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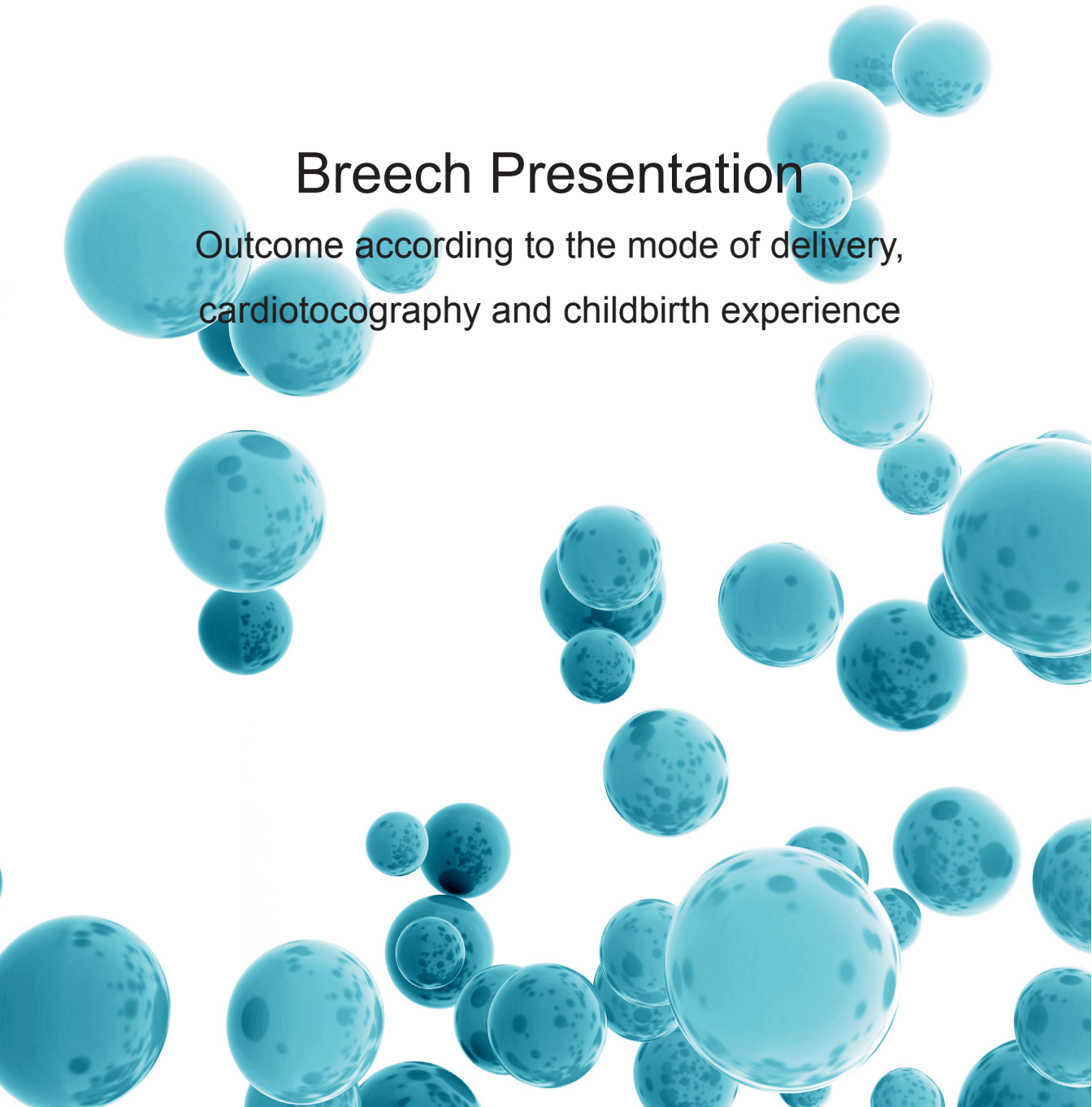
ELLI TOIVONEN

Breech Presentation

Outcome according to the mode of delivery, cardiotocography and childbirth experience



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ACADEMIC DISSERTATION
To be presented, with the permission of
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of the University of Tampere,
for public discussion in the Jarmo Visakorpi auditorium
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on 25 May 2018, at 12 o'clock.

UNIVERSITY OF TAMPERE

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University of Tampere, Faculty of Medicine and Life Sciences
Tampere University Hospital, Department of Obstetrics and Gynecology
Finland

Supervised by
Docent Jukka Uotila
University of Tampere
Finland
Docent Outi Palomäki
University of Tampere
Finland

Reviewed by
Docent Leea Keski-Nisula
University of Eastern Finland
Finland
Docent Terhi Saisto
University of Helsinki
Finland

Cover design by
Mikko Reinikka

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Dedicated to my supervisors, who offered endless support and encouragement during my years of study, and to my family, without whom this work would not have been possible

ABSTRACT

Three to four percent of term and up to 40% of preterm infants are delivered in breech presentation, but the optimal mode of delivery is unclear. The aims of this study were to compare the prognosis of breech deliveries by intended mode of delivery in both term and preterm breech deliveries and to compare the maternal childbirth experience and features of cardiotocography traces between breech and cephalic deliveries. Neonatal and maternal outcomes in term and preterm breech deliveries were compared by intended mode of delivery. Comparisons were made also between planned vaginal breech deliveries and cephalic controls. The childbirth experience of mothers attempting a vaginal breech delivery was compared to that of mothers delivering a cephalic infant. Intrapartum cardiotocography traces from intended vaginal breech deliveries were compared to traces from cephalic deliveries to investigate differences in trace patterns.

The study population comprised 1010 women giving birth to a breech infant in Tampere University Hospital during 2003 – 2015, and 440 cephalic controls from the same time period.

Two studies focused on assessing the outcome according to the mode of delivery, one in term breech presentation and the other in moderately and late preterm breech deliveries (gestational age 32+0 – 36+6 weeks). The comparisons were made between intended vaginal breech deliveries and intended cesarean breech deliveries, and between intended vaginal breech and intended vaginal cephalic control deliveries. No neonatal mortality was observed, and severe morbidity was rare in all groups. Low Apgar scores (<7) at the age of one minute were more common in infants in the intended vaginal delivery (VD) groups compared to planned cesarean delivery (CD) groups in both term and preterm cohorts, but no differences were observed at the age of five minutes. Median umbilical artery pH values were lower in infants in the breech VD groups compared to the breech CD groups. The need for neonatal intensive care and the rate of neonatal morbidity

were similar across the groups and higher in the preterm cohorts. Similarly, low one-minute Apgar scores were more common in the planned vaginal breech delivery groups compared to the cephalic groups, but the incidence of a low five-minute Apgar score was comparable between groups, although more common in the preterm cohorts. Planned VD was more often converted to a CD in term breech deliveries than in term cephalic deliveries.

The childbirth experience was assessed with a questionnaire describing different aspects of the delivery, and deliveries in the cephalic control group were matched according to the actual mode of delivery. No major differences in the birth experiences were observed between the breech and cephalic groups. However, mothers in the breech group felt more often than mothers in the cephalic group that they could not choose the birthing position. Primiparity, actual delivery by CD, infant birth trauma (including minor trauma such as bruising and more severe injuries such as fractures or Erb's palsy), prolonged second stage of labor and prolonged hospital stay predicted negative delivery experience in both breech and cephalic deliveries.

Cardiotocography (CTG) traces from breech deliveries displayed late decelerations and decreased variability more often compared to traces from cephalic deliveries, but the association of these patterns with adverse neonatal outcome was not statistically significant. Multivariable analysis identified breech presentation and complicated variable decelerations as predictors for neonatal acidemia and low five-minute Apgar scores. Breech presentation at delivery and pathological CTG trace were independent predictors for low one-minute Apgar scores.

Allowing a trial of labor in selected women with the fetus in breech presentation remains a justified option based on this study. However, strict criteria in selecting the candidates for and managing a trial of vaginal breech labor should be applied. The maternal delivery experience is as positive as in cephalic delivery, but mothers expecting a breech infant should be informed of the increased risk of emergency CD. Extra support should be supplied to mothers with risk factors for a negative delivery experience, such as primiparous women, women with prolonged second stage of labor or prolonged hospital stay, women who have planned a VD but deliver by a CD, and women whose newborns suffer from birth trauma. CTG

traces from breech deliveries display pathological patterns more often than those from cephalic deliveries. Fortunately, neonatal depression necessitating treatment is rare after vaginal breech delivery.

TIIVISTELMÄ

Väitöskirjatutkimuksen tarkoituksena oli selvittää perätilasynnytyksen ennustetta ja parasta hoitoa. Erityisesti tarkoitus oli tutkia, onko suunniteltu alatiesynnytys turvallinen vaihtoehto suunnitellulle keisarileikkaukselle sikiön syntyessä perätilassa sekä verrata perätilassa ja päätarjonnassa tapahtuvan alatiesynnytysyrityksen ennustetta. Kahdessa tutkimuksessa keskityttiin äidin ja lapsen synnytyksenjälkeiseen terveyteen ja yhdessä tutkimuksessa tarkasteltiin äidin kokemusta synnytyksessä. Neljännessä osatyössä verrattiin perätilassa syntyvien lasten sykekäyriä päätarjonnassa syntyvien lasten sykekäyriin ja etsittiin vastasyntyneen huonokuntoisuudesta varoittavia sykekäyrämuutoksia.

Tutkimusväestö koostui Tampereen yliopistollisessa keskussairaalassa 2003 - 2015 perätilalapsen synnyttäneistä äideistä ja heidän lapsistaan sekä samalla ajanjaksolla synnyttäneistä päätarjontaisista verrokeista. Yhteensä aineistossa oli 1010 perätilasynnytystä ja 440 päätarjontaista synnytystä.

Synnytystapaa vertailevissa tutkimuksissa tarkasteltiin lasten ja äitien vointia perätilalapsen alatiesynnytysyrityksen ja perätilalapsen suunnitellun keisarileikkauksen jälkeen. Vertailut tehtiin myös perätilalapsen alatiesynnytysyrityksen ja päätarjontaisen lapsen alatiesynnytysyrityksen välillä. Verrattaessa täysiaikaisena perätilassa alatiesynnytysyrityksen jälkeen syntyneiden lasten syntymänjälkeistä vointia suunnitellulla keisarileikkauksella syntyneiden perätilalasten vointiin havaittiin, että alatiesynnytysryhmässä lasten Apgar-pisteet yhden minuutin iässä olivat useammin alle 7 kuin keisarileikkauksella syntyneillä lapsilla. Samoin napanuoravaltimon pH-arvo oli alatieryhmässä keskimäärin matalampi kuin keisarileikkausryhmässä. Apgar-pisteissä ei ollut kuitenkaan eroa ryhmien välillä viiden minuutin iässä, eikä eroa havaittu myöskään vastasyntyneiden tehohoidon tarpeessa tai yleisessä sairastuvuudessa. Kukaan tutkimusaineiston lapsista ei kuollut vastasyntyneisyyskaudella ja lasten hoitotoimenpiteitä vaatinut huonokuntoisuus oli harvinaista. Kun perätilassa alatiesynnytystä yrittäneitä

verrattiin päätarjontaisiin verrokkeihin, lasten Apgar-pisteet minuutin iässä olivat useammin matalat perätilaryhmässä kuin verrokeilla, mutta viiden minuutin iässä eroa ei ollut. Perätilan alatiesynnytysyritykset päättyivät useammin keisarileikkaukseen kuin päätarjontaisten lasten alatiesynnytysyritykset.

Ennenaikaisesti (raskausviikoilla 32+0 – 36+6) syntyneiden lasten ryhmässä vertailut tehtiin perätilassa alatiesynnytysyrityksen jälkeen ja ilman alatiesynnytysyritystä keisarileikkauksella syntyneiden lasten kesken. Lisäksi alatiesynnytysyrityksen jälkeen syntyneitä perätilalapsia verrattiin raskauden keston suhteen kaltaistettuihin, alatiesynnytysyrityksen jälkeen syntyneisiin normaalitarjontaisiin lapsiin. Verrokkisynnytykset oli kaltaistettu myös sen mukaan, oliko äiti aiemmin synnyttänyt alateitse. Tulokset olivat samankaltaiset kuin täysiaikaisena syntyneillä: alatiesynnytystä yrittäneiden ryhmässä minuutin Apgar-pisteet olivat useammin matalat verrattuna sekä keisarileikkauksella ilman alatiesynnytysyritystä syntyneisiin lapsiin että verrokkilapsiin, mutta viiden minuutin iässä eroa ei havaittu. Tehohoidon tarve oli yleisempää perätilaryhmissä kuin verrokkiryhmässä, vaikkakaan ero ei ollut tilastollisesti merkitsevä.

Äidin synnytyskokemus oli perätilalapsen alatiesynnytysyrityksen jälkeen keskimäärin samanlainen kuin normaalitarjontaisen lapsen alatiesynnytysyrityksen jälkeen, kun ryhmät oli vakioitu toteutuneen synnytystavan suhteen. Perätilalapsen synnyttäneet kokivat useammin, ettei heillä ollut valinnanvaraa synnytysasennon suhteen, mutta muuten kokemuksissa ei ollut merkitseviä eroja. Ensisynnyttäjyys, pitkä ponnistusvaihe, lapsen synnytysvamma, alatiesynnytysyrityksen päättyminen keisarileikkaukseen ja pitkittynyt sairaalahoito lisäsivät kielteisen kokemuksen todennäköisyyttä sekä perätilaryhmässä että verrokkiryhmässä.

Perätilasynnytyksessä sikiön sykekäyrissä nähtiin useammin vähentynyttä sykkeenvaihtelua ja myöhäisiä hidastumia verrattuna päätarjontaisten verrokkien synnytyksiin, mutta näiden muutosten ennustearvo sikiön huonokuntoisuudelle ei ollut merkitsevä. Patologiseksi luokiteltu sykekäyrä sekä perätarjonta lisäsivät riskiä matalille yhden minuutin Apgar-pisteille, kun taas komplisoituneet vaihtelevat hidastumat sekä perätarjonta lisäsivät matalien viiden minuutin Apgar-pisteiden ja matalan napavaltimon pH-arvon todennäköisyyttä.

Tutkimuksen perusteella sikiön ollessa perätarjonnassa myös alatiesynnytys on vaihtoehto. Alatiesynnytyksen edellytykset tulee kuitenkin tarkkaan arvioida ja synnytyssairaalassa on oltava mahdollisuus päättää synnytys nopeasti keisarileikkauksella, mikäli merkkejä sikiön huonovointisuudesta havaitaan tai synnytys ei edisty normaalisti. Synnytyskokemus on yhtä hyvä kuin päätarjontaisen lapsen synnytyksessä, mutta suurentuneesta riskistä joutua keisarileikkaukseen on kerrottava äidille etukäteen. Erityistä tukea on tarjottava äideille, joilla on riski kokea kielteinen synnytyskokemus, kuten ensisynnyttäjille ja niille äideille, joiden ponnistusvaihe tai sairaalassaoloaika pitkittyy, joiden alatiesynnytysyritys päättyy sektioon tai joiden lapsilla on synnytysvamma. Sikiön sykekäyrässä nähdään enemmän patologisia kuvioita verrattuna normaalitarjontaisen sikiön sykekäyrään. Vastasyntyneiden hoitoa vaativa huonokuntoisuus on kuitenkin harvinaista perätilan alatiesynnytysyrityksen jälkeen.

TABLE OF CONTENTS

1 LIST OF ORIGINAL PUBLICATIONS

This dissertation is based on the following publications. They are referred to in the text by their Roman numerals and reprinted with permission from the publishers.

I Toivonen E, Palomäki O, Huhtala H, Uotila J. Selective vaginal breech delivery at term – still an option. Acta Obstet Gynecol Scand. 2012;91:1177-83.

II Toivonen E, Palomäki O, Korhonen P, Huhtala H, Uotila J. Impact of the mode of delivery on maternal and neonatal outcome in spontaneous-onset breech labor at 32+0 – 36+6 weeks of gestation: a retrospective cohort study. In press. Eur J Obstet Gynecol Reprod Biol. 2018;225:13-8

III Toivonen E, Palomäki O, Huhtala H, Uotila J. Maternal experiences of vaginal breech delivery. Birth 2014;41:316-22.

IV Toivonen E, Palomäki O, Huhtala H, Uotila J. Cardiotocography in breech versus vertex delivery: an examiner-blinded, cross-sectional nested case control study. BMC Pregnancy Childbirth 2016;16:319.

2 ABBREVIATIONS

ACOG American College of Obstetricians and Gynecologists

bpm beats per minute

CEQ The Childbirth Experience Questionnaire

CI Confidence Interval

CD Cesarean delivery

CTG Cardiotocography

ECV External cephalic version

FIGO International Federation of Gynaecology & Obstetrics

NICU Neonatal Intensive Care Unit

OR Odds Ratio

VAS Visual analogue scale

VD Vaginal delivery

3 INTRODUCTION

Most fetuses lie in vertex presentation at a term pregnancy. However, the fetus is in breech presentation in 3-4% of term pregnancies, presenting its feet, buttocks, or both [Cunningham et al., 2010]. The incidence of breech presentation is related to gestational age, as 40% of fetuses present breech at 20 weeks but only 6-8% do so at 34 weeks [Arulkumaran 2012]. It is thought that the fetus assumes cephalic presentation by exercising normal movements; thus, factors that impair normal fetal mobility may cause abnormal presentation. Fetal and uterine malformations have been identified as risk factors for breech presentation [Heinonen et al., 1982; Arulkumaran 2012], as have a low volume of amniotic fluid [Zsirai et al., 2016; Macharey et al., 2017a], smoking [Witkop et al., 2008], and low birthweight for gestational age [Krebs et al., 1999; Zsirai et al., 2016; Macharey et al., 2017a]. While perinatal mortality and morbidity are increased in infants born in breech presentation, the extent of impact that mode of delivery has on the risks is uncertain [Vidaeff 2006; Zsirai et al., 2016].

As soon as modern medicine enabled safe cesarean delivery (CD), the optimal mode of breech delivery became a contentious issue. The difficulties in predicting abnormal delivery and the severity of possible complications led some to recommend a policy of routine CD [Wright 1959], although many preferred a more conservative approach as CD still predisposed mothers to increased morbidity, and the benefits for the fetus were not clear in all populations [Hall et al., 1956]. Despite concerns of complications and loss of obstetrical skill, the rates of CDs have increased, and in many countries, for example in Greece, Italy, Spain, Saudi Arabia and the United States, over 80% of breech infants are born by a CD [Vidaeff 2006]. In Finland during 2004 – 2010, 46.7% of nonmalformed singleton breech infants without intrauterine growth restriction had undergone a trial of labor [Macharey et al., 2018].

The relative rarity of the phenomenon and the numerous confounding factors associated with breech presentation and delivery complicate research. Randomized controlled trials should be designed as multicenter studies to achieve a large enough study population to demonstrate differences in rare outcomes (such as perinatal death). This approach compromises the uniform management of the deliveries and comprehensive enrolment of patients, although it improves the statistical power of the study. The Term Breech Trial, a large multicenter randomized controlled trial that included 2088 deliveries, was conducted to end the debate about the optimal mode of delivery. In this study, perinatal outcomes were significantly better in the group that underwent elective CD [Hannah et al., 2000]. These results significantly affected the clinical practice and reduced the numbers of vaginal breech deliveries [ACOG 2002; Rietberg et al., 2005; Hartnack Tharin et al., 2011].

Despite many obstetrical societies encouraging elective CD after the Term Breech Trial, some centers with a strong tradition of vaginal breech delivery continued to allow trial of labor to selected women with their fetuses in breech presentation. Smaller, nonrandomized studies from these hospitals produced reassuring data [Giuliani et al., 2002; Alarab et al., 2004; Uotila et al., 2005], and further criticism against the methodology of randomized controlled trials was expressed [Kotaska 2004]. This led to the publication of new guidelines permitting trial of labor in selected cases of breech presentation [ACOG 2006] and demonstrated that the debate on the breech delivery was not over.

The most important criterion for vaginal breech delivery is maternal desire for natural birth and high motivation; thus, mothers expecting a breech infant need to be offered concise information and evidence-based care to support their decision on mode of delivery.

4 REVIEW OF THE LITERATURE

4.1 Definitions

Table 1. Definitions of terms used in this dissertation

Breech presentation	The fetal gluteal region, instead of cephalic, enters the pelvis first [Cunningham et al., 2010]
Complete breech	Both hips and knees flexed [Arulkumaran 2012]*
Incomplete breech	Both hips flexed, one knee flexed and the other extended [Arulkumaran 2012]*
Frank breech	Both hips flexed, both knees extended [Arulkumaran 2012]*
Footling breech	One or both feet presenting [Arulkumaran 2012]*
Term delivery	Delivery after 37 completed gestational weeks
Late preterm delivery	Delivery at 34+0 – 36+6 gestational weeks
Moderately preterm delivery	Delivery at 32+0 – 33+6 gestational weeks
External cephalic version	Using physical manipulation through the abdominal wall to alter the fetal presentation so that the head is made the presenting part [Cunningham et al., 2010]
Assisted breech delivery	Maternal effort should deliver the infant's lower body and trunk up to the scapulae [Clinch 1989]. The shoulders and the head can be delivered using various techniques
Partial breech extraction	The breech is allowed to deliver spontaneously to the level of the umbilicus. The fetus is then grasped at the bony pelvis and steady, gentle traction applied downwards [Cunningham et al., 2010]. The shoulders and the head can be delivered using various techniques
Total breech extraction	Before spontaneous delivery of the breech, fetal feet are grasped and pulled through the birth canal or, during cesarean delivery, through the uterine incision. Successively higher portions of the fetus are grasped and pulled with gentle traction. The delivery is completed as in partial breech extraction [Cunningham et al., 2010]

*See Figure 1

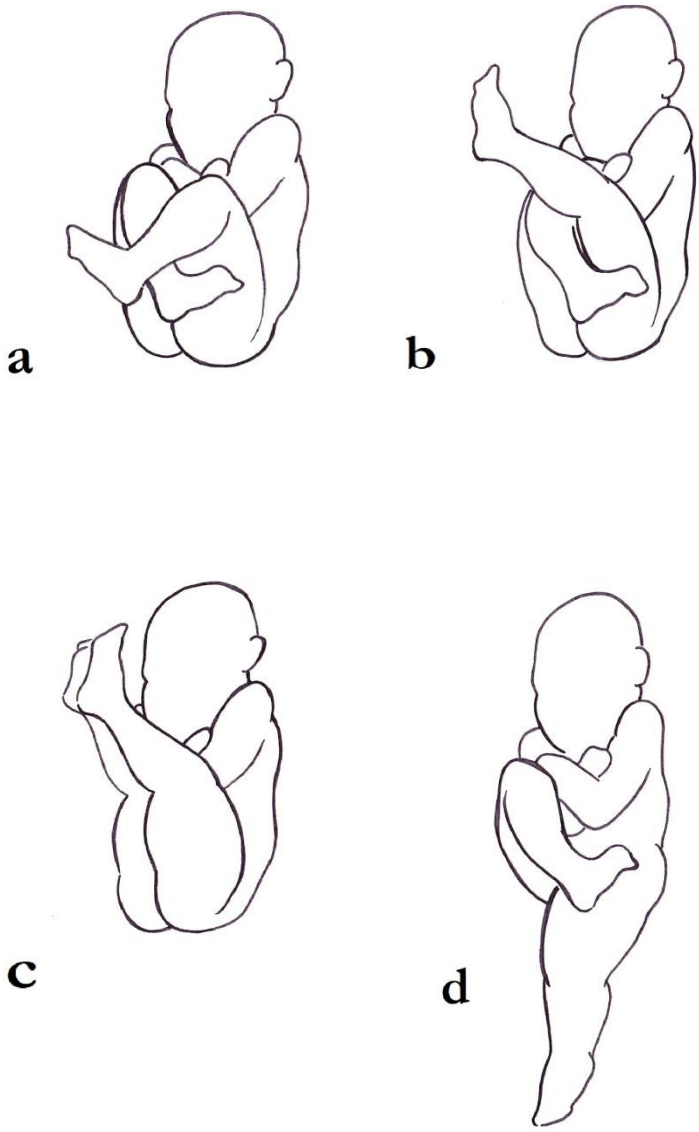


Figure 1. Variations of breech presentation. a. complete breech; b. incomplete breech; c. frank breech; d. footling breech. Figure published with permission from the artist, Jani Ylönen.

