among the centers (34).

### **Neurological long-term outcome of children born in breech position**

Children born after a trial of vaginal breech labor have similar long-term outcomes as children born by planned cesarean section. A trial of vaginal breech labor was not associated with cerebral palsy, epilepsy, intellectual disability, autism, speech or language problems, visual or auditory defects or hyperactivity at the age of four, if conducted with women with low-risk breech pregnancies. Our findings are consistent with earlier findings (45,138,146,213,217). Neurodevelopmental disorders among offspring maybe caused by preconceptional factors, antenatal risk factors during the ongoing pregnancy and intrapartum factors including birth asphyxia (Table 12) (144). The aim of our study was to evaluate the

individual risk for adverse neurodevelopmental outcome at the age of four of children born after an attempted vaginal breech delivery. We excluded other possible risk factors for adverse neonatal outcome such as fetal growth restriction, multiple pregnancies, placental abruption and preterm delivery to investigate the individual risk for adverse neurodevelopmental outcome at the age of four years after a trial of vaginal breech labor. After the exclusion of these factors, children in both groups had similar neurodevelopmental long-term outcomes regardless of the mode of delivery. These results are consistent with earlier findings (146,213,217) as well as with recently published Norwegian data by Bjellmo (45). A follow-up study of the term breech trial children at two years of age could not find a difference regarding neurodevelopmental delay between the planned cesarean birth group (3.1 %) and the planned vaginal birth group (2.8 %) either (138).

Nevertheless we have to admit that a trial of vaginal breech labor is associated with adverse short-term outcomes. The children in the vaginal trial group had a lower umbilical artery pH and lower 5-minute Apgar scores (12,51,218,219). Our data showed that the perinatal mortality rate in a trial of vaginal breech labor was 0.08 %, which is considerably lower than in the term breech trial (1.3 %) (12). The question arises why the neonates are suffering from adverse short-term morbidity but not from long-term morbidity? The answer is most likely linked to the fact that during a trial of vaginal breech labor fetuses suffer more often from cord compression, which results in an acute respiratory acidosis from which a healthy term newborn easily recovers but not a compromised fetus (for example a growth restricted fetus).

**Table 12:** Possible risk factors for adverse neurodevelopmental disorders among offspring acquired before birth

Risk factors for adverse neurodevelopmental disorders acquired during pregnancy		
Preconceptional	Antenatal	Intrapartum
Maternal hypothyroidism	Congenital anomalies	Birth asphyxia
Maternal hyperthyroidism	Preterm delivery	Meconium aspiration
Medications	Fetal growth restriction	Prolonged labor
	Placental changes	Instrumental deliveries
	Placental abruption	Abnormal fetal presentation
	Infections	
	Maternal heart diseases	
	Preeclampsia	
	Seizures	

## **Future aspects**

Further studies for the prediction of adverse neonatal outcomes in breech delivery are needed:

- The short and long-term outcomes of growth-restricted fetuses undergoing a trial of vaginal breech delivery should be studied. Also, the short and long-term outcomes of fetuses with fetal growth restriction below the < 10<sup>th</sup> and the 2<sup>nd</sup> percentile in breech presentation should be reviewed, to review if all growth restricted fetuses are at higher risk for adverse neonatal outcome.
- Further studies on the effect of maternal diabetes and earlier cesarean delivery as risk factors for adverse outcomes are needed, to understand better their pathophysiology and to avoid complications.

Preterm breech delivery needs further studies:

- Outcome of vaginal delivery in extremely preterm (<28 weeks), very preterm (28 to <32 weeks) and moderate to late preterm (32 to <37 weeks) breech delivery should be reviewed.
- Neurodevelopmental outcome in preterm breech delivery needs further examination.

Training

- More education and training for health care staff, specifically obstetricians and midwives, is needed to give women and fetuses optimal care during delivery and to minimize the intrapartum risks of vaginal breech delivery.

## CONCLUSIONS

Breech presentation of the fetus at term was associated with a higher antepartum stillbirth rate and with possible risk factors that are in themselves associated with a higher perinatal mortality and morbidity compared to pregnancies with the fetus in vertex presentation. Fetuses in breech presentation at term should undergo an ultrasound examination for fetal malformations and should be reviewed for other risk factors for adverse fetal outcome before delivery. An induction of labor at term while the fetus in breech presentation is possible for a selected population of women since it was not associated with a higher fetal morbidity or mortality. We were able to show that the neonatal mortality and morbidity of the offspring undergoing a trial of vaginal breech labor was lower and not as high as claimed by the Term Breech Trial. An active second delivery stage lasting more than 40 minutes, a low intrapartum cesarean section rate and epidural anesthesia during labor were associated with higher neonatal morbidity. A trial of vaginal breech labor at term was not associated with an adverse neurodevelopmental outcome of the children at the age of four.

As many guidelines state women should be counseled that vaginal breech delivery is associated with a slightly higher risk of perinatal mortality and morbidity compared to an elective cesarean section.

Our study showed that it is important to select women carefully for a trial of vaginal breech labor and the significance of an adequate intrapartum management to avoid adverse neonatal short-term outcome. The study showed that adverse short-term morbidity after a trial of vaginal breech labor was not associated with adverse neurodevelopmental outcome at the age of four among offspring. Guidelines for breech presentation should be updated and doctors must continuously train related maneuvers and forceps deliveries for a safe vaginal breech labor.

The radical changes in breech delivery management implemented after the publication of the Term Breech Trial might have been rushed and exaggerated, as the Term Breech Trial was a well-designed, but not a well-performed study. Elective cesarean section as a standard treatment for every breech presentation might be the wrong choice, as it is associated with a higher risk for the mother and her offspring during future pregnancies. Women and health

care professionals should have the possibility to choose the safest method to deliver a fetus in breech presentation and in some women a vaginal breech delivery trial might be the best option.



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## **ORIGINAL PUBLICATIONS**