4.2 History of breech delivery

4.2.1 Vaginal breech delivery

Breech deliveries and their challenges have been described since antiquity. Aristotle has been quoted as considering that only vertex infants could be delivered spontaneously [Fianu 1976]. Some primitive societies saw breech presentation as a bad omen and counteracted it with superstitious practices, but as early as the first century A.D., Celsus described the safe way to deliver breech infants [Ghosh 2005]. Managing vaginal breech deliveries was considered an obstetric art for centuries, defining the skill of the obstetrician. The importance of waiting for spontaneous delivery of the body, avoiding the pulling of the infant, and bringing down the arms as soon as possible to prevent them from being extended, was recognized already in the 1st and 2nd centuries A.D. Apparently this doctrine was forgotten until the 16th century, when it was again described in Rösslin's influential textbook of midwifery, *Der Swangern Frauen und Hebammen Rosengarten [A Garden of Roses for Pregnant Women and Midwives]* [Løvset 1937]. However, it was impossible to determine the fetal condition during labor before the stethoscope was invented in the 19th century, and rapid delivery of the fetus by breech extraction was advised. Francois Mauriceau, a French surgeon and accoucheur (male midwife), who has been credited with establishing modern obstetrics and separating it from surgery, described breech extraction in his cornerstone book *The Accomplisht Midwife, Treating of the Diseases of Women with Child, and in Child-Bed* [Mauriceau 1673].

Until the 19th century, vaginal delivery (VD) was the only real option in breech presentation, as CD carried significant risks for the mother. Some of the maneuvers still used in vaginal breech deliveries are dated very early, such as the extraction of the aftercoming head by inserting the index finger into the fetal mouth. This was known in ancient Greece as the Hera maneuver as, according to mythology, Goddess Hera helped Alcmene to deliver one of her twins, Hercules, in breech presentation using this method. Mauriceau described this technique in the third edition of his book and today it is named in his honor [Karamanou et al.,

2013] as Mauriceau maneuver (the term Mauriceau-Smellie-Veit maneuver is also used).

4.2.2 Cesarean delivery

In premodern times CD carried a high risk of maternal death, although tales of surviving mothers and infants existed in many cultures. It was primarily performed to retrieve the fetus from the dead mother, either to save the newborn, or to bury the infant separately, as required by religious practices.

Hemorrhage and infectious morbidity were the main causes of maternal mortality in the early ages of CDs. Lister's promotion of antisepsis in the 1870's contributed greatly to the safety of surgery in general, and operative interventions also became more feasible in the field of obstetrics. Treating blood loss became possible with the advent of blood transfusions, in addition to treating infections with antibiotics. In fact, the first successful transfusion was described in 1829 by James Blundell, an English obstetrician, who performed it on a patient suffering an excessive postpartum hemorrhage [Learoyd 2012]. During the first half of 20th century, the introduction of antisepsis, antibiotics and blood banking enabled relatively safe CDs and, thus, allowed obstetricians to choose between vaginal and abdominal delivery.

4.2.3 Breech delivery in the 20th century

4.2.3.1 Conservative approach to breech delivery

Although a CD was no longer the procedure of last resort, most obstetricians and academic leaders in the first half of the 20th century preferred conservative measures and restricted its use to very selected cases [Cyr 2006]. The development of modern technology to monitor fetal well-being, good availability of operating rooms for emergency CDs and enhanced neonatal care improved greatly the fetal safety of vaginal breech delivery. However, as CD became gradually more widespread, several authors in the 1950's reported lower mortality rates in breech

infants that were delivered abdominally compared to those born vaginally. Goethals analyzed 268 vaginal and 34 CD breech deliveries from 1940 - 1952, describing a neonatal mortality rate of 2.6% in the vaginal group and zero in the CD group, and one maternal death after a CD [Goethals 1956]. Hall and Kohl aggregated data from breech deliveries in several centers and presented a total neonatal mortality rate of 14.4% (3.1% in term, non-malformed breech infants). They concluded that although CD has the highest perinatal survival rate (91.1% of CDs *vs.* 85.6% of VDs), it shouldn't be used in all breech deliveries [Hall et al., 1956]. On the contrary, in his report of 358 term breech deliveries with a CD rate of 22% and perinatal mortality of 2%, Wright attributed the lower mortality rate to the higher incidence of CD compared to Hall and Kohl's population. After reviewing the work of his contemporaries, he recommended a policy of routine CD for viable breech infants [Wright 1959].

Despite these findings, not all obstetricians unequivocally favored CD over VD. Johnson pointed out in 1959 that most of the neonatal mortality in breech deliveries was attributed to prematurity and that "there is no rapid royal road to the reduction of fetal mortality and morbidity in breech presentation and deliveries." He reported the corrected perinatal mortality rate at 4.6% including deaths attributed to prematurity in his series of 171 breech deliveries [Johnson 1959]. Law, noting similar results, reported corrected perinatal mortality of only one percent, when intrauterine deaths, severe malformations and infants weighing less than 1500 grams were excluded. Law disapproved of breech extraction under general anesthesia, but, interestingly, he promoted general anesthesia and routine forceps use for the delivery of the aftercoming head [Law 1955], a policy that today seems invasive. Gram and Kærn described a much more conservative approach in 1964, claiming that the more spontaneous the course of delivery, the better the results. They recommended applying pudendal anesthesia and reported a corrected perinatal mortality rate of 0.6 % for the full-term infants [Gram et al., 1965].

A Finnish dissertation focusing on the prognosis and management of breech deliveries was published by Kauppila in 1975 [Kauppila 1975]. The study population comprised mothers delivering breech infants in predecessors of Tampere University Hospital, Tampereen Synnytyslaitos in 1952 – 1961 and Tampereen Keskussairaala in 1963 - 1970, a total of 2227 breech deliveries, which

were compared to 59260 nonbreech deliveries during the same period. Kauppila observed declining perinatal mortality and increasing CD rates in all deliveries over the study period. The overall CD rate for term breech deliveries substantially increased from 10.9% in 1952 - 1961 to 28.3% in 1963 - 1970, while the corrected perinatal mortality rate in corresponding years was 2.24% and 0.49% for term breeches. In this study, 20.1% of the breech deliveries compared to 5.0% of the nonbreech deliveries were deemed premature (weighing less than 2500 grams). Perinatal mortality among premature breech infants was devastatingly high at 51.1% (23.3% in nonbreech deliveries), although a significant decline was also seen in perinatal mortality among the premature deliveries during study years. In addition to high rates of low birth weight infants among breech deliveries, Kauppila described frequent congenital malformations in 9.7% of the breech infants, comparing this to the general frequency of malformations in Finland at the time (1.1-2.1% in all deliveries). Birth trauma was observed in 7.0% of term breech deliveries, including cerebral hemorrhage, Erb's palsy, clavicular fractures, and other injuries. Kauppila concluded that increasing CD rates had lowered the perinatal mortality and recommended extensive indications to CD in breech presentation.

Based on accumulating scientific evidence and obstetricians' own experiences, the elevated perinatal mortality and morbidity of breech infants was recognized as an obstetric challenge. However, instead of adapting the policy of routine CD, many obstetricians chose to seek methods to predict the success of trial of VD in breech presentation, as well as more effective modalities to monitor fetal well-being during labor. Fetopelvic disproportion was thought to cause a significant percentage of complications; thus, algorithms were proposed to calculate fetopelvic indices and adequacy of maternal pelvis [Ohlsen 1975; Westin 1977]. The benefits of continuous cardiotocography monitoring to detect fetal asphyxia were noticed [Donnai et al., 1975]. Routine fetal blood sampling in the second stage of labor was proposed, in addition to continuous CTG monitoring [Wheeler et al., 1975; Hill et al., 1976], although some authors suspected the reliability of the capillary samples taken from the edematous breech or foot [Donnai et al., 1975]. Despite these advances and active debate on the optimal route of delivery for the fetus presenting the breech, the rate of cesarean breech deliveries continued to increase

[Baskett et al., 1981; Weekes 1983]. Attitudes of obstetricians were shifting towards finding reasons for permitting VD of the breech fetus instead of looking for indications to perform CD [Hill et al., 1976].

4.2.3.2 The age of debate

Since the early 20th century, rising CD rates had concerned obstetricians [Cyr 2006], and the need was evident for scientific data to manage breech deliveries. The fact that breech presentation was a risk factor for neonatal depression, regardless of the mode of delivery [Calvert 1980], encouraged further research, most of which was retrospective. A meta-analysis [Gifford et al., 1995] combined the results of nine studies from 1980 to 1988, acquiring pooled data of 3056 breech deliveries. The risk of birth trauma and combined outcome of birth trauma and neonatal death were increased in the trial of labor group compared to the no trial of labor group.

The meta-analysis also included two randomized studies. Collea and associates randomized 208 women with breech fetuses into two groups according to the planned mode of delivery [Collea et al., 1980]. They observed a low rate of birth trauma in the VD group and a striking maternal morbidity rate (49.3%) in women whose actual mode of delivery was CD, recommending a trial of VD to avoid maternal morbidity. However, the results were not analyzed with an intention-to-treat model common to modern trials. Further, if the maternal adverse outcomes were analyzed according to the planned mode of delivery, the difference would not be statistically significant (45 of 115 women in the planned VD and 47 of 93 in the planned CD group had complications, p=0.10). Another randomized study included 70 women in the intended VD group and 35 in the planned CD group [Gimovsky et al., 1983], all giving birth to a fetus in nonfrank breech presentation. They reported one neonatal death, attributed to inadequate maternal co-operation, in the VD group *vs.* none in the CD group, but neonatal morbidity was similar across the groups.

As the two randomized studies did not recommend a policy of routine CD, many centers continued to offer vaginal management of breech deliveries and some even increased their VD rates without compromising neonatal outcome [Albrechtsen et

al., 1997]. Some studies grouped the deliveries according to the actual mode of delivery [Erkaya et al., 1997; de Leeuw et al., 1998], with the VD group thus consisting mostly of uncomplicated deliveries and the CD group probably including cases with less favorable prognosis. Studies with intention-to-treat analyses and liberal use of planned CD reported statistically significant differences in neonatal morbidity in favor of CD [Koo et al., 1998; Diro et al., 1999]. However, some regarded the neonatal risk as so small that VD could be attempted in selected cases [Diro et al., 1999] whereas others stressed the importance of individual assessment and shared decision-making [Koo et al., 1998].

Studies comparing actual VD to actual emergency and actual elective CDs found that VD was associated with increased neonatal mortality and morbidity compared to the elective CD group [Thorpe-Beeston et al., 1992; Krebs et al., 1995; Roman et al., 1998], although Lindqvist et al reported similar mortality but increased risk of a low Apgar score in a Swedish registry-based study of 6542 breech deliveries [Lindqvist et al., 1997]. Furthermore, Lee et al. analyzed a large birth registry cohort of 371 692 term and preterm breech deliveries from the United States, grouped according to actual mode of delivery, and observed a 1.6 – 3.0 –fold neonatal mortality in the VD group, depending on the weight category [Lee et al., 1998].

Several reports with reasonable study designs observed comparable outcomes between planned VD and planned CD, in addition to studies favoring elective CD. Hall and associates observed no difference in neonatal mortality between planned VD or planned CD groups in 1736 breech deliveries [Hall et al., 1993], and Danielian and associates studied the same population and reported that morbidity rates up to 4-5 years of age in infants did not differ between the mode of delivery [Danielian et al., 1996]. Likewise, Irion and associates concluded in their study of 705 deliveries that neonatal morbidity was similar in planned VD and planned CD and noted a significant increase in maternal infections after an elective CD [Irion et al., 1998]. Also, Roberts and associates demonstrated in their registry-based study of 16 562 breech deliveries that although the rate of elective CD in breech presentation increased from 49.1% in 1990 to 58.4% in 1997, perinatal mortality among all breech births was not decreased [Roberts et al., 2000].

4.2.4 The Term Breech Trial

As data from numerous retrospective studies were contrasting and the two randomized trials were underpowered to show differences in immediate neonatal outcomes between VD and CD, the demand for strong data remained. In 2000, Hannah and associates published The Term Breech Trial [Hannah et al., 2000], a multicenter, randomized, controlled trial that included 2088 women expecting a breech infant, from 26 countries in six continents. The results were clear: perinatal mortality and severe morbidity were threefold in the intended VD group compared to planned CD group. Furthermore, with a policy of routine CD, one infant in every 14 deliveries would avoid death or serious morbidity. Several subgroup analyses showed similar results regardless of the experience of the clinicians, presence of labor complications, or the study center's perinatal mortality rate. In accordance to these results, the authors proposed a policy of routine CD for the term breech fetus.

Although the Term Breech Trial was designed to end the debate over the optimal mode of delivery, and the results were certainly unambiguous, its implications were not universally accepted. Inclusion of 121 centers, which was necessary for gathering large enough a population, led to variable levels of patient care, and both the limits for "safe" VD set in the study and management protocols were seen as unsatisfactory compared to modern western care [Halmesmäki 2001; Hauth et al., 2002; Keirse 2002]. For example, obstetric ultrasound examinations were not consistently used, and fetal size and attitude of the head were only assessed clinically in more than 30% of the deliveries. Furthermore, continuous CTG was not mandated [Hannah et al., 2000]. In addition to the criticism towards the management of the deliveries, the applicability of an intention-to-treat randomized design to a relatively rare, delicate event was questioned [Kotaska 2004; Glezerman 2006]. Adherence to inclusion criteria was also questioned, as neonatal mortality cases included a twin and a stillborn cephalic infant who had probably died before enrolment [Hannah et al., 2000].

4.2.5 Breech delivery in the 21st century

Despite the passionate debate ignited by the Term Breech Trial, several national guidelines were updated, some recommending a policy of routine CD for all breech deliveries [ACOG 2002]. Consequently, rates of planned cesarean breech delivery continued to increase [Alexandersson et al., 2005; Sullivan et al., 2009]. Similarly, in the Netherlands the CD rate for term breech deliveries quickly rose from 50% to 80% following the publication of the Term Breech Trial, resulting in improved neonatal outcome [Rietberg et al., 2005]. Better neonatal outcomes were also demonstrated in a Danish cohort study that revealed an increase in planned CDs for the term breech fetuses from 55.5% to 73.0% and a decrease in intrapartum or early neonatal mortality from 0.13% to 0.05% [Hartnack Tharin et al., 2011]. Although the impact of the Term Breech Trial on clinical practice was evident, it was questioned whether an opposite conclusion would have had such a great effect, or was this merely an acceleration of a pre-existing trend [Lashen et al., 2002]. However, centers with a strong tradition of vaginal breech delivery continued to offer this option to women, criticizing the management of study deliveries in the Term Breech Trial. It was also contemplated whether the reduction in already very low perinatal mortality would justify the increased CD rates [Hartnack Tharin et al., 2011], as perinatal mortality rates were significantly lower in many centers compared to the Term Breech Trial. The dangers of a universal CD policy were demonstrated in anecdotal reports describing maternal death after a CD and neonatal death after an unattended home birth in a system that did not offer a trial of VD even in very favorable circumstances [Kotaska 2011].

Retrospective reports were published, again with conflicting findings. An Austrian study that included 699 breech deliveries concluded that in the study center, allowing a trial of VD did not increase neonatal mortality or morbidity compared to planned CD. The strength of this study was the extended follow-up of the infants (median age 57 months) as no difference in developmental delay was observed between the groups [Giuliani et al., 2002]. Similarly, a Swedish retrospective analysis of 711 breech deliveries with an infants' registry-based follow-up period of 1.5 – 11.5 years demonstrated comparable outcomes in

children born by either a planned CD or a trial of VD [Hellsten et al., 2003]. However, some new data from centers with high levels of care also supported the findings of the Term Breech Trial. Analysis of 1050 breech deliveries in a Swedish hospital showed a remarkably higher rate of short-term neurologic morbidity (3.4% *vs.* 0.3%) in children born after a trial of VD compared to those that were born by an elective CD [Herbst et al., 2001]. Table 2 shows the main features and conclusions of some retrospective studies after the Term Breech Trial with an intention-to-treat design.

Table 2. Main results of some retrospective, intention-to-treat studies comparing the intended mode of delivery in term or near-term breech presentation

Study	Breech deliveries GA at birth Study years	VD rate planned/actual	Neonatal morbidity	5 min Apgar score ≤ or <7 (pCD vs. pVD)	Maternal morbidity	Conclusion
Sanchez-Ramos et al., 2001, **USA**	n=848 ≥35 weeks 1986 - 1997	32.1% / 23.9%	No differences in admission to NICU or birth trauma	3.3% *vs* . 4.8%, *p* =NS	More common in pCD than in pVD	CD in selected cases associated with maternal morbidity without corresponding improvement in neonatal outcomes
Herbst et al., 2001, **Sweden**	n=1050 ≥37 weeks 1988 - 2000	66.6% / 57.4%	Referral to NICU, asphyxia and neurologic morbidity more common in pVD than in pCD	0% *vs.* 3.6%, *p* =0.0005		Neonatal morbidity may be reduced with pCD
Golfier et al., 2001, **France**	n=1116 ≥37 weeks 1991 - 1995	37.1% / 30.6%	Neurologic morbidity, birth trauma, referral to NICU more common in pVD than in pCD	0.7% *vs* . 2.2%, *p* =0.034	Only mild complications increased in pCD	pVD increases neonatal mortality and morbidity, elective CD should be preferred
Belfrage et al., 2002, **Norway**	n=575 ≥36 weeks 1996 – 2001	77.9% / 65.4%	Early neonatal morbidity and referral to NICU more common in pVD than in pCD	0.8% *vs.* 4.2%, *p* =0.043	2.4% after pCD and 5.1% after pVD, *p* =0.18	Elective CD reduces the risks for the fetus compared to pVD
Giuliani et al., 2002, **Austria**	n=699 ≥37 weeks 1993 - 1999	68.8% / 48.9%	No differences in early neonatal morbidity or in long-time morbidity (median follow-up 57 months)	0% *vs.* 0.6%, *p* =NS		Planned VD is an option

Kayem et al., 2002**, France**	n=501 ≥37 weeks 1993 - 1999	64.3% / 39.1%	No differences in neonatal mortality, severe morbidity or incidence of severe birth trauma	1.1% *vs* . 2.8%, *p* =NS		No excess mortality or morbidity observed in selected vaginal breech deliveries
Hellsten et al., 2003**, Sweden**	n=711 ≥37 weeks 1990 - 1999	62.6% / 52.2%	No differences in admission to NICU or long-term morbidity (registry-based follow-up to 1.5 – 11.5 years)	0.8% *vs* . 2.2%, *p* =NS	Postpartum anemia in 16% after pCD and in 11% after pVD, *p* =0.049	Selective vaginal breech delivery is not disqualified as an option
Sibony et al., 2003**, France**	n=610 ≥37 weeks 1992 - 1998	84.3% / 66.7%	No difference in neonatal morbidity or birth trauma	Not present in any group		Self-assessment by centers offering vaginal breech delivery is preferred
Alarab et al., 2004**, Ireland**	n=641 ≥37 weeks 1997 - 2000	46.5% / 22.8%	No mortality or severe neonatal morbidity in nonmalformed infants	0% *vs.* 0.7%, *p* =NS		Safe vaginal breech delivery can be achieved with strict selection criteria, intrapartum protocol and an experienced obstetrician
Ulander VM et al., 2004**, Finland**	n=2910 ≥37 weeks 1987 - 1989	43.6% / 38.7%	No difference in perinatal mortality, intracranial bleeding, convulsions, respiratory distress or gastrointestinal diseases. Increased rate of birth trauma after pVD compared to pCD. More outpatient department visits after pCD than after pVD to the age of 7 years	0.4% *vs.* 2.2%, *p* <0.001	No statistically significant differences in maternal mortality, thrombosis or need for interventions	Except for lower Apgar scores, planned vaginal breech delivery in selected cases is as safe as planned CD

Table continues on next page. GA, gestational age; min, minute; VD, vaginal delivery; pVD, planned vaginal delivery; pCD, planned cesarean delivery; CD, cesarean delivery, NICU, neonatal intensive care unit

Table 2 continues

Study	Breech deliveries GA at birth Study years	VD rate planned/actual	Neonatal morbidity	5 min Apgar score ≤ or <7 (pCD vs. pVD)	Maternal morbidity	Conclusion
Uotila et al., 2005, **Finland**	n=986 ≥37 weeks 1995 - 2002	59.8% / 46.1%	No difference in neonatal morbidity	0% *vs.* 2.0%, *p* =0.002		In selected cases, term breech birth can safely be managed vaginally, the risk for adverse outcome is small
Krupitz et al., 2005**, Austria**	n=882 ≥37 weeks 1993 - 2003	43.3% / 32.2%	No difference in neonatal morbidity	Not reported		Attempted vaginal breech delivery is justified
Goffinet et al., 2006**, France and Belgium**	n=8105 ≥37 weeks 2001 -2002	31.2% / 22.2%	No difference in neonatal morbidity or transfer to NICU. Birth trauma more common after pVD than after pCD	0.5% *vs* . 1.5%, *p* <0.001		Planned vaginal breech delivery can be offered to women after providing them with clear and complete information
Vistad et al., 2013**, Norway**	n=568 ≥37 weeks 2001 - 2011	50.9% / 32.6%	Admission to NICU more common after pVD than after pCD, no difference in birth trauma or long-term morbidity	0% *vs.* 2.4%, *p* <0.01	Mean blood loss higher after pCD than after pVD	Vaginal breech delivery is acceptable if selection guidelines are followed, fetal monitoring is of high quality, and the volume of breech deliveries is sufficient to maintain competence

Borbolla Foster et al., 2014, **Australia**	n=766 ≥37 weeks 1999 - 2010	31.7% / 19.1%	No difference in need for NICU or neonatal morbidity	1.9% *vs.* 4.9%, *p* =0.03	4.8% after pCD and 8.2% after pVD, *p* =0.06	Under strict obstetric protocols, attempted VD remains an option in selected cases
Mattila et al., 2015**, Finland**	n=1418 ≥37 weeks 2002 - 2012	28.6% / 23.8%	NICU admission more common after pVD than after pCD	1.0% *vs.* 6.0%, *p* <0.001	More puerperal infections after pCD than pVD	Planned VD results in short-lasting delayed recovery compared to planned CD, and based on current data VD is an option
Bin et al., 2016**, Australia**	n=5197 ≥37 weeks 2009 - 2012	6.8% / 4.2%	Severe neonatal morbidity, admission to NICU and birth trauma more common after pVD than after pCD	0.5% *vs* . 4.3%, *p* <0.001	Postpartum hemorrhage more common after pVD than after pCD	Planned CD is associated with lower risk of neonatal morbidity than planned VD in women who are classified as eligible for vaginal breech birth

GA, gestational age; min, minute; VD, vaginal delivery; pVD, planned vaginal delivery; pCD, planned cesarean delivery; CD, cesarean delivery; NICU, neonatal intensive care unit

The Term Breech Trial Collaborative Group published several follow-up studies on the original study participants [Hannah et al., 2002; Hannah et al., 2004; Hodnett et al., 2005]. In their follow-up of 923 children at the age of two years, no difference was observed in neurodevelopmental delay or death between groups of intended VD or planned CD, although the study was underpowered to detect small differences due to asphyxia [Whyte et al., 2004]. Citing this finding and retrospective studies from centers with strict selection criteria and management, the American College of Obstetricians and Gynecologists revised their guidelines, allowing a trial of VD in selected cases [ACOG 2006]. Some authors recommended basing management protocols on self-assessment reports in centers that were still practicing vaginal breech delivery [Koo et al., 1998; Sibony et al., 2003]. Vaginal breech delivery was not completely forgotten, as seen in a Canadian study that presented a low but increasing actual VD rate: 2.7% of breech deliveries in 2003 compared to 3.9% in 2011 [Lyons et al., 2015]. In Finland, vaginal breech delivery has accounted for 0.6–0.7% of all deliveries in 1987–2016 [Heino et al., 2017]. The study hospital has a strong tradition of vaginal breech delivery, and the proportion of vaginal brech deliveries has been 1.0–1.4% of all deliveries in 2007–2017.

4.3 Preterm breech delivery

The incidence of breech presentation is highest in very preterm deliveries (up to 33.3% in 21-24 weeks of gestation [Cunningham et al., 2010]) and decreases as gestational age increases. The body is proportionately smaller compared to the head in premature than in term fetuses, thus increasing the risk of head entrapment especially in VD. The risks of cord prolapse and birth trauma are also increased in preterm deliveries [Biswas et al., 2013]. However, the maternal risks of CD increase in very preterm CD [Reddy et al., 2015]. The mother is exposed to the risks of a CD, and the infant may still die due to complications of prematurity in a worst case scenario.

As is the case of term breech delivery, the optimal mode of delivery in preterm breech deliveries is controversial. Penn et al. planned a randomized study but

managed to recruit only 13 women from 26 hospitals in 17 months [Penn et al., 1996]. Due to lack of adequate sample size in randomized studies, the data are drawn from numerous retrospective reports, the largest being based on national cohorts. A Dutch study included 8356 preterm breech deliveries from 2000 – 2011 and observed decreased perinatal mortality with planned CD compared to intended VD in the subgroup of gestational age 28–32 weeks [Bergenhenegouwen et al., 2015]. Composite perinatal mortality and morbidity was more common in the intended VD group in the whole study population and also in gestational age subgroups of 26–28 weeks and 28–32 weeks. Similarly, a Swedish study demonstrated benefits from planned CD compared to a trial of labor in a study of 2674 preterm breech deliveries at 25–36+6 weeks of pregnancy, but the effect was not observed in subgroups of gestational ages 28–33 weeks or 34–36 weeks [Herbst et al., 2007]. Smaller observational studies have reported increased survival after a CD especially in smaller birthweight or gestational age cohorts [Lamont et al., 1983; Demol et al., 2000; Högberg et al., 2007; Mousiolis et al., 2012]. However, especially in centers with high CD rates for breech deliveries the selection bias may contribute significantly [Biswas et al., 2013], as in these studies the VDs may represent less well planned and more emergent events. Some studies have also reported equal mortality and morbidity rates regardless of mode of delivery [Wolf et al., 1999; Kayem et al., 2008; Kayem et al., 2015] .

4.4 External cephalic version

Manipulating the fetal position into cephalic presentation by applying pressure to the mother's abdomen is known as external cephalic version (ECV). This technique was known already in ancient Greece [Bradley-Watson 1975]. The procedure was used routinely in obstetric practice before the 1970's due to its apparent effectiveness in reducing breech presentation at delivery. However, it became less commonly used as the neonatal risks associated with the procedure were recognized [Bradley-Watson 1975] and approach to CD in general became increasingly liberal [Hofmeyr et al., 2015b]. Rising CD rates prompted research on ways to reduce primary CDs, and several randomized studies on ECV were published with favorable results. A Cochrane review concluded that attempting ECV at or near term may substantially reduce the chance of breech birth or CD

[Hofmeyr et al., 2015b]. A British study including 805 consecutive ECV attempts reported no neonatal mortality attributable to the ECV attempt, emergency CD after 0.5% and admission to hospital after 5% of the attempts [Collins et al., 2007]. Similarly, a meta-analysis comprising 12 955 ECVs reported two neonatal deaths attributable to the procedure and an emergency CD rate of 0.35% immediately after the procedure [Grootscholten et al., 2008]. Given the safety and efficacy of the ECV, several obstetrical societies encourage attempting it in suitable cases to increase chances of uncomplicated VD [ACOG 2016; The Royal Australian and New Zealand College of Obstetricians and Gynaecologists 2016; Impey et al., 2017].

4.5 Management of breech delivery

4.5.1 Decision on the mode of delivery

As several studies have demonstrated the protective effect of CD on the breech-presenting fetus, it is clear that not all mothers of breech-presenting infants are eligible candidates for VD. Thorough information on the current evidence on the mode of delivery worldwide as well as the data from the delivery hospital should be supplied to the parents to achieve an informed choice.

The mother's desire for a CD should be respected, but if she prefers VD, medical indications for CD should be carefully evaluated and informed consent acquired [Goffinet et al., 2006]. However, exact criteria for a trial of labor are not uniformly agreed. Estimation of fetal weight with ultrasonography is recommended and large infants are generally seen as unfit for a trial of labor, but authors disagree on the cut-off value of estimated fetal weight. Some recommend elective CD for infants weighing more than 3500g [Apuzzio et al., 2002]; others demonstrate good perinatal outcome with a cut-off estimated fetal weight of 4000g [Sanchez-Ramos et al., 2001; Uotila et al., 2005] or even 4500g in selected cases [Albrechtsen et al., 1997; Vistad et al., 2013; Kessler et al., 2015]. Many centers use X-ray or magnetic resonance pelvimetry in assessing the pelvic adequacy [Golfier et al., 2001; Herbst et al., 2001; Belfrage et al., 2002; Hellsten et al., 2003; Ulander VM et al., 2004; Uotila et al., 2005], which has been shown to reduce the number of emergency

CDs due to prolonged labor in women attempting vaginal breech delivery [van Loon et al., 1997; Fait et al., 1998]. However, several studies do not specify the minimum required measurements, and different centers even use different measurements [Golfier et al., 2001; Hellsten et al., 2003; Ulander VM et al., 2004]. A small obstetric conjugate was associated with an emergency CD in a study including 24 breech deliveries. The authors suggested a cutoff value of 11.4-11.7 cm [Joyce et al., 1975]. A recent German study demonstrated that the interspinous diameter is associated with the actual mode of delivery in primiparous women with obstetric conjugate >12 cm (a prerequisite for vaginal breech delivery in German guidelines). The authors encouraged allowing a trial of labor especially if the interspinous diameter is ≥11 cm [Hoffmann et al., 2016]. The pelvimetry measurements should not be used with millimeter specific limits, as the interobserver variability is remarkable even with magnetic resonance imaging. [Korhonen et al., 2010]

Footling presentation is associated with increased risk of cord prolapse [Cunningham et al., 2010]; thus, most centers allow a trial of labor only for frank, complete and incomplete breeches. Hyperextension of the fetal neck is a contraindication for a trial of labor and should be ruled out before attempting VD, as VD in these cases may result in neurological damage in up to 25% of cases [Weinstein et al., 1983].

Although spontaneous onset of labor is preferred and some guidelines advise against induction of labor [Kotaska et al., 2009], good results of induced vaginal breech deliveries have been presented [Nishijima et al., 1981; Rojansky et al., 2001; Macharey et al., 2016; Bleu et al., 2017; Jarniat et al., 2017]. Considering induction well before pregnancy reaches post-term has been suggested [Macharey et al., 2016], as breech-presenting fetuses inherently have higher risk of stillbirth, and the risk in all pregnancies increases as gestational age advances. Conversely, in a Spanish study labor was induced not until 41+5 gestational weeks in cases of prolonged pregnancy [Burgos et al., 2017].

Table 3 details the criteria used in the study hospital for attempting VD in breech presentation.

Table 3. Criteria for attempting vaginal breech delivery during the study period in Tampere University Hospital

No contraindications for VD	Regardless of fetal presentation; such as placenta previa or nonreassuring fetal status
Shared decision-making	After supplying thorough information to the parents, their choice on mode of delivery should be respected
Magnetic resonance imaging or X-ray pelvimetry	Conjugata vera ≥11.5 cm Interspinous diameter ≥10 cm Intertuberous diameter ≥10 cm Sagittal outlet diameter ≥10 cm Sum of interspinous, intertuberous and sagittal outlet diameters ≥32 cm
Ultrasound estimate of fetal weight	Less than 4000 g Intrauterine growth restriction or prematurity not absolute contraindications for a trial of labor, but elective CD performed more liberally
Presentation	Frank, complete or incomplete breech
Attitude of the fetal head	Flexed or neutral
Onset of labor	Induction of labor is allowed for standard obstetric indications Post-term pregnancy terminated at ≥41 gestational weeks

CD, cesarean delivery; VD, vaginal delivery

4.5.2 Intrapartum management

Continuous fetal heart rate monitoring is recommended throughout breech labor [White et al., 1984; Goffinet et al., 2006; Kotaska et al., 2009], as cord compression is common after the breech reaches the perineum, and this is better tolerated by a nonhypoxic fetus [Impey et al., 2017]. ST-segment analysis may be used as an adjunct to conventional CTG [Kessler et al., 2015]. In 1972, Eliot and Hill proposed that fetal pH should be measured every five minutes from the time the breech reaches the perineum until delivery to detect fetal distress [Eliot et al., 1972], and pH samples obtained from the fetal buttock have been shown to correlate to cord pH at delivery [Brady et al., 1989]. Despite the applicability of fetal pH sampling also in breech presentation, in modern obstetrics many caregivers choose to perform a CD instead if fetal distress is suspected. The threshold to convert a trial of VD to an emergency CD should indeed be kept low

to ensure the safety of the mother and the infant [Macharey et al., 2017c]. This caution is partly due to the increased neonatal morbidity inherent to breech presentation, and partly due to the more arduous delivery compared to cephalic presentation, necessitating good fetal resources during the last moments of the second stage of delivery. Contrary to cephalic deliveries, instrumental VD is not an option in case of acute fetal distress in late second stage of delivery.

Authors of retrospective studies with good outcomes disagree on the use of oxytocin to augment labor. Some avoid augmentation, and regard failure to progress an indication to CD [Alarab et al., 2004], whereas others have administered oxytocin in the case of lack of progress in the first stage if needed and systematically to all women at full dilatation [Kayem et al., 2002]. Similarly, the role of neuraxial analgesia is unclear [Impey et al., 2017], although two recent Finnish studies have reported increased risk of adverse neonatal outcome in deliveries with epidural anesthesia [Macharey et al., 2017b; Macharey et al., 2017c]. Due to increased risk of cord prolapse especially in nonfrank breech presentation or in deliveries of small fetuses [Cunningham et al., 2014], careful assessment of the presenting part should be carried out immediately after the rupture of membranes to rule out occult cord prolapse.

Contrary to cephalic delivery, in vaginal breech delivery the largest and least compressible fetal part passes the birth canal last, thus exposing the infant for a longer period of cord compression and resulting in asphyxia. Conversely, expediting delivery may increase birth trauma. Although a Cochrane review could not evaluate the effects of expediting the delivery due to a lack of trials [Hofmeyr et al., 2015a], spontaneous or assisted breech delivery is strongly preferred to breech extraction in several guidelines [Kotaska et al., 2009; Impey et al., 2017]. Little evidence exists regarding the techniques of assisting breech delivery [Impey et al., 2017], and the maneuvers still in use date back to the 1930's or even back several centuries [Louwen et al., 2017].

Episiotomy has been traditionally used liberally in managing vaginal breech delivery [Law 1955], but the recently updated British guidelines prefer selective rather than routine episiotomy also in breech presentation [Impey et al., 2017]. A French study

reported a decline in the episiotomy rate in vaginal breech delivery from 57% in 1994 to 28% in 2009-2010 [Lansac et al., 2015].

The birthing position in breech delivery has been traditionally limited to the semirecumbent position. However, reports that encourage upright or all-fours position have been published and show reduced need for interventions and fewer maternal injuries [Bogner et al., 2015; Louwen et al., 2017].

The study hospital assists the shoulders using the Løvset maneuver [Løvset 1937] or the classical method, and facilitates the delivery of the aftercoming head preferably with the Mauriceau maneuver. If difficulties in assisting the head are encountered, Piper forceps are today used, although they were not in use during the study period. Figures 2-4 demonstrate the maneuvers used in the study hospital. In addition, Table 4 details the intrapartum management protocol of the study hospital.

Figure 2. The Løvset technique for assisting the delivery of the shoulders. a. The fetus is grasped from the bony pelvis after the scapulae are delivered. b. The trunk is rotated and brought down so that the posterior shoulder (here the left shoulder) becomes anterior and c. appears under the pubic arch. The arm descends spontaneously or d. is brought out. The rotation is repeated to the other side (here counterclockwise) to free the other shoulder. Figure published with permission from the artist, Jani Ylönen.

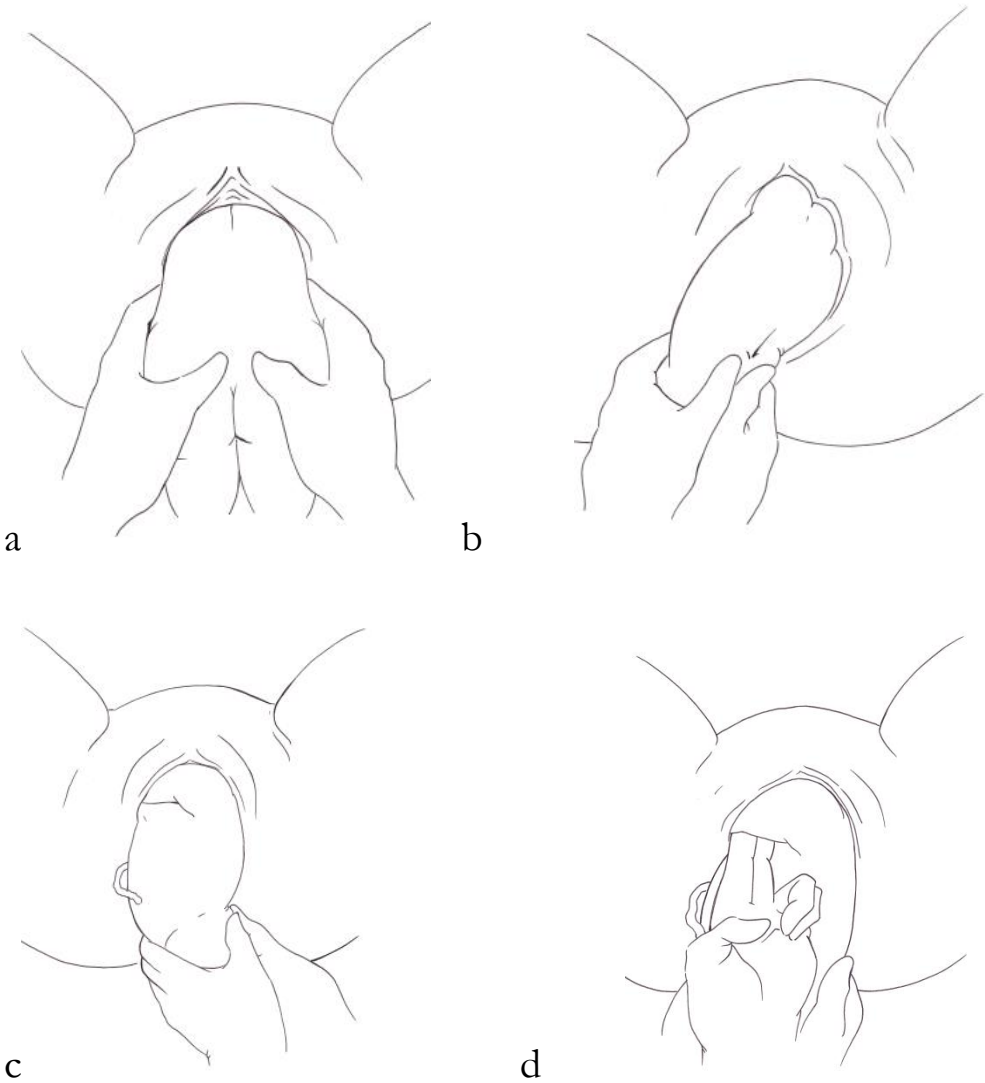


Figure 3. The classical method for assisting the delivery of the shoulders. The fetus is lifted in sagittal direction to deliver the posterior shoulder, then pulled gently down to deliver the anterior shoulder. Figure published with permission from the artist, Jani Ylönen.

Figure 4. The Mauriceau maneuver for assisting the delivery of the head. The infant rests on the operator's forearm, and the flexion of the neck is maintained by pressure on the fetal maxilla by the operator's fingers. Figure published with permission from the artist, Jani Ylönen

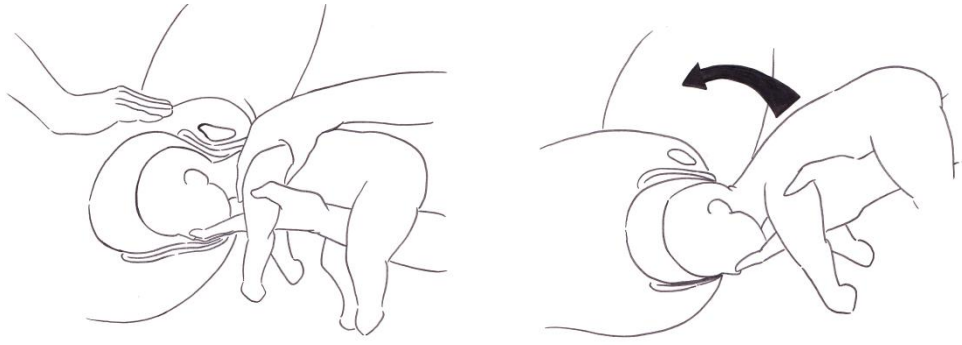


Table 4. Intrapartum management of attempted vaginal breech deliveries during the study period.

Electronic fetal monitoring	Continuous cardiotocography, preferably using an internal electrode after the rupture of membranes
	Monitoring of mother's heart rate if external electrode in use
Amniotomy	Performed if the signal quality of external fetal heart rate monitoring is inadequate
Oxytocin	Used with similar indications as in cephalic deliveries
Emergency CD	Performed liberally in cases of arrested labor or suspected fetal distress
	Available within 10 minutes
pH sampling	Not performed; if needed, CD performed
Maneuvers used	Løvset maneuver for the shoulders and Mauriceau maneuver for the head
	Classical maneuvers occasionally used
Birthing position	Semirecumbent position
Personnel	Midwives care for the family during first stage of labor
	Experienced obstetrician present at delivery
	Pediatrician present at delivery

CD, cesarean delivery

4.6 Cardiotocography

4.6.1 History of cardiotocography

Monitoring fetal heart rate and uterine contractions, known as cardiotocography (CTG), is a technique to confirm fetal well-being before and during labor. Fetal heart rate characteristics reflect the fetal central nervous system's outflow, and the technique aims to detect intrapartum central hypoxia to allow intervention before permanent neurological damage occurs. The method was introduced in the late 1960's and is very widely used in modern obstetrics [Stout et al., 2011]. Although the efficacy of continuous fetal heart rate monitoring compared to intermittent auscultation in preventing fetal death is subject to debate [Vintzileos et al., 1995; Alfirevic et al., 2013; Ananth et al., 2013], it is recommended during labor of mothers with high-risk conditions as well as during breech labor [FIGO 1987; Royal College of Obstetricians and Gynecologists 2001; ACOG 2009].

4.6.2 Interpretation of the cardiotocograph

The association between fetal heart rate patterns and fetal compromise were identified by early research, but despite numerous publications on the topic, a consensus has not formed on exact definitions. Research has been impeded by the varying definitions and interpretations of the patterns [National Institute of Child Health and Human Development Research Planning Workshop 1997]. The difficulty of interpretation in clinical use also prompted the development of international guidelines for the use of electronic fetal monitoring, including definitions of various patterns [National Institute of Child Health and Human Development Research Planning Workshop 1997] and often also an overall rating system [FIGO 1987; ACOG 2009; Ayres-de-Campos 2015]. Although the rating systems differ, definitions of various patterns are relatively similar in most publications.

4.6.2.1 Cardiotocography classification

With the exception of late and prolonged decelerations and absent variability [Low et al., 1999], few fetal heart rate patterns are indicative of fetal distress on their own. On the contrary, a tracing with normal baseline and baseline variability, accelerations, and no decelerations excludes fetal distress quite reliably [Williams et al., 2003]. The problem lies between these extremes, as most tracings display some suspicious features, most of which do not require intervention, but some of which signal fetal compromise. Different classification systems have been developed to improve and standardize the clinical use of CTG [Parer et al., 2007; ACOG 2010; National Institute for Health and Care Excellence 2014]. The three-tier system, presented by the International Federation of Obstetrics and Gynaecology in 1987 [FIGO 1987] is probably the most widely accepted consensus that has yet been reached [Ayres-de-Campos et al., 1999; Ayres-de-Campos et al., 2011]. According to the FIGO classification, CTG tracings are classified as normal, suspicious or pathological according to the absence or presence of several trace patterns. Table 5 shows the details of the classification.

Table 5. Classification of cardiotocography tracings according to FIGO 1987 guidelines [FIGO 1987; Amer-Wahlin et al., 2007].

Classification	Basal heart rate (bpm)	Baseline variability (bpm)	Decelerations
Normal	110-150	5 – 25 Accelerations	Early uniform decelerations Variable decelerations (duration <60 seconds and depth of <60 bpm)
Suspicious	100-110 150-170	<5 >25	Variable decelerations (duration <60 seconds and depth of <60 bpm)
Pathological	>170 <100 for >3 minutes	<5 for >60 minutes Sinusoidal pattern	Complicated variable decelerations (duration >60 seconds or depth >60 bpm) Late uniform decelerations

bpm, beats per minute

FIGO did not provide detailed instructions on appropriate management of different trace classes, but advised that fetal scalp blood sampling should be carried out if suspicious or pathological patterns were noted and the clinical situation did not necessitate immediate delivery. Novel techniques such as fetal ST-segment analysis were introduced to reduce unnecessary interventions caused by the low specificity of fetal heart rate abnormalities [Melin et al., 2008].

FIGO updated the guidelines in October 2015, stressing the repetitiveness of the decelerations and including increased variability (more than 25 bpm) in the pathological class. Table 6 shows the 2015 guidelines.

Table 6. Classification of cardiotocography tracings according to FIGO 2015 [Ayres-de-Campos 2015]

Classification	Basal heart rate (bpm)	Baseline variability (bpm)	Decelerations
Normal	110 – 160	5 – 25	No repetitive* decelerations
Suspicious	No pathological features, but lacking at least one characteristic of normality		
Pathological	<100	<5 for more than 50 min in baseline segments, or more than 3 min during decelerations >25 for more than 30 min Sinusoidal pattern	Repetitive* late or prolonged decelerations for >30min or >20min if variability is reduced Prolonged deceleration >5 min

bpm, beats per minute; min, minute
*Decelerations are considered repetitive when associated with more than 50% of uterine contractions.

4.6.3 Cardiotocography in vaginal breech delivery

As soon as cardiotocography was introduced, researchers were keen to find out the effect of fetal position on the heart rate patterns. Wheeler and Greene reviewed the CTG traces of first stages of labor in 42 accomplished vaginal breech deliveries bertween 1971 and 1973 [Wheeler et al., 1975]. They reported that all of the 15 infants who were in poor condition at birth had displayed abnormal fetal heart rate patterns, most exhibiting more than one abnormality. The most common abnormality was a combination of baseline tachycardia, decelerations and loss of variability. The authors contemplated the management of abnormal patterns in vaginal breech delivery and proposed combining fetal heart rate tracing and fetal pH measuring.

White and Cibils studied the CTG traces of 302 breech-presenting fetuses weighing over 500 g from 1971 to 1980, with a CD rate of 31% [White et al., 1984]. The traces represented the antepartum or first stage of labor, as they were recorded prior to complete dilation or CD. The authors noted that only 33% of the traces did not display decelerations. They compared cases that displayed variable (40%)

and variable with a late component (23%) decelerations to those who displayed early (3%) or no decelerations. The group displaying variable decelerations had significantly higher neonatal mortality and morbidity rates. In contrast, if uterine contractions triggered accelerations, neonatal mortality and morbidity were significantly lower. The high frequency of variable decelerations was attributed to cord compression, and as further compression is inevitable during the second stage of labor, the authors recommended continuous CTG for all vaginal breech deliveries to allow expediting the delivery in the case of impending fetal deterioration. Similarly, Ohel and associates investigated the CTG traces of 35 term breech fetuses from the second stage of labor and described variable decelerations in 77% of cases [Ohel et al., 1988].

The umbilical cord was observed to be shorter in breech compared to vertex fetuses in a Turkish report investigating 201 breech and 149 cephalic pregnancies of at least 36 weeks of gestation [Talas et al., 2008]. The authors also reported that 70.6% of the breech fetuses displayed decreased variability in their antepartum CTG traces, compared to 21.5% of the cephalic fetuses, and that these breech fetuses had even shorter cords than breech fetuses displaying normal variability. Nishijima and associates studied the CTG traces from the first stage of 48 breech and 26 cephalic deliveries with induced labor. They observed reduced variability especially during late first stage of labor in primiparous breech compared to primiparous cephalic deliveries (normal variability in 7.8% of breech deliveries *vs.* 20.8% of cephalic deliveries). The rate of variable or late decelerations was similar between breech and cephalic deliveries. The very low prevalence of normal variability may be associated with the use of diazepam and pentazocine for analgesia. Furthermore, the study group did not detail their definition of normal variability [Nishijima et al., 1981].

Fetal ST-waveform analysis has also been used in breech deliveries, although evidence supporting this is sparse, because most studies on ST-analysis excluded breech presentations. Kessler and associates analyzed 433 breech and 5577 vertex deliveries that were monitored with continuous CTG and ST-segment analysis. They concluded that the method is feasible during vaginal breech delivery, although interventions were more often triggered by preterminal trace than ST-

segment changes in breech compared to vertex deliveries [Kessler et al., 2015]. ST-signal loss was more common in breech than in cephalic deliveries, but further research on the same population revealed that erroneous ST events were as common in breech and in cephalic deliveries [Sletten et al., 2015].

In conclusion, several authors have observed decreased variability and abnormal decelerations in breech deliveries [Wheeler et al., 1975; Nishijima et al., 1981; White et al., 1984; Ohel et al., 1988; Talas et al., 2008]. However, most studies are conducted several decades ago, and the validity of the results is hampered by varying definitions. Furthermore, data comparing traces from breech and cephalic deliveries is sparse, especially regarding the second stage of delivery.

4.7 The birthing experience

Childbirth experience may have profound consequences for the mother's health [Ballard et al., 1995; Ford et al., 2009]; thus, it also affects maternal-infant bonding. A negative delivery experience is associated with lower sexual satisfaction after delivery [Handelzalts et al., 2018]. Furthermore, a positive experience can produce lasting feeling of empowerment, whereas a negative experience is associated with anger and a negative self-image [Simkin 1991]. Creating a positive childbirth experience allows the delivery room staff to enhance early parenting self-efficacy [Bryanton et al., 2008]. The perceptions of the delivery experience have been shown to endure for more than a decade [Bossano et al., 2017]. A study observing the delivery experiences of 20 women initially after delivery and 15-20 years later showed that a negative delivery experience may become even more negative over time, but it never becomes more positive [Simkin 1992].

Several instruments have been developed for assessing the delivery experience [Nilver et al., 2017]. Some are targeted to ensure the quality of maternity care and include maternal experiences of antepartum, intrapartum and postpartum care [Dzakpasu et al., 2008; Scheerhagen et al., 2015], while others focus on maternal experience after either VD or CD [Morgan et al., 1999; Gungor et al., 2012]. Many questionnaires that primarily assess the delivery experience, not on a prespecified

mode of delivery, focus on isolated aspects of the experience, such as fear of childbirth [Wijma et al., 1998] or satisfaction for the care of labor [Smith 2001].

The management of vaginal breech delivery differs significantly from that of a cephalic delivery, not least because the mother's own choice of delivery method is more pronounced in breech than cephalic deliveries. Also, birthing position has traditionally been limited, episiotomy recommended, and an obstetrician instead of a midwife delivers the fetus. Unplanned medical interventions, such as converting a planned VD to an emergency CD, are also more common in breech compared to cephalic deliveries [Ulander et al., 2004]. They have been demonstrated to be related to maternal dissatisfaction [Dencker et al., 2010]. These differences in management of deliveries may cause differences in birthing experiences of mothers delivering breech or cephalic infants.

The decision-making process regarding the mode of delivery is difficult and may warrant additional support, as described in a qualitative study of 12 French women [Guittier et al., 2011]. Various difficulties were noted in an Australian study of 22 women planning a vaginal breech delivery, as vaginal breech delivery is not widely offered in their country. The women felt a loss of choice (of mode and place of birth and caregivers) and even that they had to fight the system that offered only CD [Homer et al., 2015]. Similar results were observed in a study comprising 204 mothers choosing a vaginal breech delivery, primarily from English-speaking countries [Petrovska et al., 2017b]. General attitudes towards breech delivery may be negative, as in another study on the same population, less than half of women felt supported by their family and friends, and just over a half felt supported by their caregiver [Petrovska et al., 2016].

Few studies exist on breech childbirth experience, and none of them compare it with a cephalic delivery experience. Hannah and associates assessed the childbirth experience of 1596 women who had participated in the Term Breech Trial using their own questionnaire inquiring women's likes and dislikes in relation to their childbirth experience [Hannah et al., 2002]. Women were contacted three months after the delivery, and 41.9% in the planned CD group and 40.7% in the VD group reported disliking nothing about the childbirth experience, whereas 4.6% in both groups reported liking nothing about the childbirth experience [Hannah et al.,

2002]. Molkenboer and associates used the same questionnaire to evaluate 183 mothers who had given birth to an infant in breech presentation at the same time but who were not participating in the study. The management protocol preferred vaginal breech delivery, and this was the planned method for 140 women. Fewer women in the planned VD group reported disliking nothing about the delivery experience than in the planned CD group (14.3% *vs.* 20.9%) although the difference was not statistically significant [Molkenboer et al., 2008]. Founds observed nine women in rural Jamaica, a very different setting with limited access to external cephalic version or CD. She described women reporting feelings of satisfaction after a quick VD, but also women who considered never having another pregnancy due to a negative experience with pregnancy and delivery [Founds 2007]. Petrovska and associates studied women planning a vaginal breech delivery in an environment favoring elective CD and reported that 89.4% would attempt a vaginal breech delivery in subsequent pregnancy [Petrovska et al., 2016]. Their population comprised highly motivated mothers, as they had to actively seek an expert willing to assist in a vaginal breech delivery. Some of these women highlighted the importance of an opportunity to try a vaginal breech delivery, regardless of the actual mode of delivery [Petrovska et al., 2017b].

5 AIMS OF THE STUDY

The goals of this study were: (1) to assess the neonatal and maternal outcomes in term and in moderately and late preterm breech deliveries and compare them to cephalic deliveries and (2) to evaluate the birthing experiences and cardiotocography tracings in term breech and cephalic deliveries. Specific aims were:

1. To compare neonatal and maternal outcome between planned vaginal and planned cesarean delivery with fetus in breech presentation at term, and to compare the outcomes of intended vaginal breech deliveries to that of intended vaginal cephalic deliveries (Study I)

2. To compare the neonatal and maternal outcomes of moderately and late preterm breech deliveries that were allowed a trial of labor to preterm breech planned cesarean deliveries and to compare the neonatal and maternal outcomes of the breech deliveries with trial of labor to cephalic preterm deliveries (Study II)

3. To compare the delivery experience of mothers who had planned vaginal breech deliveries to that of mothers who had planned vaginal cephalic deliveries (Study III)

4. To evaluate the differences in cardiotocography tracings obtained from intended vaginal breech deliveries and intended vaginal cephalic deliveries (Study IV)

6 SUBJECTS AND METHODS

6.1 Subjects

All study subjects had given birth to a live singleton infant in Tampere University Hospital. As Study I was entirely registry-based, permission was obtained from the Science Center of Pirkanmaa Hospital District, which in turn has been licensed to grant permissions for registry-based studies by the local ethical committee. Permission to conduct the entirety of studies II-IV was obtained from the Ethical Committee of Pirkanmaa Hospital District (permission R12236, 13th November 2012), because Study III required contacting the women included in the study.

Total study population included 1010 women who had given birth to a breech infant in Tampere University Hospital between 2003 and 2015, and 440 control women who had delivered a cephalic infant. All studies were of retrospective design.

Study I included all women expecting a term breech infant from January 2004 to January 2009 (n=768). A cephalic control was selected for every planned vaginal breech delivery. Nineteen congenitally ill children were excluded, 12 in the planned CD group, 5 in the planned VD group, and 2 in the cephalic control group. This resulted in 254 planned VDs, 497 planned CDs, and 257 cephalic deliveries.

In Study II, all preterm (<37 weeks of gestation) breech deliveries with 32 completed gestational weeks from April 2003 to December 2015 (n=272) were evaluated for inclusion retrospectively. Iatrogenic deliveries (n=76), severely malformed infants (n=4) and fetuses with marked antepartum distress (n=16) were excluded to avoid confounding and to focus on the effect of the mode of delivery on the neonatal outcome. A cephalic control was selected for every breech infant with a trial of labor (n=103). The controls were matched by gestational age at delivery (±5 days) and whether or not the mother had previously given birth vaginally. The intended CD group comprised 73 deliveries after exclusions.

Study III included all women planning a vaginal breech delivery at term from January 2008 to October 2012. Cephalic control delivery was selected for each breech delivery, matched by the actual mode of delivery (spontaneous vaginal or emergency CD) and whether or not they had previously given birth vaginally. Those who had given birth again after the study delivery were excluded, as a more recent delivery experience could have affected the perception of the study delivery. One hundred fifty-four mothers expecting a breech infant and 154 expecting a cephalic infant received the Childbirth Experience Questionnaire, and 97 (63%) in the breech group and 73 (47%) in the cephalic group returned it.

Study IV included those planned term vaginal breech deliveries from January 2007 to April 2009 from which a CTG trace of adequate quality could be obtained (n=108). The control group comprised intended vaginal cephalic deliveries from the same time period, matched by actual mode of delivery (spontaneous or operative, the latter including vacuum extractions and emergency CDs).

Table 7 details the number of deliveries and the proportions of planned and actual vaginal breech deliveries in Studies I-IV.

Table 7. Characteristics of deliveries in Studies I-IV.

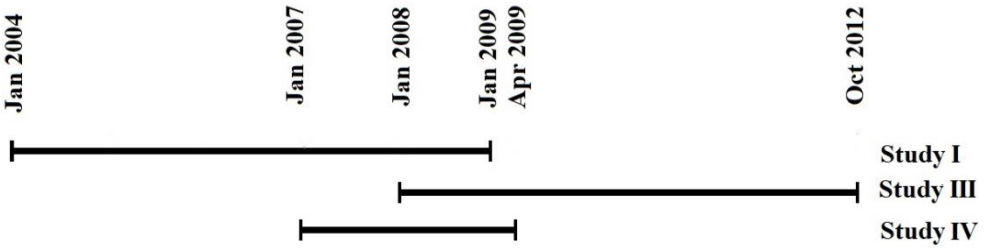
	Study I	Study II	Study III	Study IV
Number of breech deliveries	751	176	97	108
Planned vaginal breech deliveries (%)	33.8	58.5	100	100
Accomplished vaginal breech deliveries (%)	24.6	52.3	78.4	77.8
Number of cephalic controls	257	103	73	108
Controls matched by	Not matched	Gestational age at birth Previous VD (yes/no)	Actual mode of delivery Previous VD (yes/no)	Actual mode of delivery

VD, vaginal delivery

Some deliveries were included in more than one study, because all term breech deliveries of each study period were evaluated for inclusion in Studies I, III and IV, and the study periods overlapped. Sixteen breech deliveries met the inclusion criteria for all studies, 102 for studies I and IV, and three breech deliveries were included in Studies III and IV. Figure 5 shows the timing of the study periods in

studies including term deliveries. Study II included all spontaneously onset preterm breech deliveries of at least 32 gestational weeks during April 2003 – December 2015.

Figure 5. Study periods of Studies I, III and IV.



6.2 Methods

6.2.1 Management of deliveries during the study period

6.2.1.1 Setting

The study hospital is a tertiary center receiving not only all deliveries from nearby communities but also high-risk deliveries from surrounding secondary centers. Care was provided for 5000 – 5500 deliveries annually during the study period, and the overall CD rate was 15.6 – 18.1%. Anesthesiologist and pediatric services are continuously available, and an emergency CD can be performed within 10 minutes in very urgent situations.

6.2.1.2 Management of breech deliveries

During the study period (2003 – 2015), women expecting a fetus with persisting breech presentation at term were offered external cephalic version in the absence of contraindications, and about 40% of attempts were successful. If the version

was unsuccessful or the infant returned to breech, mothers were informed of attempted vaginal and elective CD options and allowed to choose between the two. Table 3 on page 44 details the criteria for a trial of labor in the study hospital. Trial of labor was allowed after one CD, but not if the mother had had two or more previous CDs. If VD was contraindicated regardless of fetal presentation (such as in women with placenta previa, or in conditions necessitating immediate delivery, for example in threatening eclampsia or fulminant chorioamnionitis), the external version was not offered and a CD was performed.

Continuous CTG was used during labor, with scalp electrodes applied to the fetal buttocks preferably after spontaneous rupture of the membranes or if signal quality was inadequate by external electrode. In the case of suspected fetal distress, pH sampling was not utilized; instead, an emergency CD was performed liberally. Oxytocin was used to enhance poor progress of labor. Midwives cared for the family before and after delivery, but the second stage of labor was managed by an obstetrician or an experienced resident. Løvset maneuver was used to assist the delivery of the shoulders, and the aftercoming head was usually delivered by Mauriceau maneuver. Breech extraction was not performed. During the study period, forceps were not used for the delivery of the aftercoming head, although more recently their use has become an option if traditional methods fail. The physician in charge dictated a short report of the delivery, and this report was used in assessing whether the delivery of the aftercoming head was difficult or not.

6.2.1.3 Management of preterm deliveries with spontaneous onset of labor after 32 completed gestational weeks

Corticosteroids were used to accelerate lung maturation when threatening premature labor was established before 35+0 gestational weeks. Tocolytic agents were administered in an attempt to delay the delivery until 35+0 gestational weeks if delivery was not warranted by maternal or fetal complications. Cephalic preterm deliveries were managed by midwives, unless obstetrician intervention was needed in the case of complications other than prematurity.

6.2.2 Neonatal morbidity

Studies I-IV assessed any illness or additional need for monitoring, as well as birth trauma (excluding bruises and small lacerations). Apgar score was assessed for every infant, and umbilical artery pH values were available for more than 90% of the infants. Studies I, III and IV included only term deliveries, and in these studies, neonatal morbidity was assessed according to the Term Breech Trial's criteria (shown in Table 8). Furthermore, the frequency of perinatal infections (elevation of biochemical markers or clinical impression of infection leading to treatment with antibiotics) was assessed. In Study II, which included only preterm deliveries, the rate of neonatal infections with a positive blood culture was evaluated due to the lower threshold of antibiotics use according to clinical judgment among preterm infants. In Studies I-IV, hyperbilirubinemia necessitating phototherapy and hypoglycemia warranting additional care were assessed. Studies I and II evaluated the rate of respiratory morbidity (respiratory problems warranting additional care or monitoring, ranging from transient tachypnea to intubation and ventilation). In Study IV, neonatal acidemia was defined as umbilical artery pH≤7.10 due to infrequency of more severe acidemia and high base deficit.

Table 8. Severe neonatal morbidity according to the Term Breech Trial [Hannah et al., 2000]*

Apgar score	<4 at the age of five minutes
Metabolic acidosis	Umbilical artery base deficit >15 mmol/L
Need for intensive care	Intubation and ventilation for ≥24 hours
	Tube feeding for ≥4 days
	Admission to NICU ≥4 days
Severe birth trauma	Intraventricular or intracerebral hemorrhage
	Subdural hematoma
	Spinal cord injury
	Basal skull fracture
	Fracture of long bone or clavicle
	Peripheral nerve injury present at hospital discharge
	Clinically significant genital trauma
Neurologic damage	Seizures
	Hypotonia for ≥2 hours
	Stupor or coma
	Decreased response to pain

NICU, neonatal intensive care unit

*Infants were considered to suffer from serious morbidity when one or more criteria listed in the table were fulfilled

Logistic regression analysis was performed in Study II to discover risk factors for the need for neonatal intensive care. The association of neonatal intensive care unit (NICU) admission with gestational age, being allowed a trial of labor and being small for gestational age (birthweight smaller than 2 standard deviations according to the Finnish growth charts [Dunkel et al., 2011]) was examined. Furthermore, the association of maternal illnesses, such as diabetes or hypertensive disorders, with NICU admission was assessed.

6.2.3 Measuring the delivery experience

Eligible women were mailed an introduction letter, consent to participate, and The Childbirth Experience Questionnaire (CEQ) in Study III. The questionnaires were sent to mothers during the first months of 2013. Mothers in the study population had given birth to a term breech infant in 2008-2012; thus, some received the questionnaire five years after the delivery.

The CEQ was developed in Sweden and the Swedish version has been validated in 920 primiparous women [Dencker et al., 2010]. The questionnaire was translated into Finnish by two independent professional translators and then back-translated into Swedish to ensure an accurate translation. The questionnaire's original creator approved the Finnish translation. The CEQ comprises 19 items that are answered on a 4-point Likert scale (respondent must choose from a. Totally agree, b. Mostly agree, c. Mostly disagree and d. Totally disagree) and three on a VAS scale (respondent places a mark on a 100 millimeter line, and the response is interpreted according to the distance in millimeters from the beginning of the line). The items represent four domains during childbirth: the mother's own capacity (perceived self-efficacy, personal control, and coping), professional support, perceived safety and participation. Table 9 details the domains and their items. Items are given points from 1 to 4, and the domain score is calculated as the mean of the domain's item scores. A higher score indicates a more favorable experience.

Table 9. Four domains and 22 items of the Childbirth Experience Questionnaire.

Own capacity	**Perceived safety**
Labor and birth went as I expected.	I felt scared during labor and birth.
I felt strong during labor and birth.	I have many positive memories from birth.
I felt capable during labor and birth.	I have many negative memories from birth.
I was tired during labor and birth.	Some of my memories from childbirth make me feel depressed.
I felt happy during labor and birth.	My impression of the team's medical skills made me feel secure.
I felt that I handled the situation well.	As a whole, how secure did you feel during childbirth?**
As a whole, how painful did you feel childbirth was?**	
As a whole, how much control did you feel you had during childbirth?**	
Professional support	**Participation**
My midwife devoted enough time to me.	I felt I could have a say whether I could be up and about or lie down.
My midwife devoted enough time to my partner.	I felt I could have a say in deciding my birthing position.
My midwife kept me informed about what was happening during labor and birth.	I felt I could have a say in the choice of pain relief.
My midwife understood my needs.	
I felt very well cared for by my midwife.	

**The item is answered on a VAS scale

The delivery experience was defined as negative if all four domain scores of the response were in the lowest quartile, in order to investigate risk factors for a negative experience. Association of the following factors with a negative childbirth experience was tested using binary forward logistic regression: breech presentation, primiparity, delivery ending in a CD, infant birth trauma, total duration of the delivery, duration of the second stage of labor, hospital stay before or after delivery, maternal complications, maternal infections, severe maternal bleeding or need for transfusions, neonatal morbidity, and undiagnosed breech presentation at labor.

6.2.4 Recording and interpreting the cardiotocography traces

CTG trace was recorded by an external Doppler electrode until spontaneous rupture of the membranes occurred, according to management guidelines. The use of an external electrode was continued after the membranes ruptured if the signal quality was good, but most often a scalp electrode was applied to the fetal buttock to achieve optimal signal. The tracings were interpreted independently by two senior obstetricians, blinded to fetal presentation, actual mode of delivery and neonatal outcome. Only 60 minutes immediately preceding delivery were interpreted; thus, the traces represented mostly the second stage or the late first stage of labor. Trace features were evaluated according to FIGO 1987 guidelines [FIGO 1987], and the obstetricians provided their estimate on the baseline variability, occurrence of accelerations, and presence and type of decelerations, as well as the number of uterine contractions per 10 minutes. The last 10 minutes of trace were not included in the classification unless severe bradycardia occurred, as profound fetal heart rate changes are almost always observed before delivery. This dissertation chose the 1987 classification to interpret the CTG traces, because the 2015 classification was not published at the time of conducting the study on CTG traces. The obstetricians evaluated traces together in order to establish a consensual estimate after providing their individual interpretations; that estimate was used to compare traces between breech and cephalic deliveries. Incidences of individual trace features as well as frequencies of overall trace classification were compared between breech and cephalic deliveries.

The concept of adverse neonatal outcome was defined as umbilical artery pH of $\leq$7.10 or a five-minute Apgar score <7 to determine whether or not certain trace features predicted adverse neonatal outcome. Binary logistic regression analysis was used to test the association of adverse neonatal outcome with overall trace classification and the following features: absence of accelerations, presence of late decelerations, complicated variable decelerations and decreased baseline variability. Furthermore, the association of breech presentation, oxytocin augmentation and uterine tachysystole (more than five contractions in a ten-minute period) with adverse neonatal outcome was studied.

6.2.5 Statistical methods

Statistical analyses were performed using SPSS for Windows. Version 14.0 (SPSS Inc., Chicago, IL, USA) was used in Study I, version 21.0 (IBM Corp., Armonk, NY, USA) in Studies III and IV and version 22.0 (IBM Corp., Armonk, NY, USA) in Study II. The results of categorical values were described as frequencies and percentages in Studies I-IV, and chi-square and Fisher's exact test were used in comparisons between the groups. Quantitative data were expressed as medians with minimum and maximum values in Studies I and II, and means and ranges were used in Studies III and IV. Accordingly, the Mann-Whitney U-test was used in Studies I and II and Student's T-test in Studies III and IV to compare means. All *p*-values are two-tailed, and a *p*-value of <0.05 was considered statistically significant. Forward binary logistic regression was performed in Studies II - IV and the results were presented as odds ratios (OR) and their 95% confidence intervals (CI).

Studies I and II made comparisons between both the planned vaginal breech and the planned cesarean breech delivery groups and the planned vaginal breech and cephalic control groups. Studies III and IV compared the planned vaginal breech group to the planned vaginal cephalic delivery control group. Subgroup analyses were made in two cohorts according to gestational age in Study II, in addition to the main analyses that included all preterm deliveries. Logistic regression analysis included all preterm breech deliveries in Study II. Logistic regression analyses included all study deliveries, regardless of fetal presentation, in Studies III and IV.

7 RESULTS

7.1 Term breech delivery by mode of delivery and compared to cephalic controls (I)

Of the 751 eligible women who had delivered a breech infant, 254 (33.8%) had planned VDs and 497 (66.2%) had planned CDs. The study population also included a control group comprising 257 women who had delivered a cephalic infant. Vaginal delivery was accomplished in 174 (68.5%) of the planned breech VDs. Additionally, 11 women (2.2%) in the planned CD group actually delivered vaginally; thus, the overall actual vaginal breech delivery rate was 24.6%. In the cephalic control group, 219 infants (85.2%) were delivered spontaneously, 25 were delivered vaginally with vacuum extraction and 13 deliveries ended in an emergency CD. The mode of delivery was thus significantly more often converted from the original plan in the planned breech VD group compared to both other groups.

Women expecting a breech infant were significantly more often primiparous than women expecting a cephalic infant. They also had uterine or genital anomalies significantly more compared to women with the fetus in cephalic presentation. Breech presentation was diagnosed during labor more often among women in the planned VD group than among women in the planned CD group, but external cephalic version had been attempted as often in both groups. Mothers in the planned VD group had chronic illnesses less often compared to mothers in the planned CD group. However, despite the higher rate of chronic maternal morbidity in the CD group, the most common indication for a planned CD was maternal request for a CD or fear of VD (the only indication in 53.3% of the planned CDs). The gestational age at birth was higher in the planned VD group compared to the planned CD group and even higher in the cephalic group. Table 10 details the women included in Study I.

Table 10. Details of women in Study I. All women delivered at term.

	Breech			Cephalic	
	Planned VD (1) n=254	Planned CD (2) n=497	*p* value 1 *vs.* 2	Planned VD (3) n=257	*p* value 1 *vs.* 3
Primiparous (%)	66.1	69.6	0.33	43.2	<0.001
Any chronic illness (%)	11.8	22.5	<0.001	10.1	0.54
Uterine or genital anomalies (%)	2.4	4.0	0.24	0	0.013
Attempted cephalic version (%)	47.2	43.5	0.32		
Induction of labor (%)	20.5	0	<0.001	17.5	0.393
The breech presentation was not diagnosed before labor (%)	16.9	5.8	<0.001		
The mode of delivery was not the planned one (%)	31.5	20.7	0.001	14.8	<0.001
- Emergency CD (%)	25.2	18.5	0.033	5.1	<0.001
Gestational age at delivery (weeks+days, median)	39+6	39+1	<0.001	40+1	0.004

VD, vaginal delivery; CD, cesarean delivery. *p* values of categorical variables were calculated using χ^2 test. Medians were compared using Mann-Whitney U test.

7.1.1 Neonatal outcome (I)

None of the infants died in the study population. At the age of one minute, infants in the planned VD group displayed a low Apgar score (<7) more often compared to infants both in the planned CD group and cephalic controls. Median umbilical artery pH value of neonates in the planned VD group was lower than median pH value of neonates in the planned CD group (7.28 *vs.* 7.32, $p<0.001$, and 7.29 in the cephalic group), and the incidence of acidotic cord pH (<7.00) was higher in the planned VD group compared to the planned CD group. However, no statistically significant differences were observed between the groups in Apgar scores at the age of five minutes, in the rates of NICU admission or in the incidence of severe morbidity. Table 11 describes the details of neonatal outcomes. Perinatal infections were observed more often in the planned VD group compared to the planned CD

group (4.3% *vs.* 1.2%, p=0.006), but there was no difference between the planned VD and cephalic control group (4.3% *vs.* 3.9%).

Table 11. Neonatal outcome in term breech deliveries by mode of delivery and compared to cephalic controls.

	Breech					Cephalic		
	Planned VD (1) n = 254		Planned CD (2) n=497		*p* value 1 *vs.* 2	Planned VD (3) n=257		*p* value 1 *vs.* 3
	n	%	n	%		n	%	
1 min Apgar score					<0.001			<0.001
- ≥7	193	76.0	459	92.4		246	95.7	
- 4-6	46	18.1	30	6.0		5	1.9	
- ≤3	15	5.9	8	1.6		6	2.3	
5 min Apgar score					0.390			0.214
- ≥7	250	98.4	493	99.2		255	99.2	
- 4-6	4	1.6	3	0.6		1	0.4	
- ≤3	0		1	0.2		1	0.4	
Cord pH <7.00	4	1.6	0		0.014	0		0.059
Admission to NICU	2	0.8	4	0.8	1	1	0.4	0.622
Severe morbidity*	2	0.8	1	0.2	0.266	3	1.2	1

CD, cesarean delivery; VD, vaginal delivery; min, minute; NICU, neonatal intensive care unit. *p* values were calculated using χ^2 and Fisher's exact test.
*Neonatal morbidity according to the Term Breech Trial [Hannah et al., 2000]. See Table 8 on page 62 for detailed description.

Severe neonatal morbidity according to the criteria of the Term Breech Trial was rare in all groups. Table 21 on pages 92-93 details the cases fulfilling these criteria.

7.1.2 Maternal outcome (I)

One mother died of a pulmonary embolism 12 days after an elective CD, which was scheduled due to placenta previa and was complicated by uncontrolled bleeding necessitating a hysterectomy. Women in the planned CD group suffered from massive bleeding (>1500 mL or the need for transfusions) more often than women in the planned VD group (8.0% *vs.* 2.0%, p=0.001), but no statistically significant differences were observed between the groups in infectious or surgical complications.

7.2 Preterm breech delivery by mode of delivery and compared to cephalic controls (II)

One hundred seventy-six preterm breech deliveries with a gestational age of at least 32 weeks met the inclusion criteria during the study period. One hundred three women were allowed a trial of labor and 73 were managed by a CD without trial of labor. The cephalic control group (n=103) was matched according to gestational age and whether or not the woman had previously accomplished a VD.

7.2.1 Characteristics and outcomes of all preterm study deliveries (II)

Infants in the breech trial of labor group were smaller than the cephalic controls. No differences in maternal morbidity or smoking during pregnancy were observed between the groups except for uterine and genital anomalies, which were most common in the breech CD group and least common in the cephalic control group. Median blood loss was lower in deliveries in the breech trial of labor group than in deliveries in the breech CD group, but no statistically significant differences were observed in the incidence of massive bleeding (defined as ≥1500 mL or the need for transfusions) nor in the rates of puerperal infections or surgical complications between the groups. Table 12 details the neonatal and maternal outcomes.

Table 12. Details of neonatal and maternal outcomes of preterm breech deliveries with 32 completed gestational weeks.

	Breech			Cephalic	
	Trial of labor (1) n=103	Planned CD (2) n=73	*p* value 1 *vs.* 2	Trial of labor (3) n=103	*p* value 1 *vs.* 3
Median birthweight (g)	2540	2470	0.249	2680	0.034
Median gestational age at delivery (weeks+days)	35+6	35+4	0.282	35+5	0.682
Uterine or genital anomalies (%)	7.8	17.8	0.043	1.0	0.017
Infant transferred to NICU (%)	16.5	23.3	0.261	7.8	0.055
Median maternal blood loss (mL)	350	500	<0.001	350	0.978
Blood loss ≥1500 mL or need for transfusions (%)	3.9	6.8	0.379	1.9	0.407

CD, cesarean delivery; NICU, neonatal intensive care unit. *p* values of categorical variables were calculated using χ^2 test. Medians were compared using Mann-Whitney U test.

No neonatal mortality was observed in the study groups. Infants in the breech trial of labor group more often had low Apgar scores (less than seven) at the age of one minute compared to the cephalic group, but no difference between the groups was observed at the age of five minutes. Table 13 shows the distribution of Apgar scores at the age of one and five minutes in the groups. Median umbilical artery pH was lower in the breech trial of labor group compared to the breech CD group (7.25 *vs.* 7.32, $p<0.001$), but none of the infants displayed acidotic (<7.00) umbilical artery pH, and pH <7.05 was observed in only one infant (in the breech trial of labor group). Umbilical artery pH value was missing in 2.4% of the breech trial of labor group, 5.4% of the breech CD group and 1.6% of the cephalic infants. Neonatal intensive care was needed less often in the breech trial of labor group than in the breech CD group, although the difference failed to reach statistical significance (16.5% *vs.* 23.3%, $p=0.261$). Severe neurologic morbidity was rare, as one infant in the breech trial of labor group had seizures and three cases of grade 1 intracerebral hemorrhage were diagnosed, one in the breech CD group and two in the cephalic group.

Table 13. Apgar scores of spontaneous onset preterm breech deliveries of ≥32 completed gestational weeks, by mode of delivery and compared to cephalic controls.

	Breech				p value 1 *vs.* 2	Cephalic		p value 1 *vs.* 3
	Trial of labor (1) n = 103		Planned CD (2) n=73			Trial of labor (3) n=103		
	n	%	n	%		n	%	
1 min Apgar score					0.138			<0.001
- ≥7	73	70.9	60	82.2		96	93.2	
- 4-6	18	17.5	10	13.7		6	5.8	
- ≤3	12	11.7	3	4.1		1	1.0	
5 min Apgar score					0.697			0.151
- ≥7	94	91.6	67	91.8		100	97.1	
- 4-6	8	7.5	6	8.2		2	1.9	
- ≤3	1	0.9	0	0		1	1.0	

CD, cesarean delivery; min, minute. *p* values were calculated using χ^2 test.

7.2.2 Outcomes of deliveries according to gestational age (II)

Further subgroup analyses of spontaneous onset deliveries were made according to the gestational age. The moderately preterm cohort comprised deliveries at 32+0 –

33+6 weeks of gestation (37 breech and 17 cephalic deliveries); the late preterm cohort comprised deliveries at 34+0 – 36+6 weeks of gestation (139 breech and 86 cephalic deliveries).

7.2.2.1 The moderately preterm cohort

Nineteen women with the fetus in breech presentation were allowed a trial of labor and 18 were managed by a CD without a trial of labor. Of the 19 women with a trial of preterm breech labor, 18 actually delivered vaginally, compared to none of the 18 women in the planned CD group ($p<0.001$) and 15 of the 17 women delivering a preterm cephalic infant ($p=0.481$). No differences in the incidence of low Apgar scores were observed between the breech groups. However, infants after a breech trial of labor displayed low Apgar scores (<7) at both one and five minutes more often than infants after a trial of labor in cephalic presentation (at the age of one minute, 36.8% in the breech trial of labor group *vs.* none in the cephalic group, $p=0.005$, and at the age of five minutes, 21.1% *vs.* none, $p=0.045$). No statistically significant differences were observed in rates of NICU admissions between infants in the study groups (57.9% of infants after a breech trial of labor, 66.7% of infants after a breech CD, and 35.3% after a trial of labor in cephalic presentation were admitted to the NICU).

7.2.2.2 The late preterm cohort

Of the 139 women with spontaneous-onset late preterm breech deliveries, 84 were allowed a trial of labor and 55 were managed by a CD without a trial of labor. Seventy-four of the 84 women with a trial of labor actually delivered vaginally compared to none of the 55 in the planned CD group ($p<0.001$) and 83 of the 86 women who delivered a cephalic infant ($p=0.039$). A low Apgar score (<7) at the age of one minute was more common in neonates born after a breech trial of labor compared to neonates born after a breech CD (27.4% *vs.* 10.9%, $p=0.019$) and in neonates born after a trial of labor in cephalic presentation (27.4% *vs.* 8.1%, $p=0.001$), but five-minute Apgar scores were comparable between groups. Of the 84 neonates born after a breech trial of labor, 7.1% were admitted to NICU, compared to 9.1% of 55 neonates born after a breech CD group and 2.3% of 86

neonates born after a cephalic trial of labor. These differences were not statistically significant.

7.2.3 Risk factors for the need of neonatal intensive care (II)

Logistic regression analysis was performed on all spontaneous-onset preterm breech deliveries to identify risk factors for adverse neonatal outcome, and NICU admission was used as a surrogate marker. Increasing gestational age was identified as a protective factor (OR 0.25; 95% CI: 0.16 – 0.38), whereas being small for gestational age (OR 5.15; 95% CI: 1.78 – 14.97) increased the need for neonatal intensive care in the univariate analyses. Trial of labor, maternal hypertensive condition or maternal diabetes were not associated with admission to NICU. Multivariable analysis revealed that increasing gestational age (p<0.001, OR 0.24, 95% CI: 0.16 – 0.38) protected infants from NICU admission and being small for gestational age (p=0.018, OR 7.39, 95% CI: 1.40 – 39.03) predisposed infants to the need for neonatal intensive care.

7.3 Characteristics of term and preterm breech deliveries (I-II)

Vaginal delivery was accomplished more often in preterm deliveries than in term deliveries. The delivery of the aftercoming head was described as challenging slightly more often in moderately preterm vaginal breech deliveries than in term or late preterm vaginal breech deliveries, but difficulties were encountered in CDs too. Birth trauma was rare in all groups. Maternal morbidity was seen more often in term breech deliveries compared to preterm breech deliveries. Table 14 shows the details of term and preterm breech deliveries.

Table 14. Details of term and preterm study deliveries

	Term (≥37+0 gestational weeks) Study I				Late preterm (34+0 – 36+6 gestational weeks) Study II				Moderately preterm (32+0 – 33+6 gestational weeks) Study II			
	Planned VD n = 254		Planned CD n=497		Trial of labor n=84		Planned CD n=55		Trial of labor n=19		Planned CD n=18	
	n	%	n	%	n	%	n	%	n	%	n	%
Vaginal delivery	174	68.5	11	2.2	74	88.1	0		18	94.7	0	
Challenging delivery of the head	22	8.7	28	5.6	10	11.9	7	12.7	4	21.1	2	11.1
5 min Apgar score <7	4	1.6	4	0.8	5	6.0	3	5.5	4	21.1	3	16.7
Infant birth trauma*	2	0.8	0		2	2.4	0		0		0	
Maternal complication†	39	15.4	89	17.9	9	10.7	9	16.4	1	5.3	2	11.1

VD, vaginal delivery; CD, cesarean delivery; min, minute

*Excluding bruises and small lacerations

†For example, infections (except respiratory and mastitis), surgical complications, transfusions, bleeding ≥1500mL, grade III perineal tears

7.4 Maternal experiences of vaginal breech delivery (III)

7.4.1 Management of the deliveries in Study III

One hundred seventy of the 308 women who were sent the Childbirth Experience Questionnaire (CEQ) returned it; of those, 97 (57.1%) had delivered breech infants and 73 (42.9%) cephalic infants. The total response rate was 55.2 percent (63.0% in the breech group and 47.4% in the cephalic group, respectively). Three of the respondents did not answer all the questions. All domain scores could, thus, be calculated for 167 mothers, but at least two domain scores could be calculated for all mothers. All study deliveries were planned VDs with breech or cephalic presentation, and 78.4% in the breech group and 80.8% in the cephalic group had actually delivered vaginally (p=0.693). No difference in labor induction was observed between the groups (17.5% in the breech group and 17.8% in the cephalic group, p=0.962), but oxytocin augmentation was more common in the breech group (83.5% *vs.* 47.9% in the cephalic group, p<0.001). Neuraxial analgesia was used similarly in both groups (67.0% in the breech group *vs.* 65.8% in the cephalic group, p=0.864), but episiotomy was performed more commonly in the breech group (63.5% *vs.* 30.4% in the cephalic group, p<0.001). Mean duration of a completed VD was significantly shorter in the breech group than in the cephalic group (8 hours and 25 minutes *vs.* 10 hours and 7 minutes, p=0.037).

7.4.2 Outcomes of the deliveries in Study III

Infants in the breech group more often had a low one-minute Apgar score (<7) compared to the cephalic group (22.7% *vs.* 11.0%, p=0.047), but there was no difference regarding the Apgar score at five minutes. One infant in the breech group suffered from Erb's palsy and damage to the phrenic nerve, and one infant in the breech group and one in the cephalic group had clavicular fractures. Additionally, six infants in the breech group had bruises or minor abrasions. The incidence of maternal complications was similar in both groups.

7.4.3 The birthing experience according to the Childbirth Experience Questionnaire (III)

The responses to the individual items of the CEQ were presented in percentages agreeing with the item (percentages of totally agreeing and mostly agreeing combined) in the original publication of Study III. The following section presents the full responses in the original four-point format.

7.4.3.1 First domain: Capacity

The first domain of the CEQ evaluates the mother's own capacity (perceived personal control, self-efficacy, and coping) with six questions in Likert scale and two in VAS scale. Domain scores were similar in both groups. Mothers in the breech group tended more often to feel strong and happy during labor and birth and thought they handled the situation well, but these differences did not reach statistical significance. Table 15 details the items of the first domain and the distribution of responses to them.

Table 15. Domain I: Own capacity

	Breech deliveries n=97		Cephalic deliveries n=73		p value
	n or mean	% or SD	n or mean	% or SD	
Total domain score	2.64	0.64	2.55	0.64	0.366
Labor and birth went as I had expected					0.559
- Totally agree	17	17.5	16	21.9	
- Mostly agree	37	38.1	32	43.8	
- Mostly disagree	23	23.7	15	20.5	
- Totally disagree	20	20.6	10	13.7	
I felt strong during labor and birth					0.342
- Totally agree	22	22.7	10	13.7	
- Mostly agree	45	46.4	33	45.2	
- Mostly disagree	20	20.6	22	30.1	
- Totally disagree	10	10.3	8	11.0	
I felt capable during labor and birth					0.937
- Totally agree	12	12.4	9	12.3	
- Mostly agree	50	51.5	36	49.3	
- Mostly disagree	26	26.8	19	26.0	
- Totally disagree	9	9.3	9	12.3	
I was tired during labor and birth					0.665
- Totally agree	15	15.5	7	9.6	
- Mostly agree	23	23.7	18	24.7	
- Mostly disagree	35	36.1	26	35.6	
- Totally disagree	24	24.7	22	30.1	
I felt happy during labor and birth					0.052
- Totally agree	14	14.4	6	8.2	
- Mostly agree	53	54.6	30	41.1	
- Mostly disagree	20	20.6	28	38.4	
- Totally disagree	10	10.3	9	12.3	
I felt that I handled the situation well					0.640
- Totally agree	44	45.8	28	38.4	
- Mostly agree	38	39.6	32	43.8	
- Mostly disagree	10	10.4	11	15.1	
- Totally disagree	4	4.2	2	2.7	

SD, standard deviation. *p* values of categorical variables were calculated using χ^2 test and means compared using Student's T-test. Table continues on next page

Table 15 continues from previous page

	Breech deliveries n=97		Cephalic deliveries n=73		p value
	n	%	n	%	
As a whole, how painful did you feel your childbirth was?*†					0.488
- 0-40	19	19.8	8	11.0	
- 41-60	21	21.9	17	23.3	
- 61-80	35	36.5	30	41.1	
- 81-100	21	21.9	18	23.1	
As a whole, how much control did you feel you had during childbirth?**					0.853
- 81-100	25	25.8	19	26.0	
- 61-80	25	25.8	21	28.8	
- 41-60	15	15.5	8	11.0	
- 0-40	32	33.0	25	34.2	

*Higher VAS score indicates more painful experience **Higher VAS score indicates stronger feeling of control †Breech n=96

p values were calculated using χ^2 test.

7.4.3.2 Second domain: Professional support

The second domain of the CEQ assesses professional support with five questions in Likert scale. Domain scores did not differ between the groups. Mothers in the breech group felt slightly more often that their midwives devoted enough time to them, but this difference was not statistically significant. Table 16 shows the items and the mothers' responses to them.

Table 16. Domain II: Professional support

	Breech deliveries n=97		Cephalic deliveries n=72		p value
	n or mean	% or SD	n or mean	% or SD	
Total domain score	3.40	0.67	3.42	0.71	0.880
My midwife devoted enough time to me					0.280
- Totally agree	61	62.9	47	65.3	
- Mostly agree	27	27.8	13	18.1	
- Mostly disagree	7	7.2	8	11.1	
- Totally disagree	2	2.1	4	5.6	
My midwife devoted enough time to my parter †					0.960
- Totally agree	50	52.1	40	56.3	
- Mostly agree	31	32.3	21	29.6	
- Mostly disagree	12	12.5	8	11.3	
- Totally disagree	3	3.1	2	2.8	
My midwife kept me informed about what was happening††					0.805
- Totally agree	47	49.0	40	55.6	
- Mostly agree	31	32.3	22	30.6	
- Mostly disagree	14	14.6	8	11.1	
- Totally disagree	4	4.2	2	2.8	
My midwife understood my needs					0.945
- Totally agree	53	54.6	41	56.9	
- Mostly agree	28	28.9	18	25.0	
- Mostly disagree	14	14.4	11	15.3	
- Totally disagree	2	2.1	2	2.8	
I felt very well cared for by my midwife					0.990
- Totally agree	62	63.9	46	63.9	
- Mostly agree	27	27.8	20	27.8	
- Mostly disagree	6	6.2	4	5.6	
- Totally disagree	2	2.1	2	2.8	

†Breech n=96 and cephalic n=71 ††Breech n=96

SD, standard deviation. *p* values of categorical variables were calculated using χ^2 test and means compared using Student's T-test.

7.4.3.3 Third domain: Perceived safety

The third domain comprises six items (five in Likert scale and one in the VAS scale) and evaluates perceived safety during delivery. Mothers who gave birth to breech infants tended to report positive memories of childbirth more often than mothers giving birth to cephalic infants, but this difference was not statistically significant. The total domain score was similar in both groups. Table 17 details the items and the mothers' responses.

Table 17. Domain III: Perceived safety

	Breech deliveries n=97		Cephalic deliveries n=73		p value
	n or mean	% or SD	n or mean	% or SD	
Total domain score	2.95	0.85	3.01	0.82	0.667
I felt scared during labor and birth					0.904
- Totally disagree	22	22.7	20	27.4	
- Mostly disagree	25	25.8	18	24.7	
- Mostly agree	33	34.0	24	32.9	
- Totally agree	17	17.5	11	15.1	
I have many positive memories from childbirth†					0.407
- Totally agree	41	42.7	24	33.3	
- Mostly agree	26	27.1	20	27.8	
- Mostly disagree	17	17.7	20	27.8	
- Totally disagree	12	12.5	8	11.1	
I have many negative memories from childbirth†					0.920
- Totally disagree	22	22.9	18	25.0	
- Mostly disagree	33	34.4	27	37.5	
- Mostly agree	28	29.2	19	26.4	
- Totally agree	13	13.5	8	11.1	
Some of my memories from childbirth make me feel depressed†					0.902
- Totally disagree	50	52.1	40	55.6	
- Mostly disagree	18	18.8	14	19.4	
- Mostly agree	19	19.8	11	15.3	
- Totally agree	9	9.4	7	9.7	

SD, standard deviation. *p* values of categorical variables were calculated using χ^2 test and means compared using Student's T-test. Table continues on next page

Table 17 continues from previous page

	Breech deliveries n=97		Cephalic deliveries n=73		p value
	n	%	n	%	
My impression of the team's†† medical skills made me feel secure					0.688
- Totally agree	58	59.8	45	62.5	
- Mostly agree	18	18.6	16	22.2	
- Mostly disagree	17	17.5	8	11.1	
- Totally disagree	4	4.1	3	4.2	
As a whole, how secure did you feel during childbirth?*					0.849
- 81-100	47	48.5	39	53.4	
- 61-80	23	23.7	17	23.3	
- 41-60	10	10.3	5	6.8	
- 0-40	17	17.5	12	16.4	

†Breech n=96 and cephalic n=72 ††Cephalic n=72 *Higher VAS score indicates feeling more secure
p values were calculated using χ^2 test.

7.4.3.4 Fourth domain: Participation

The fourth domain of the CEQ comprises three items in Likert scale. It assesses participation during delivery, focusing on whether the mother felt she had a say in deciding the birthing position and pain relief methods. The total domain score was lower in the breech group than in the cephalic group (2.28 *vs.* 2.81, $p<0.001$). As expected, mothers in the breech group felt more often that they did not have a say as to whether or not they could be up and about or lie down (37.5% agreeing to this in the breech group *vs.* 62.5% in the cephalic group, $p=0.005$). Furthermore, they also felt significantly more often that they were not given a say in deciding the birthing position (20.8% agreeing to this in the breech group *vs.* 42.3% in the cephalic group, $p<0.001$). However, the mothers in the breech group also tended to feel that they did not have a say in the method of pain relief, although this difference was not statistically significant. Table 18 shows the items and the distributions of the mothers' responses.

Table 18. Domain IV: Participation

	Breech deliveries n=96		Cephalic deliveries n=72		p value
	n or mean	% or SD	n or mean	% or SD	
Total domain score	2.28	0.84	2.81	0.94	<0.001
I felt I could have a say on whether I could be up and about or lie down					0.005
- Totally agree	16	16.7	23	31.9	
- Mostly agree	20	20.8	22	30.6	
- Mostly disagree	18	18.8	13	18.1	
- Totally disagree	42	43.8	14	19.4	
I felt I could have a say in deciding my birthing position†					<0.001
- Totally agree	8	8.3	15	21.1	
- Mostly agree	12	12.5	15	21.1	
- Mostly disagree	15	15.6	20	28.2	
- Totally disagree	61	63.5	21	29.6	
I felt I could have a say in the choice of pain relief††					0.266
- Totally agree	41	43.2	41	56.9	
- Mostly agree	36	37.9	19	26.4	
- Mostly disagree	5	5.3	5	6.9	
- Totally disagree	13	13.7	7	9.7	

†Cephalic n=71††Breech n=95
SD, standard deviation. *p* values of categorical variables were calculated using χ^2 test and means compared using Student's T-test..

7.4.3.5 Negative childbirth experience

Nine (9.3%) of the breech and five (6.8%) of the cephalic delivery experiences were negative (all four domain scores are in the lowest quartile, p=0.591). Logistic regression analyses demonstrated that breech presentation was not associated with a negative delivery experience.

Primiparity was identified as a risk factor for a negative delivery experience, as well as delivery ending in a CD and the presence of birth trauma (including both minor injuries such as bruises and lacerations as well as major trauma such as fractures and Erb's palsy) in all the study deliveries. Negative birth experience was not associated with the total duration of VD, but a prolonged second stage increased

the risk for a negative experience. Prolonged hospital stay antepartum or postpartum increased the risk of negative experience. Maternal complications, infections, severe bleeding or transfusions, neonatal morbidity or undiagnosed breech presentation at labor were not associated with a negative experience. Table 19 details the results of univariate analyses.

Table 19. Univariate analysis of risk factors for a negative childbirth experience in 97 breech and 73 cephalic deliveries, all planned vaginal deliveries

	Childbirth experience						
	Normal n=153		Negative n=14		p value UA	OR UA	95% CI UA
	n or median	% or range	n or median	% or range			
Breech presentation	87	56.9	9	64.3	0.592	1.37	0.44 – 4.27
Primiparous	92	60.1	13	92.9	0.040	8.62	1.10 – 67.60
Breech presentation not diagnosed until labor	19	21.8	2	22.2	0.979	1.02	0.20 – 5.33
Antepartum hospital stay (days)	0	0, 4	1	0, 9			
Induction of labor	29	19.0	1	7.1	0.293	0.33	0.04 – 2.62
Oxytocin augmentation	106	69.3	8	57.1	0.350	0.59	0.19 – 1.80
Duration of VD (minutes)	533	85, 1402	635	141, 862	0.661	1.00	0.99 – 1.00
Duration of second stage (minutes)	18	1, 77	31	10, 88	0.038	1.04	1.002 – 1.08
Delivery converted to a CD	28	18.3	6	42.9	0.037	3.35	1.08 – 10.42
Infant birth trauma	7	4.6	3	21.4	0.022	5.69	1.29 – 25.11
Neonatal morbidity	43	28.1	7	50.0	0.096	2.56	0.85 – 7.73
Maternal complications	49	32.0	5	35.7	0.778	1.18	0.38 – 3.70
Bleeding >1000 mL or transfusions	10	6.5	3	21.4	0.062	3.90	0.94 – 16.27
Maternal infections*	11	7.2	3	21.4	0.082	3.52	0.85 – 14.51
Postpartum hospital stay (days)	3	0, 8	4	2, 8	0.012	1.53	1.10 – 2.14

UA, univariate analysis; OR, odds ratio; VD, vaginal delivery; CD, cesarean delivery. Binary logistic regression was used to calculate the odds ratios and *p* values.

*Excluding mastitis

7.5 Cardiotocography in breech versus vertex deliveries (IV)

7.5.1 Trace features in breech and cephalic deliveries (IV)

Traces from breech deliveries tended to be classified as pathological more often than those from cephalic deliveries, but the difference between the groups was not statistically significant. However, decreased variability and late decelerations were observed more often in breech deliveries compared to cephalic controls. No differences were observed in incidences of complicated variable decelerations, prolonged decelerations or any abnormal decelerations (late, prolonged, or complicated variable decelerations) grouped together. Table 20 shows the details of trace features in study groups.

Table 20. Expert interpretations of the cardiotocography traces. Reprinted from Toivonen E, Palomäki O, Huhtala H, Uotila J. Cardiotocography in breech versus vertex delivery: an examiner-blinded, cross-sectional nested case-control study. BMC Pregnancy Childbirth 2016;16:319 with permission from BioMedCentral.

	Breech deliveries n=108		Vertex deliveries n=108		P value
	n	%	n	%	
FIGO classification					0.150
- Normal	29	26.9	39	36.1	
- Suspicious	34	31.5	37	34.3	
- Pathological	45	41.7	32	29.6	
Decreased variability	29	26.9	9	8.3	<0.001
Accelerations	84	77.8	94	87.0	0.074
Late decelerations	15	13.9	3	2.8	0.003
Complicated variable decelerations	58	53.7	62	57.4	0.584
Prolonged decelerations	26	24.1	29	26.9	0.639
Any abnormal decelerations[b]	69	63.9	66	61.1	0.673

[b]Late, complicated variable or prolonged decelerations or a combination of these

7.5.2 Uterine contractility and pathological cardiotocography trace (IV)

Oxytocin augmentation was more common in the breech group than in the cephalic control group, but uterine tachysystole (more than five contractions per 10

minutes) was observed as often in both groups (18.5% in the breech group *vs.* 16.7% in the cephalic group, p=0.721). Uterine tachysystole in turn was associated with pathological trace, as 57.9% of the traces with uterine tachysystole were deemed pathological, compared to 30.9% of traces with normal uterine contractility (p=0.002). Furthermore, oxytocin augmentation tended to increase the incidence of pathological trace, as pathological trace was recorded in 38.8% of deliveries with oxytocin augmentation and in 28.1% of deliveries with spontaneous labor, although this difference was not statistically significant.

7.5.3 Neonatal outcome associated with trace features (IV)

Thirty-one of the 45 breech infants that had displayed pathological trace were delivered spontaneously, compared to 19 spontaneous deliveries of the 32 cephalic infants displaying pathological trace (p=0.389). Among the infants displaying pathological trace, a low Apgar score (less than seven) at the age of one minute was more often observed in the breech group than in the cephalic group (40% *vs.* 18.8%, p=0.047). However, no differences between the groups were observed in the five-minute Apgar score, incidence of acidotic umbilical artery pH or admission to NICU.

7.5.3.1 Primary suboptimal neonatal outcome (IV)

Primary suboptimal outcome, defined as an umbilical artery pH of ≤7.10 or a five-minute Apgar score of <7, was detected in 13 infants in the breech group and four in the cephalic group (p=0.023).

Six infants had an Apgar score of <7, four in breech presentation and two in cephalic presentation. Three of the breech and one of the cephalic infants had displayed a pathological tracing, and the rest two infants had displayed a suspicious trace.

Two infants in cephalic presentation suffered from acidemia, and both had displayed a pathological trace. Conversely, of the ten breech infants who had umbilical artery pH ≤7.10, seven had displayed pathological, two suspicious, and

one a normal trace. The breech infant with acidotic pH despite normal trace was born to a healthy primiparous mother, the breech presentation diagnosed not until labor. The onset of delivery was spontaneous at the 39th week of pregnancy, and a healthy infant weighing 3290g was delivered vaginally, receiving an Apgar score of seven at the age of one minute and nine at the age of five minutes, but displaying cord pH 7.08. No further monitoring was needed.

Pathological trace classification was associated with a suboptimal neonatal outcome (OR 4.9, 95% CI 1.7 – 14.6, p=0.004) in the univariate analyses of the entire study population. Likewise, absence of accelerations (OR 3.8, 95% CI 1.3 – 10.7, p=0.012), presence of late decelerations (OR 4.1, 95% CI 1.2 - 14.1, p=0.027), and complicated variable decelerations (OR 14.6, 95% CI 1.9 – 112.3, p=0.010) predicted a suboptimal outcome. Breech presentation was also associated with a suboptimal outcome (OR 3.6, 95% CI 1.1 – 11.3, p=0.031). Decreased baseline variability, oxytocin augmentation, or uterine tachysystole were not associated with a suboptimal outcome. Independent risk factors for a suboptimal neonatal outcome were complicated variable decelerations (OR 16.1, 95% CI 2.1 – 124.8, p=0.008) and breech presentation (OR 4.1, 95% CI 1.2 – 13.2, p=0.020).

7.5.3.2 Immediate neonatal depression (IV)

Thirty-three infants in the breech group and seven in the cephalic group displayed a low (<7) Apgar score at the age of one minute. Multivariable analysis demonstrated that a low one-minute Apgar score was independently associated with pathological trace (OR 3.2, 95% CI 1.5 – 6.7, p=0.002) and breech presentation (OR 5.9, 95% CI 2.5 – 14.3, p<0.001).

7.6 Adverse neonatal outcome in term infants according to the Term Breech Trial (I, III-IV)

The Term Breech Trial measured neonatal morbidity with a composite outcome, including measures that experts had previously identified (described in Table 8, page 62). Neonatal morbidity according to these measurements was rare in all study

deliveries in Studies I, III and IV, with six infants in the breech groups (five in an intended VD group) and four in cephalic control groups. Table 21 describes the details of these cases. The composite neonatal morbidity according to the criteria of the Term Breech Trial in all intended vaginal breech deliveries was 1.5% (5/337), compared to 0.2% (1/497) in intended cesarean breech deliveries (p=0.03) and 1.2% (4/337) in cephalic control group (p=0.74).

Table 21. Adverse neonatal outcomes in term infants according to the Term Breech Trial [Hannah et al., 2000]. See Table 8 on page 62 for detailed definitions.

Presentation Planned mode of delivery	Study	Actual mode of delivery	Gestational age (weeks + days)	Description
Cephalic Intended VD	I	Vaginal	38+3	Apgar 8-2-8, pH 7.35, no need for NICU. Wet lung
Cephalic Intended VD	I	Vaginal	38+1	Apgar 9-9, pH 7.27, no need for NICU. The umbilical cord was ruptured and newborn received transfusion of red blood cells
Cephalic Intended VD	III	Vaginal	40+5	Apgar 7-8, pH 7.21, no need for NICU. Clavicular fracture
Cephalic Intended VD	I, IV	Acute CD	38+2	Apgar 2-5, pH 7.19, 8 days in NICU. Asphyxia
Breech Intended VD	I	Vaginal	40+0	Apgar 8-9, pH 7.33, no need for NICU. Mild Erb's palsy, recovered in two weeks
Breech Intended VD	I	Vaginal	39+2	Apgar 4-7-9, pH 7.21, no need for NICU. Clavicular fracture

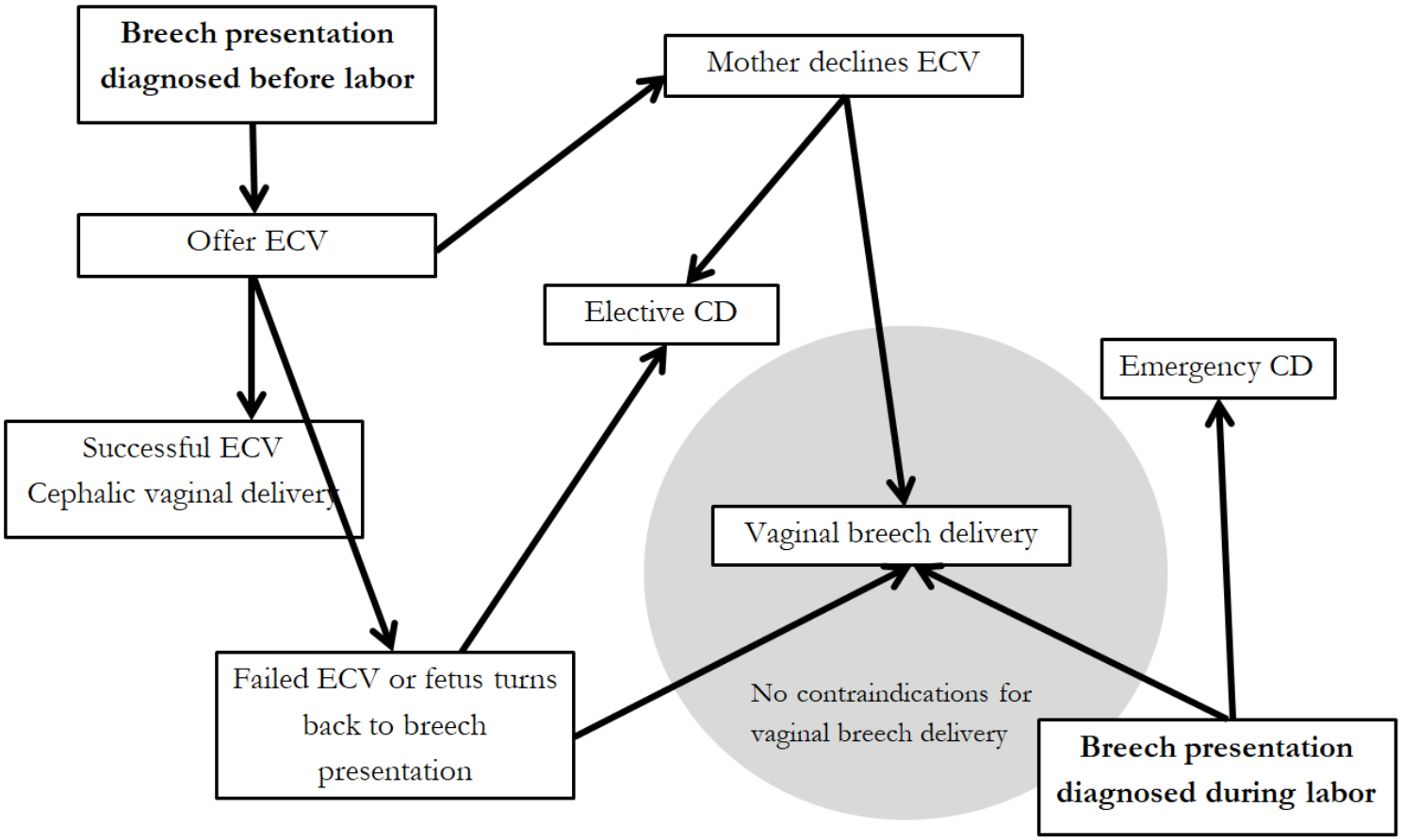
Breech Intended VD	III	Vaginal	41+4	Apgar 3-6, pH 6.95, no need for NICU. Erb's palsy and damage to the phrenic nerve due to inadequate maternal co-operation and difficult delivery of the aftercoming head
Breech Intended VD	III	Vaginal	40+6	Apgar 1-3, pH 7.29, one day in NICU. Difficult delivery of the aftercoming head, clavicular fracture and neonatal infection.
Breech Intended VD	III	Vaginal	40+1	Apgar 6-1-8, pH 7.20, three days in NICU. Meconium aspiration syndrome
Breech Intended CD	I	Elective CD	40+3	Apgar 1-2-8, pH 7.30, 6 days in NICU. Meconium aspiration syndrome

VD, vaginal delivery; CD, cesarean delivery; NICU, neonatal intensive care unit

8 DISCUSSION

The dilemma of delivering the breech-presenting fetus remains despite advances in obstetric practice in the last decades. Based on numerous retrospective and three randomized studies, the lowest neonatal mortality and morbidity rates are probably achieved by CD in most, but not all cases. As with most challenges in obstetrics, balancing the risk for the infant against the risk for the mother is difficult, and the solution varies according to individual backgrounds, environments, and families. Many women express strong desire for CD, but many will choose VD, and all need information on the risks and benefits of both modes of delivery. Modern obstetrics should focus on providing data for the families expecting a breech infant to permit an informed choice on the delivery method. Different management options of breech presentation are detailed in Figure 6.

Figure 6. Approach to breech delivery. Management protocol of planned breech delivery is described starting from the upper left corner. Management options of undiagnosed breech presentation start from the lower right corner. ECV, external cephalic version; VD, vaginal delivery; CD, cesarean delivery


Breech presentation diagnosed before labor
Mother declines ECV
Offer ECV
Elective CD
Emergency CD
Successful ECV
Cephalic vaginal delivery
Vaginal breech delivery
Failed ECV or fetus turns back to breech presentation
No contraindications for vaginal breech delivery
Breech presentation diagnosed during labor

8.1 Main results of the study (I-IV)

This study demonstrated that after attempting vaginal breech delivery, neonatal mortality and morbidity were rare. However, a trial of vaginal breech delivery predisposes infants to a low one-minute Apgar score and lower umbilical artery pH, even under strict selection and management protocol. Similar results were found in studies of term and preterm deliveries (with at least 32 weeks of gestation) alike. Further, attempting a vaginal breech delivery did not predispose mothers to a negative childbirth experience.

Cardiotocography traces from breech deliveries displayed late decelerations and decreased variability more often than traces from cephalic deliveries. Pathological trace predicts immediate neonatal depression also in vaginal breech deliveries, and especially complicated variable decelerations may signal fetal distress. Converting a trial of vaginal delivery to an emergency CD should be considered if these patterns persist during a trial of vaginal breech delivery.

8.2 Methodology

8.2.1 Retrospective design and one study center (I-IV)

Randomized controlled trials have important limitations and are not applicable to all phenomena, although they are regarded as the strongest tool for evidence-based medicine. The Term Breech Trial was an example of a well designed, well executed and large trial, but its application of large-scale randomization to complex phenomena was criticized, in addition to pointing out its methodological flaws [Kotaska 2004]. Furthermore, with declining vaginal breech delivery rates, the creation of another randomized trial with adequate sample size seems unlikely. The ethical aspects of such a study would be ambiguous due to the results from the Term Breech Trial and several observational studies. Participating centers would probably have to increase their rates of attempted vaginal breech deliveries beyond

their comfort level to achieve a large enough study population for randomization. This problem was already present in the Term Breech Trial [Kotaska 2004], and as the proportion of candidates for vaginal breech delivery in everyday clinical practice has decreased since the Term Breech Trial's publication, its effect would be even more significant today. Thus, the new data on the mode of delivery must be extracted from observational studies.

One of the most important limitations of retrospective studies is the selection bias. Breech infants with a poor prognosis were likely delivered by a planned CD to avoid further stress during delivery, resulting in bias favoring planned VD. Congenitally ill children were excluded to control this confounding, as well as iatrogenic deliveries and fetuses with antepartum distress in Study II. However, despite these exclusions, more preterm infants were small for gestational age in the CD group than in the trial of labor group, suggesting selection bias.

Breech presentation is rare and only limited number of women expecting a breech infant are good candidates for a trial of vaginal breech delivery. Thus, single-center studies can be blamed for the small numbers and inadequate power to detect rare outcomes. However, their uniform management and reporting policies constitute the strengths of single-center studies, providing valid data for similar settings. This study was conducted in a hospital with a strong tradition of vaginal breech delivery and a commitment to offering VD for mothers desiring it, as demonstrated by earlier studies on the topic from the same institution [Kauppila 1975; Uotila et al., 2005]. These results can be applied in other high-resource facilities sharing the same commitment. A policy for routine CD may be justified in an environment with fewer resources and less experience with vaginal breech delivery.

8.2.2 Outcome measures (I-IV)

Most studies on the mode of delivery in breech presentation focus on the immediate neonatal outcome due to the difficulties in managing the follow up of large study populations that are required to show differences in rare outcomes. Neonatal mortality is rare in modern high-resource settings, and studies on topics with low incidence, such as breech delivery, must rely on other neonatal outcome

measures. However, few immediate markers reflect the infant's long-term prognosis.

Umbilical artery acid-base status has been used to measure the degree of intrapartum asphyxia. Severe acidemia (pH <7.00) has been demonstrated to increase neonatal morbidity, but many newborns exhibiting values even below this are clinically well and do not need special care [van den Berg et al., 1996; Sehdev et al., 1997]. Study IV demonstrates the inconclusivity of cord blood acidemia, as an otherwise healthy infant was defined as having a primary suboptimal outcome due to low cord pH. Conversely, the arbitrarily chosen pH value for acidemia in Study IV was relatively high (<7.10) and may not represent true fetal distress. This cut-off value was chosen because events of true severe acidemia (<7.00) were very rare in the study population.

Apgar scores were introduced in 1952 to predict neonatal survival, and the five-minute score has been confirmed to be still applicable for this purpose in modern settings [Casey et al., 2001]. Low five-minute Apgar scores are associated with neonatal mortality and neurologic morbidity [Thorngren-Jerneck et al., 2001]. The value of a low one-minute score is less clear as the low one-minute score is often associated with more temporary depression [Freeman et al., 1988; Thorngren-Jerneck et al., 2001]. This study also shows this, as most infants displaying a low one-minute Apgar score had no morbidity or need for neonatal intensive care.

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8.2.3 Adverse neonatal outcome in term infants according to the Term Breech Trial (I, III-IV)

Short-term neonatal morbidity (according to the criteria of The Term Breech Trial [Hannah et al., 2000]) in all term study deliveries was more common in intended vaginal breech deliveries than in planned cesarean breech deliveries. However, the rates of short-term neonatal morbidity compared favorably to those presented in the Term Breech Trial (5.1% after planned vaginal breech delivery and 0.4% after planned CD in countries with low perinatal mortality rate, compared to 1.5% and 0.2% described in this study). This may be due to the high standard of care in the study hospital, as all candidates for vaginal breech delivery were carefully selected and the intrapartum management differs significantly from the minimum standard set in the Term Breech Trial. High standard of care was defined according to availability of very urgent emergency CD and pediatric services in the Term Breech Trial [Hannah et al., 2000], and, for example, the availability of ultrasound equipment and continuous CTG monitoring was not taken into account. A recent Finnish study from another hospital reported similar rates of neonatal morbidity (1.3%) compared to this study, using the same criteria [Macharey et al., 2017c].

In this study, short-term neonatal morbidity according to the Term Breech Trial criteria was low in all study groups, including the cephalic control groups. Fortunately, all these infants survived, although meconium aspiration syndrome (one case in intended vaginal breech delivery group and one in planned cesarean breech delivery group) is a potentially fatal complication. Most of the morbidities were transient and probably will not affect later quality of life, with the exception of damage to the phrenic nerve. The delivery of the aftercoming head was difficult in this case, and maternal co-operation in the delivery of the head was not sufficient. On the one hand, this highlights the importance of selection of the parturients eligible for attempting breech delivery, and on the other hand reflects the unpredictability of maternal reactions in emergency situations.

The morbidity criteria used in the Term Breech Trial were previously agreed upon by professionals to be important markers of neonatal morbidity [Hannah et al., 2000]. However, their positive predictive value is low, as demonstrated in the follow-up study of 920 infants who had participated in the Term Breech Trial at

birth [Whyte et al., 2004]. According to that study, the risk of death or neurodevelopmental delay was similar regardless of the intended mode of delivery (2.8% in the planned VD group *vs.* 3.1% in the planned CD group), although 3.1% in the planned VD group and 0.9% in the planned CD group suffered from short-term neonatal morbidity. Retrospective studies have described similar rates of long-term morbidity after planned VD and planned CD deliveries [Danielian et al., 1996; Hellsten et al., 2003; Ulander et al., 2004; Macharey et al., 2018], but data are sparse and the need for more research on long-term morbidity is obvious.

8.2.4 Measuring the delivery experience (III)

The Childbirth Experience Questionnaire (CEQ) was chosen for use in this study, as it was developed relatively recently in a modern healthcare system, reflecting the conditions of the deliveries in this study. Furthermore, Sweden and Finland share a similar cultural environment regarding labor and delivery, with almost all deliveries managed in a hospital setting and an internationally low CD rate. The CEQ has since been validated for use in the United Kingdom [Walker et al., 2015] and in Spain [Soriano-Vidal et al., 2016]. The Finnish translation of the CEQ was created by a team of three independent translators and approved by the original authors of the CEQ, although it has not yet been validated.

Novel questionnaires have recently been developed to assess the maternal delivery experience. The Dutch Childbirth Perception Scale was developed to evaluate the perception of delivery and first postpartum week [Truijens et al., 2014]. The Questionnaire Assessing Childbirth Experience (QACE) was developed using items from the CEQ among other questionnaires, and can be used to assess the delivery experience in both clinical and research settings [Carquillat et al., 2017]. The CEQ remains in use, however, as demonstrated by a recent study utilizing the CEQ to measure the childbirth experience after labor induction or spontaneous labor [Walker et al., 2016]

Deliveries going back several years had to be included in this setting to achieve a sufficiently large study sample of planned vaginal breech deliveries. This may have biased the results towards a more negative birthing experience, as studies assessing

the trajectory of maternal delivery experiences have demonstrated that the perception of the experience becomes more negative over time [Simkin 1992; Waldenström 2003]. Furthermore, the relatively long delay between delivery and receiving the questionnaire may have had a negative impact on the response rate. Questionnaires were sent to women less than a year after the delivery in the validation studies of the CEQ. Those studies achieved higher response rates compared to 55% in this study: 78% in the original Swedish study, 59% in the British study and 62% in the Spanish study [Dencker et al., 2010; Walker et al., 2015; Soriano-Vidal et al., 2016].

8.2.5 Cardiotocography trace interpretation (IV)

Cardiotocography reading has been demonstrated to be highly subjective, and the inter- and intraobserver agreement has been described to vary, even when following a predefined rating system [Ayres-de-Campos et al., 1999; Palomäki et al., 2006; Blackwell et al., 2011]. The traces were interpreted by two senior obstetricians to confirm the reliability of association between CTG patterns and fetal well-being in this study.

FIGO published new guidelines for interpretation of CTG traces after this study was conducted [Ayres-de-Campos 2015], but they remain to be scientifically validated. The 1987 guidelines are widely accepted [Ayres-de-Campos et al., 1999] and still in use in both clinical and research settings [Santo et al., 2017]. This study demonstrates the feasibility of the 1987 guidelines in predicting neonatal depression in vaginal breech delivery. However, this study is in line with some aspects of the new guidelines; for example, the absence of accelerations, although more common in breech than in cephalic deliveries, was not associated with an adverse neonatal outcome.

8.3 Choosing the mode of delivery (I-IV)

After the Term Breech Trial's publication, the rate of intended vaginal term breech delivery also decreased in the study hospital. In 1995 – 2002 it was 59.8% in 1995 – 2002 [Uotila et al., 2005] and in this study 33.1% during 2004 – 2012. This rate is

lower than in some centers producing new data on breech delivery [Vistad et al., 2013; Kessler et al., 2015].

The proportions of attempted and accomplished vaginal breech delivery vary considerably between centers and studies (Table 2 on pages 36-39). Part of this variation may be explained with differences in selection protocols, such as using labor induction or preferring a primary CD in cases of prolonged pregnancy. Most centers perform CD on maternal request when the fetus presents in breech, and maternal attitudes towards the mode of delivery may vary. An Israeli study demonstrated that mothers became increasingly aware of the risks associated with breech presentation and vaginal breech delivery from 1995 to 2001. Of the 154 women expecting a breech infant in 1995, 64.7% preferred elective CD, compared to 97% of the 127 women expecting a breech infant in 2001 [Yogev et al., 2002].

No clear association between frequency of elective CD and good neonatal outcome in breech deliveries can be observed. Some studies with actual VD rates exceeding 50% report better neonatal outcome after an elective CD [Herbst et al., 2001; Belfrage et al., 2002], others have achieved high actual VD rates without compromising neonatal outcome [Sibony et al., 2003]. Experience with vaginal breech delivery seems to play a role in accomplishing safe delivery, as studies with low attempted vaginal breech delivery rates report better outcome after a CD than after an attempted vaginal breech delivery [Bin et al., 2016].

Developing a strict protocol for selecting good candidates for and managing vaginal breech delivery is difficult, as good outcome has been reported in various centers regardless of differences in the management protocols. For example, the use of pelvimetry has been associated with a decrease in emergency CD but not with better neonatal outcome [van Loon et al., 1997], and little evidence exists on appropriate cutoff values of pelvimetric measurements. Another example is the use of oxytocin: good outcome has been reported both in centers that administer oxytocin routinely [Kayem et al., 2002] and centers that avoid oxytocin completely [Alarab et al., 2004]. Centers offering vaginal breech delivery should evaluate their own results regularly and modify their management policies accordingly.

8.3.1 Maternal preference

After offering and possibly attempting ECV, the first criterion in the study hospital for planning a vaginal breech delivery is the mother's willingness to attempt it. This is reflected in the high proportion of planned CDs that were performed mainly due to maternal preference or fear of VD regardless of fetal presentation. The option to choose the mode of delivery after receiving information on CD and vaginal breech delivery also puts the mother in a difficult situation, as she must undergo a rigorous decision process. A French qualitative study described mothers feeling that the decision between VD or CD is rationally impossible to make. Some mothers described deliberately avoiding the consideration of risks and basing the choice on emotions. Mothers also reflected the issue of responsibility in cases of adverse outcomes after a VD: Would the responsible one be the mother, the father, or the physician? Interestingly, in this study mothers perceived the main risk of CD to be psychological for both the mother and the infant, as they would have to be separated during the first moments of life [Guittier et al., 2011].

The mothers who choose to attempt a vaginal breech delivery as a result of the decision process are probably especially motivated and active in their labor, which in turn can be seen as a contributory factor to feeling happy and strong during delivery. The responses to the first item in the Childbirth Experience Questionnaire reflect high expectations of delivery, as more women in the breech group compared to women in the cephalic group felt that their labor had not gone as expected.

Women may consider vaginal breech delivery unsafe and prefer elective CD, as demonstrated in a study from Hong Kong [Leung et al., 2000]. However, the attitudes may vary greatly between different populations and are likely influenced by the views of obstetricians. The rate of refusal of VD by women decreased in a French hospital after a selection protocol was implemented for vaginal breech delivery [Michel et al., 2011], a trend the authors attributed to physicians' increased confidence.

Mothers suffering from untreated fear of labor were probably underrepresented in the breech group due to the different approach on the choice of the mode of

delivery between breech and cephalic delivery. However, as mothers with more recent deliveries were excluded, mothers with a very negative delivery experience resulting in secondary fear of labor and abstaining from subsequent pregnancies may have been overrepresented.

Breech presentation was diagnosed during labor significantly more often in the planned vaginal breech delivery group compared to the planned CD group. The breech presentation was diagnosed during labor in approximately in one in six planned vaginal breech deliveries. Almost all mothers in Finland participate in state-provided antepartum care that is provided by nurses, midwives and general physicians rather than obstetricians. Ultrasound screening is not routinely offered in the third trimester and diagnosing the presentation with a clinical exam may be difficult. Based on this study, the mothers seem to be more eager to attempt vaginal breech delivery if it is diagnosed during labor compared to an earlier diagnosis. A descriptive study on English-language Internet forum discussions on breech delivery observed generally negative attitudes towards vaginal breech birth. Many of the negative comments conveyed misinformation and used alarming language, and the authors called for providing accurate and unbiased information to support mothers in their choice of mode of delivery [Petrovska et al., 2017a]. The role of information initially given in the primary health care at the time of diagnosing or suspecting the breech presentation may be influential in choosing the mode of delivery, although more thorough information is provided in the delivery hospital.

In the study hospital, the information is given in a discussion at the obstetrician's office when persistent breech presentation is diagnosed. A decision aid for ECV has been developed [Nassar et al., 2007], and using decision aids may be helpful in providing information also on the choice of the mode of delivery. The importance of giving time to the family to allow for a fully informed decision was highlighted in a recent study that explored clinician's strategies in counseling families expecting a breech infant [Catling et al., 2016]. Information sheets (printed or online) in addition to discussion at the hospital could help families in basing the decision on facts. Customized information and using graphics can make information more accessible to families [Catling et al., 2016].

8.3.2 Risks associated with cesarean delivery

Maternal death due to pulmonary embolism preceded by a complicated, medically indicated CD and increased risk of massive bleeding among the study parturients demonstrates the risk of rare but potentially fatal complications of CD in this study. Pallasmaa et al. reported increasing numbers of maternal complications in Finnish CDs in 1997 – 2005 despite advances in obstetric care. CD was associated in their study with a two- to fourfold risk for thromboembolism, a fourfold risk for hemorrhage, and a three- to fourfold risk for overall severe maternal morbidity [Pallasmaa et al., 2008]. A study covering 69% of Finnish CDs during the first half of 2005 reported that 27% of mothers had some complication. Emergency CDs carried an increased risk of complications than elective operations (30.5% *vs.* 21.3%) [Pallasmaa et al., 2010]. Maternal outcomes were compared in the present study according to the intended mode of delivery, with some of the attempted VDs ending in an emergency CD. This explains the more balanced rate of complications between the groups in our study compared to other studies [Pallasmaa et al., 2008]. However, the incidence of severe bleeding was also more common in the planned CD group in this study.

Prior CD has been shown to increase the risks in subsequent pregnancies in addition to causing short-term complications. The incidence of placental pathology is higher after a CD than in women with no previous CDs [Hemminki et al., 1996; Pallasmaa et al., 2008]. The risk for uterine rupture in post-CD pregnancies regardless of the mode of delivery was 0.34% (compared to 0.04% in pregnancies without previous CDs, $p<0.001$) in a Finnish study from 1997 and 2005 [Pallasmaa et al., 2008]. The risk of uterine rupture has been estimated to be approximately 0.5-0.9% in a trial of labor after a CD [ACOG 2017]. The risk of unexplained stillbirth is also increased in pregnancy following a CD, in addition to the risks of complicated labor, and a Scottish study estimated the overall absolute perinatal mortality risk from 39 gestational weeks onwards to be 1.06 per 1000 pregnancies after a CD compared to 0.47 per 1000 pregnancies without a preceding CD [Smith et al., 2003]. Perinatal mortality related to delivery in VD after a preceding CD has been estimated to be 0.04% [Royal College of Obstetricians and Gynecologists 2015], compared to 0.13-0.17% in vaginal breech delivery [Vlemmix et al., 2014; Macharey et al., 2017c].

Cesarean delivery has also been associated with chronic pain. As many as 18% of women with a CD reported pain one year after the delivery, compared to 10% after a VD in a Finnish study [Kainu et al., 2010]. Similarly, a Chinese study concluded that CD increases the incidence of chronic pelvic pain and has a negative effect on health-related quality of life [Li et al., 2014]. A niche formed in the uterine scar, present in 60% of women with a preceding CD, can cause abnormal uterine bleeding, dysmenorrhea and dyspareunia and may need surgical treatment [van der Voet et al., 2014].

8.3.3 The effect of parity

External version is recommended in term breech pregnancies to increase the rate of cephalic VD [Hofmeyr et al., 2015b]. The procedure is less often successful in primiparous women [Brocks et al., 1984], which explains the large proportion of primiparous mothers in the term breech groups compared to the term cephalic control groups. Furthermore, uterine anomalies, overrepresented in the breech groups, are associated with infertility and decreased live birth rate [Vaz et al., 2017]. The selection bias caused by not matching the groups by parity should result in underestimating rather than overestimating the good results, as the outcome of delivery tends to be more favorable in multiparous women. The higher rate of converting a trial of vaginal delivery to a CD in breech compared to cephalic deliveries may also be partly explained by the difference in parity, although the increased rate of CTG pathologies and lower threshold to conversion probably play a larger role. However, matching the groups by primiparity would have given more accurate and practical results.

As primiparity and previous CD have been associated with a negative delivery experience [Waldenström et al., 2004], the Study III controls were matched by whether the mother had given birth vaginally before or not, rather than by actual parity. Study II used similar strategy, as matching by both parity and the mode of previous deliveries was impossible due to small number of women. The delivery of a woman with one previous CD and no vaginal deliveries was thought to resemble the delivery of a primiparous woman more than the delivery of a multiparous woman.

8.4 Good neonatal and maternal outcomes after vaginal breech delivery (I-IV)

8.4.1 Neonatal outcome

No neonatal mortality was observed in this study, and neonatal morbidity in term breech deliveries was low. Although low one-minute Apgar scores were more common and the median umbilical artery pH was lower in the planned vaginal term breech group compared to the planned CD group, these markers reflect immediate, likely transient neonatal depression. Furthermore, despite the statistically significant difference, the median umbilical artery pH was within normal ranges in all newborns in the study; thus, no clinically significant difference was observed (median umbilical artery pH 7.28 in term planned vaginal breech deliveries, and 7.25 in preterm planned vaginal breech deliveries, compared to 7.32 in term and preterm planned cesarean breech deliveries). No differences were observed regarding more severe morbidity, such as admission rates to the NICU or the five-minute Apgar scores. Similar results have been described in studies from Austria [Maier et al., 2011] and from Turkey [Demirci et al., 2011].

Severe neonatal morbidity in moderately and late preterm breech deliveries was rare and no difference was observed in morbidity rates of infants born after either a trial of VD or by a primary CD. Median umbilical artery pH was lower in the trial of labor group compared to the CD group, but no differences were observed regarding a low five-minute Apgar scores, overall morbidity or NICU admission rates. A Swedish register-based study by Herbst et al. reported similar results on the incidence of low five-minute Apgar scores in late preterm breech infants [Herbst et al., 2007] but their data didn't allow comparisons of overall morbidity. However, they reported significantly increased risk of neonatal respiratory distress syndrome in late preterm breech infants born by CD compared to those born by VD. Similarly, in a Dutch register-based study by Bergenhenegouwen et al. the neonatal morbidity in preterm breech infants born after 32 completed gestational weeks was comparable between intended CD and intended VD [Bergenhenegouwen et al., 2015].

8.4.2 Maternal outcome

Several studies have reported increased maternal morbidity after CD compared to VD [Pallasmaa et al., 2008; Demirci et al., 2011]. However, studies comparing groups by actual rather than intended mode of delivery tend to underestimate the risks of a planned VD, as it may end in an acute CD which in turn has been demonstrated to carry more risks to the mother than an elective operation [Pallasmaa et al., 2008; Pallasmaa et al., 2010]. The intention-to-treat design of this study eliminates this bias. A successful VD was accomplished in 68.5% of the term and 89.7% of preterm breech deliveries that were selected for a trial of labor, rates that are comparable to those described in recent studies [Maier et al., 2011; Michel et al., 2011; Kessler et al., 2015]. Profuse bleeding and transfusions were more common in the planned CD groups compared to planned VD groups both in term and preterm breech deliveries, despite including the more risky emergency operations in the planned VD group.

8.5 Preventing a negative delivery experience (III)

The delivery experience in planned vaginal breech delivery was on average at least as positive as in cephalic delivery. Indications of an even more positive experience were observed in some aspects, but these results were not statistically significant. However, delivery by an emergency CD was associated with a more negative delivery experience, as in cephalic presentation [Waldenström et al., 2004]. Mothers should be better informed that to ensure fetal and maternal safety, the threshold to convert a trial of labor to an emergency CD is kept low in breech deliveries. This results in an increased risk of the delivery ending in an emergency CD in attempted vaginal breech delivery compared to cephalic deliveries.

Oxytocin augmentation, labor induction, or overall prolonged delivery were not associated with a negative experience in this study, unlike what was reported in a previous Swedish study [Waldenström et al., 2004] and in the Spanish validation study for the CEQ [Soriano-Vidal et al., 2016]. Adequate progress is an important

prerequisite for a successful vaginal breech delivery, and it is likely that breech deliveries with slow progress were more aggressively converted to a CD than cephalic deliveries. Primiparity was recognized as a risk factor for a negative experience in the current study and in the Spanish validation study [Soriano-Vidal et al., 2016]. Furthermore, infant birth trauma and a prolonged second stage of labor were demonstrated to increase the risk for a negative experience, as well as a prolonged hospital stay before or after the delivery. Extra support should be offered to mothers who have these risk factors.

More than 80% of women in both study groups felt that they could have a say in their pain relief. Analgesia should be offered similarly for women delivering either a breech or a cephalic infant, but women in the breech group responded totally disagreeing more often and totally agreeing less often that they felt having a say in the choice of pain relief. More attention should be focused on ensuring that these woman can choose their preferred method of pain relief.

Mothers in the breech group more often felt that they did not have a say on the birthing position, and indeed in the study hospital the birthing position is limited to the traditional semi-recumbent position. Bogner et al. reported their results on delivering breech fetuses on the all-fours position and concluded that it is an alternative to the classic semi-recumbent position [Bogner et al., 2015], but their report included only 41 pairs of classic and all-fours deliveries. More importantly, lower pH values were observed in the all-fours group compared to the classic group. Conversely, a recent German study described good results in upright vaginal breech delivery. Neonatal morbidity possibly related to the mode of delivery was reduced from 5% in the dorsal delivery position (40 women) to 0.9% in the upright delivery position (229 women), although the difference was not statistically significant [Louwen et al., 2017]. Thus, more data are needed before applying the results widely in clinical practice; however, the impact on the overall birthing experience of being unable to choose the birthing position is unclear. Many mothers noted on their responses that choosing the birthing position is not an option in breech delivery, accepting this as a fact. The Participation scale (including items on the birthing position) in the original validation study of the CEQ had rather small effect sizes in discriminating groups that are known to differ in childbirth experience, and the authors contemplated that the sensitivity of this scale

could be augmented with modification of the items [Dencker et al., 2010]. The expertise of midwives and physicians is crucial to the safety of vaginal breech delivery in any birthing position.

8.6 What parents expecting a breech infant should be told

Based on this study, vaginal breech delivery is an option if strict selection criteria are met and the delivery is managed in a high-resource setting with experienced staff. Transient neonatal depression is more common after planned vaginal breech delivery than after planned CD or planned vaginal cephalic delivery, but the risk of severe morbidity is not different from planned cesarean breech delivery or planned vaginal cephalic delivery. A recent Finnish study demonstrated that induction of labor can be used with standard obstetric indications, and induction at term may be advantageous [Macharey et al., 2016]. Analgesia is offered similarly as in cephalic deliveries. Pathologic CTG patterns are more common in breech than in cephalic deliveries, necessitating continuous CTG monitoring. The risk for converting the attempted VD to an emergency CD is higher and the birthing position during the second stage of delivery is limited compared to cephalic deliveries. With the exception of these differences, the average childbirth experience is as positive as in cephalic deliveries.

Studies from different settings have conflicting results regarding the neonatal outcome of a vaginal breech delivery, but no differences have been observed regarding long-term infant morbidity. CD carries an increased risk of maternal mortality and severe morbidity as well as risks regarding a subsequent pregnancy. The risks of VD after a CD should be discussed if the family is planning to have more children. Balancing the risks of the newborn and the mother can be very difficult and extra support should be offered to parents who must make this decision.

9 CONCLUSIONS

I Planning a vaginal delivery in term breech presentation is an option in selected cases.

II Allowing a trial of labor in selected preterm breech deliveries with a gestational age of at least 32 weeks does not result in an inferior neonatal outcome, and a routine policy of cesarean delivery could not be recommended based on this study

III Women's childbirth experience after an intended vaginal term breech delivery is as positive as after an intended cephalic delivery, when results are matched by actual mode of delivery.

IV Decreased variability and late decelerations are seen more often in breech compared to cephalic delivery. Pathological trace is associated with immediate neonatal depression in breech and cephalic deliveries, and especially complicated variable decelerations may signal more severe distress.

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12 ORIGINAL COMMUNICATIONS

AOGS
ACTA Obstetricia et Gynecologica Scandinavica

AOGS MAIN RESEARCH ARTICLE

Selective vaginal breech delivery at term – still an option

ELLI TOIVONEN[1], OUTI PALOMÄKI[2], HEINI HUHTALA[1,3] & JUKKA UOTILA[2]

[1]*University of Tampere, Tampere,* [2]*Department of Obstetrics and Gynecology, Tampere University Hospital, Tampere, and* [3]*Research Unit, Tampere University Hospital, Tampere, Finland*

Key words
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Correspondence
E. Toivonen, University of Tampere, School of Medicine, 33041 Tampere, Finland. E-mail: elli.toivonen@uta.fi

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The authors have stated explicitly that there are no conflicts of interest in connection with this article.

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Abstract

Objective. To compare the neonatal outcome between planned vaginal or planned cesarean section (CS) breech delivery and planned vaginal vertex delivery at term with singleton fetuses. *Design*. A cohort study. *Setting*. Delivery Unit, Tampere University Hospital, Finland, with 5200 annual deliveries. *Population*. The term breech deliveries over a period of five years (January 2004 to January 2009), a total of 751 breech deliveries, and 257 vertex controls. *Methods*. The data were collected from the mother's medical records, including a summary of the newborn. In the case of neonatal health problems, the pediatric records were also examined. *Main outcome measures*. Maternal and neonatal mortality and morbidity as defined in the Term Breech Trial. Low Apgar scores or umbilical cord pH as secondary endpoints. *Results*. There was no neonatal mortality. Severe morbidity was rare in all groups, with no differences between groups. The Apgar scores at one minute were lower in the planned vaginal delivery group compared with the other groups, but there was no difference at the age of five minutes. Significantly more infants in the vaginal delivery group had a cord pH < 7.05. There was one maternal death due to a complicated CS in the planned CS group and none in the other groups. Mothers in the planned CS group suffered significantly more often from massive bleeding and needed transfusions. *Conclusions*. Vaginal delivery remains an acceptable option for breech delivery in selected cases.

Abbreviations: CS, cesarean section; NICU, neonatal intensive care unit; planned CS, planned breech cesarean section; planned VD, planned vaginal breech delivery.

Introduction

About 3–4% of fetuses remain in breech presentation at term. A breech birth seems to predispose newborn children to asphyxia and birth traumas, and thus the method of delivery has been a subject of debate for decades. The Term Breech Trial by Hannah et al. in 2000 is by far the largest randomized controlled trial on the subject. The results of that study strongly favored elective cesarean section as the method of delivery; neonatal mortality and serious morbidity were threefold in the planned vaginal delivery group compared with the elective cesarean section (CS) group (1). The study affected clinical practice and guidelines in many countries (2–4), and subsequently, some studies showed reduced neonatal mortality and morbidity rates due to increased numbers of planned CSs (3,4).

However, the Term Breech Trial was not universally accepted (5,6). In particular, its validity was questioned because the level of care in some centers was not comparable to Western hospitals (7). Due to criticism of the Term Breech Trial, and the fact that many non-randomized population-based studies failed to find a link between poor perinatal outcome and vaginal breech delivery (8–12), new guidelines were published permitting vaginal delivery in selected cases of breech presentation (13).

Key Message

With careful selection of patients and a low trigger point for change in mode of delivery, vaginal breech delivery is still an acceptable option.

In Finland, the vast majority of breech deliveries take place in hospitals with continuous anesthesia and pediatric coverage, as well as equipment for cardiotocographic and ultrasonographic monitoring of the fetus. Moreover, pregnancy care ensures that at-risk pregnancies are identified and the mode of delivery planned accordingly. After the Term Breech Trial, the role of planned CS as the method of delivery has increased also in our hospital, but for a significant proportion of breech presentations a trial of vaginal delivery is still allowed.

The aim of the present study was to assess selective vaginal breech delivery in the era after the Term Breech Trial. During the study period, the results of the Term Breech Trial had led to an elevated rate of elective cesarean sections, but vaginal delivery still remained an acceptable option. The neonatal and maternal outcomes of planned vaginal breech delivery (planned VD) were compared with those after planned breech cesarean section (planned CS) or planned vaginal delivery in vertex presentation.

Material and methods

The patient records of Tampere University Hospital from January 2004 to January 2009 were searched for deliveries with fetuses in breech presentation. As this was a cohort study and deliveries were managed according to the hospital's standard protocol, informed consent of the patients was not required. The study protocol was approved by the ethical committee. Only live singleton fetuses with a gestational age of at least 37 weeks were included. These were divided into two groups, depending on the intended method of delivery. Those that were planned to be delivered by elective cesarean section were classified as planned CS, whereas those planned to be delivered vaginally were classified as planned vaginal delivery, regardless of the actual mode of delivery. Some of the breech presentations were not diagnosed until late pregnancy, some not even before the onset of labor, and these were classified as vaginal if a trial was allowed and as planned CS if not, even though the actual mode of delivery in these cases was mostly emergency CS. As a result of this, some of the babies in the elective CS group were born after a gestational age of 40 weeks. For every planned vaginal breech delivery, a term, singleton fetus in vertex presentation was selected as a control. The vertex control was the next delivery recorded after the breech delivery in the delivery room logbook, excluding elective CSs. Nineteen infants suffering from congenital diseases were excluded, and the final study population totaled 1008 deliveries, of which 497 (66.2% of breech deliveries) were in the planned CS group, 254 (33.8% of breech deliveries) in the planned VD group, and 257 in the vertex group. The delivery unit is a tertiary center with about 5200 annual deliveries. During the study period, there were a total of 24 850 deliveries in our hospital, and the incidence of term, singleton breech delivery was thus 3.1%. The overall CS rate during the study period varied between 15.6 and 18.1%.

The data were obtained mainly from the mother's medical records concerning the delivery, which also included summary information on the newborn infant's health during the mother's hospital stay. If the child had health problems, the pediatric records were also examined.

A little less than half (44.7%) of the breech presentations had been subjected to an attempted version. During the study period, 40% of attempts were successful. The mothers willing to attempt vaginal delivery were examined by pelvic X-ray or magnetic resonance imaging to rule out a narrow pelvic outlet (defined as interspinous diameter <10 cm, intertuberous diameter <10 cm, sagittal outlet diameter <10 cm, or the sum of these three diameters <32 cm). The fetus was evaluated by ultrasonography, and if the estimated fetal weight exceeded 4000 g, vaginal delivery was contraindicated. During labor, the fetal heart rate was continuously monitored, and if there were signs of serious fetal distress, an emergency CS was performed (crash emergency CS within 10 min, and in less urgent situations, emergency CS within 20–40 min). Fetuses were delivered by obstetricians or experienced residents. As is the hospital's practice, the Løvset and Mauriceau maneuver was generally used. In our hospital, forceps are not used in breech deliveries. The criteria for breech delivery at our hospital are similar to those presented in the Society of Obstetrics and Gynecology of Canada guidelines in 2009 (14).

Two previous CSs were considered an indication for an elective CS, as well as hyperextension of the fetal head and any presentation other than frank or complete breech. However, the most common indication was either the mother's fear of vaginal delivery or her expressed desire for an elective CS.

The primary end-point was neonatal mortality or serious morbidity and serious maternal morbidity, according to the criteria of the Term Breech Trial (1). Low Apgar scores, defined as ≤ 6, at one or five minutes, and an umbilical artery pH <7.05 were secondary end-points.

All statistical analyses were performed using SPSS for Windows 14.0 (SPSS Inc., Chicago, IL, USA). Quantitative data were expressed as medians with minimum and maximum values. The results of categorical variables were described by percentages. The comparisons were performed between the planned VD and planned CS groups, and also between the planned VD and vertex groups. The Mann–Whitney U-test, Fisher's exact test and chi-squared test were used, as appropriate. A p-value of <0.05 was considered statistically significant. All p-values are two-sided.

Results

The mode of delivery changed significantly more often and was more often emergency CS in the planned VD group

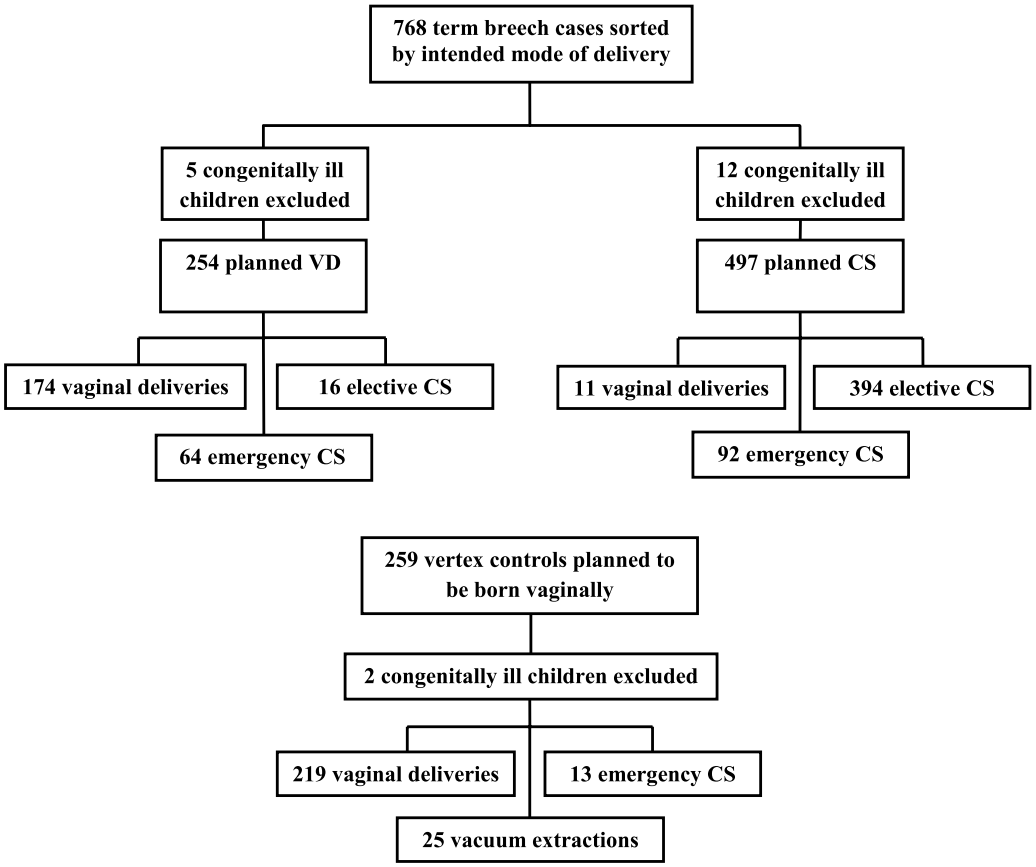

Figure 1. The intended and actual modes of delivery within the study group. Abbreviations: CS, cesarean section; planned VD, planned vaginal breech delivery; and planned CS, planned breech cesarean section.

compared with both other groups. Of all the breech deliveries, 185 (24.6%) were actually vaginal, 410 (54.6%) elective CSs, and 156 (20.8%) emergency CSs. Figure 1 shows the intended and actual modes of delivery of the study population.

Demographic data and some other maternal and delivery parameters compared between the groups are detailed in Table 1. Mothers in both of the breech presentation groups were significantly more often primiparous than mothers in the vertex group. There was also a significant difference in chronic maternal morbidity between the breech delivery groups. The prevalence of uterine and genital anomalies was higher among the breech groups compared with the vertex group. Breech presentation was diagnosed before the onset of labor significantly more often in the planned CS group. When comparing the breech groups, the pregnancy continued over 41 weeks significantly more often in the planned VD group, and the median duration of pregnancy was slightly longer. In the vertex group, the gestational age at delivery was even more often over 41 weeks and the median duration of pregnancy the longest.

There was no neonatal mortality in the study population. Newborns in both the planned CS group and vertex group had Apgar scores of 7 or higher more often and lower scores less often than in the planned VD group at the age of one minute, but there was no significant difference at the age of five minutes. Also reflecting the less favorable immediate outcome of the delivery, infants in the planned VD group had an umbilical cord pH of <7.05 significantly more often than infants in either the planned CS or vertex group. Infants in the planned VD group suffered significantly more often from neonatal infections compared with the planned CS group, but the rate of infections in the planned VD group was similar to the vertex group. However, there was no difference between the groups in the frequency of admission to the neonatal intensive care unit (NICU). Neonatal outcome in the groups is shown in Table 2.

Table 1. Demographic data and some parameters concerning the mother or the delivery, compared in the groups of planned vaginal breech delivery (planned VD), planned breech cesarean section (planned CS) and vertex delivery.

	Planned VD ($n = 254$)		Planned CS ($n = 497$)		p-Value (planned VD vs. planned CS)	Vertex ($n = 257$)		p-Value (planned VD vs. vertex)
	n or median	Percentage or range	n or median	Percentage or range		n or median	Percentage or range	
Mother's age (years)	29	18–44	30	16–45	0.014	29	17–46	0.67
Primiparous	168	66.1	346	69.6	0.33	111	43.2	<0.001
No previous vaginal deliveries	174	68.5	393	79.6	0.001	121	49.0	<0.001
Gestational diabetes	33	13.0	66	13.3	0.91	31	12.1	0.75
Pregestational diabetes	1	0.4	5	1.0	0.37	2	0.8	0.57
Hypertensive conditions	16	6.3	44	8.9	0.22	12	4.7	0.42
Any chronic illness	30	11.8	112	22.5	<0.001	26	10.1	0.54
Uterine or genital anomalies[a]	6	2.4	20	4.0	0.24	0		0.013
Attempted cephalic version	120	47.2	216	43.5	0.32	–		–
The breech presentation was not diagnosed before labor	43	16.9	29	5.8	<0.001	–		–
The mode of delivery was not the planned one	80	31.5	103	20.7	0.001	38	14.8	<0.001
Emergency cesarean section	64	25.2	92	18.5	0.033	13	5.1	<0.001
Gestational age at delivery weeks	39^{+6}	37^{+0}–42^{+2}	39^{+1}	37^{+0}–42^{+2}	<0.001	40^{+1}	37^{+0}–42^{+3}	0.004

Note: Values are expressed as medians and ranges or n and percentages.
[a]Mostly unicornic uterus or uterus duplex.

The occurrence of severe morbidity was low. Three neonates among breech infants (one in the planned CS and two in the planned VD groups) and three in the vertex group had serious neonatal morbidity, according to the criteria of the Term Breech Trial (1). There was no difference in overall neonatal morbidity between the groups. There were two birth traumas in the planned VD group, one in the vertex group and none in the planned CS group. In contrast, there were no occurrences of long NICU stay or Apgar scores of <4 in the planned VD group, whereas in the other groups

Table 2. Neonatal outcome compared in the groups of planned VD, planned CS and vertex delivery.

	Planned VD ($n = 254$)		Planned CS ($n = 497$)		p-Value (planned VD vs. planned CS)	Vertex ($n = 257$)		p-Value (planned VD vs. vertex)
	n or median	Percentage or range	n or median	Percentage or range		n or median	Percentage or range	
Birthweight (g)	3320	1935–4543	3380	1750–4760	0.33	3630	2320–4775	<0.001
One minute Apgar								
≥7	193	76.0	459	92.4	<0.001	246	95.7	<0.001
<4	15	5.9	8	1.6	0.001	6	2.3	0.042
Five minute Apgar								
≥7	250	98.4	493	99.2	0.33	255	99.2	0.40
<4	0		1	0.2	0.47	1	0.4	0.32
Umbilical artery pH	7.28	6.80–7.46	7.32	7.01–7.52	<0.001	7.29	7.05–7.54	0.044
Missing data	6	2.4	27	5.4	0.052	4	1.6	0.51
Umbilical artery pH <7.05	6	2.4	1	0.2	0.004	0		0.013
Child admitted to NICU	2	0.8	4	0.8	0.98	1	0.4	0.56
Perinatal infection	11	4.3	6	1.2	0.006	10	3.9	0.80
Hyperbilirubinemia	7	2.8	8	1.6	0.29	7	2.7	0.98
Hypoglycemia	12	4.7	16	3.2	0.30	3	1.2	0.017

Note: Values are expressed as medians and ranges or n and percentages. Abbreviation: NICU, neonatal intensive care unit.

Table 3. Serious neonatal morbidity, defined according to the Term Breech Trial (1), excluding significant congenital illnesses – case reports.

Group	Actual mode of delivery	Description
Vertex	Vaginal delivery, 38^{+3} weeks	Apgar 8–2-8[a], pH 7.35, no need for NICU. Pediatric diagnosis: wet lung
Vertex	Vaginal delivery, 38^{+1} weeks	Apgar 9–9[b], pH 7.27, no need for NICU. The umbilical cord was ruptured and baby received transfusion of red blood cells
Vertex	Acute cesarean section, 38^{+2} weeks	Apgar 2–5[b], pH 7.19, eight days in NICU. Diagnosis: asphyxia
Intended vaginal	Vaginal delivery, 40^{+0} weeks	Apgar 8–9[b], pH 7.33, no need for NICU. Diagnosed with mild Erb's palsy and recovered in two weeks
Intended vaginal	Vaginal delivery, 39^{+2} weeks	Apgar 4–7-9[a], pH 7.21, no need for NICU. Diagnosis: clavicular fracture
Planned CS	Elective CS, 40^{+3} weeks	Apgar 1–2-8[a], pH 7.30, six days in NICU. Diagnosis: meconium aspiration syndrome

[a]Apgar score at 1, 5 and 15 minutes of age
[b]Apgar score at 1 and 5 minutes of age
Abbreviation: NICU, neonatal intensive care unit.

there was one of each. The incidents of severe morbidity, defined according to the Term Breech Trial (1), are detailed in Table 3.

In the planned CS group, one mother died of a pulmonary embolism 12 days after an elective CS. The operation included hysterectomy due to uncontrolled bleeding because of a placenta previa. Women in the planned CS group suffered significantly more often from massive bleeding (defined as >1500 mL) requiring transfusions. There were no significant differences between the groups in the frequency of puerperal infections or surgical complications (Table 4).

After comparing the intention-to-treat groups, some analysis on the breech deliveries was made of the groups according to the actual mode of delivery. Severe bleeding (>1500 mL) was significantly more common among cesarean sections, occurring in 1.1% of vaginal deliveries, 8.0% of elective CSs ($p = 0.001$ in comparison to vaginal deliveries) and 6.4% of emergency CSs ($p = 0.008$ in comparison to vaginal deliveries). There were no statistically significant differences in neonatal morbidity or admittance to the NICU.

When comparing primiparous and multiparous women who actually gave birth vaginally, it was noted that breech infants of primiparous mothers received Apgar scores of <4 at one minute significantly more often (9.3 vs. 0%; $p = 0.010$) than breech infants of multiparous women, but there were no significant differences in the Apgar scores at five minutes. Median pH was lower (7.22, range 6.89–7.46) in the breech infants born to primiparous women in comparison to breech infants born to multiparous women (7.31, range 7.09–7.46; $p < 0.001$). Median pH of breech infants born to primiparous mothers was also lower in comparison to vertex infants born to primiparous women (7.29, range 7.09–7.41; $p = 0.002$). There was no difference in NICU admittance or infant morbidity between the primiparous and multiparous breech delivery groups.

Table 4. Maternal complications compared in the groups of planned VD, planned CS and vertex delivery.

	Planned VD ($n = 254$)		Planned CS ($n = 497$)		*p*-Value (planned VD vs. planned CS)	Vertex ($n = 257$)		*p*-Value (planned VD vs. vertex)
	n	Percentage	*n*	Percentage		*n*	Percentage	
Death	0		1	0.2	–	0		–
Bleeding >1500 mL	5	2.0	40	8.0	0.001	6	2.3	0.78
Received transfusions	8	3.1	33	6.6	0.046	6	2.3	0.57
Curettage	3	1.2	1	0.2	0.08	3	1.2	0.99
Evacuated hematoma	0		4	0.8	0.15	0		
Puerperal infections[a]	25	9.8	36	7.2	0.22	17	6.6	0.18
Ileus	1	0.4	1	0.2	–	0		–
Surgical injury	0		2	0.4	–	0		–
Any complication	40	15.7	77	15.5	0.93	27	10.5	0.08

Note: Values are expressed as *n* and percentages.
[a]Excluding mastitis and respiratory infections.

Discussion

As in many centers with the tradition of vaginal breech delivery, the guidelines following the publication of the Term Breech Trial were not entirely accepted in our hospital, even though the frequency of elective CS as the method of breech delivery has increased. Our study was a follow-up to the study by Uotila et al. done in 1995–2002 in the same hospital (8), and it was noted that the proportion of intended CSs has increased from one in three to two in three. In the present study, neonatal morbidity remained low and was even lower in both of the breech groups when compared with the previous study (8). The large proportion of primiparous women in the breech groups compared with the vertex group was probably because external version is more often successful among multiparous women. The parity of the vertex group was not matched to the breech group. As there were significantly more primipara in the breech group, the comparison to vertex deliveries might include some bias. However, as the delivery outcome is more favorable in multiparous than in primiparous women, this selection bias might make our study underestimate the already good results. The high proportion of primipara among the breech deliveries also partly explains the fact that the actual manner of delivery was changed from vaginal to CS in 31% of the deliveries in the planned VD group. However, the rate of change in delivery mode was comparable to that of recent studies (15,16). The higher prevalence of maternal chronic illnesses in the planned CS group is probably partly due to the fact that vaginal delivery was sometimes contraindicated because of the mother's illness.

In accordance with previous reports (1,9,17,18), vaginal breech delivery seemed to predispose infants to low one minute Apgar scores and lower umbilical cord pH in our material, especially in primiparous mothers. Birth traumas, although rare, and perinatal infections were also more common among the babies born vaginally. However, no evidence of overall increased mortality or severe morbidity among infants either born or intended to be born vaginally emerged in the present study, nor were there differences in the five minute Apgar scores or the proportion of neonates admitted to the NICU. Two recent studies have provided similar results and concluded that, if strict selection criteria are met, vaginal delivery is as safe as planned CS and lacks the possible complications in the next pregnancy (16,19). In one single center, the rate of vaginal deliveries has even been increased without impairing the neonatal outcome by using a decision protocol (15). In our study, CS seems to have increased the mother's risk of massive bleeding. The maternal death preceded by a complicated CS and massive bleeding shows that, though usually safe, CS carries a small chance of life-threatening complications. Previous reports have also shown that CS carries an increased risk of immediate as well as long-term maternal complications (20–24). Moreover, it has been suggested that vaginal delivery plays an important role in the maturation of the newborn (25,26). The long-term effects of vaginal delivery were not studied, but previous studies have not found differences in long-term neurological morbidity (9,27).

Given the overall good neonatal outcome and the increased risk of massive bleeding in the planned CS group, our study demonstrates that the dilemma of breech delivery remains. With a proper selection of patients for trial of vaginal delivery, and a low trigger point for change in mode of delivery if there are signs of asphyxia or poor progress of labor, vaginal breech delivery is still an acceptable option.

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Full length article

Impact of the mode of delivery on maternal and neonatal outcome in spontaneous-onset breech labor at 32^{+0}–36^{+6} weeks of gestation: A retrospective cohort study

Elli Toivonen[a,*], Outi Palomäki[b], Päivi Korhonen[c], Heini Huhtala[d], Jukka Uotila[b]

[a] School of Medicine, University of Tampere, Tampere, Finland
[b] Department of Obstetrics and Gynecology, Tampere University Hospital, Tampere, Finland
[c] Department of Pediatrics, Tampere University Hospital, Tampere, Finland
[d] Faculty of Social Sciences, University of Tampere, Tampere, Finland

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ABSTRACT

Objective: To compare neonatal and maternal outcomes in spontaneously onset preterm breech deliveries after trial of labor (BTOL) and intended cesarean section (BCS), and between BTOL and vertex control deliveries, in singleton fetuses at 32^{+0}–36^{+6} weeks of gestation.
Study design: Retrospective single center cohort study in a Finnish University Hospital including all spontaneous-onset preterm breech deliveries with 32 completed gestational weeks in 2003–2015. The study population comprised a total of 176 preterm breech and 103 vertex control deliveries, matched by gestational age and whether the mother had given birth vaginally before or not. Infants with severe malformations and antepartum fetal distress were excluded. Subgroup analyses were made in two cohorts according to gestational age. Main outcome measures were maternal and neonatal mortality and morbidity, low cord pH and Apgar score.
Results: No mortality was observed, and severe morbidity was rare. No difference in incidence of low cord pH or five-minute Apgar score was observed between the groups. Apgar scores at the age of one minute were comparable in the breech groups but more often low in the BTOL group compared to the vertex control group. 16.5% of neonates in the BTOL group, 23.3% in the BCS group and 7.8% in the vertex group needed intensive care. In logistic regression analysis, lower gestational age and being small for gestational age were associated with the need for neonatal intensive care. Being allowed a trial of labor was not associated with the need for neonatal intensive care. Maternal morbidity was similar across the groups, but median blood loss was more pronounced in the BCS group compared to the BTOL group.
Conclusion: In breech deliveries at 32^{+0}–36^{+6} gestational weeks, trial of labor did not increase neonatal morbidity compared to intended cesarean delivery. Infants born after a trial of labor in breech presentation display low one-minute Apgar score and need intensive care more often compared to vertex controls.

Introduction

Preterm birth occurs in 6–11% of deliveries and predisposes infants to excess mortality and morbidity [1]. Randomized data on the optimal mode of preterm delivery are sparse, and a 2013 Cochrane review could not recommend a policy of either vaginal or planned cesarean delivery for preterm deliveries irrespective of the fetal presentation [2]. In premature breech deliveries the optimal mode of delivery is even more controversial, as evidence concerning term breech deliveries is conflicted [3–7], and the circumstances of preterm breech delivery do not permit randomized controlled trials [8,9].

Although the incidence of breech presentation is highest in very preterm deliveries and decreases as gestational age advances [10], it is also more common in moderately and late preterm deliveries than term deliveries. Furthermore, as the majority of preterm deliveries consist of late preterm deliveries and morbidity is still higher than in term deliveries [11–13], their impact on the healthcare system is considerable.

Abbreviations: TOL, trial of labor; BTOL, breech trial of labor; CS, cesarean section; BCS, breech cesarean section; NICU, neonatal intensive care unit.

* Corresponding author at: Tampere University, 33014 Tampere University, Tampere, Finland.
E-mail address: toivonen.elli.m@student.uta.fi (E. Toivonen).

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The aim of this study was to compare the neonatal and maternal outcomes of moderately and late preterm breech deliveries with spontaneous onset of labor at 32^{+0}–36^{+6} gestational weeks between groups of intended vaginal and intended cesarean deliveries. A secondary goal was to compare the neonatal outcomes between preterm breech and vertex deliveries after a trial of vaginal delivery.

Materials and methods

All singleton preterm breech deliveries at 32^{+0}–36^{+6} weeks of gestation from April 2003 to December 2015 in Tampere University Hospital were evaluated for inclusion. Fig. 1 demonstrates the composition of the study population. As the cause necessitating iatrogenic delivery may affect both neonatal and maternal outcome, only deliveries with spontaneous onset of labor were included. Fetuses with severe malformations were excluded, as well as fetuses whose prognosis was unfavorable due to antepartum fetal distress, as in cases with pathological antepartum cardiotocography trace necessitating acute cesarean section.

Breech deliveries were grouped by intended mode of delivery, resulting in 103 deliveries in the breech trial of labor cohort (BTOL) and 73 in the intended breech cesarean delivery cohort (BCS). Furthermore, for every delivery in the BTOL group, a vertex control was established using the delivery room logbook. All 103 controls were intended vaginal deliveries with spontaneous onset of labor, matched by gestational age at delivery (±5 days) and whether the mother had given birth vaginally before or not. These deliveries formed the vertex trial of labor group (TOL). Data were collected from the medical records of mothers and infants.

To control confounding in delivery outcome due to different degrees of prematurity, subgroup analysis was conducted in two cohorts according to gestational age. The moderately preterm cohort consisted of deliveries from 32^{+0} to 33^{+6} gestational weeks and included 19 BTOL deliveries, 18 BCS deliveries, and 17 vertex TOL deliveries. The late preterm cohort covered deliveries from

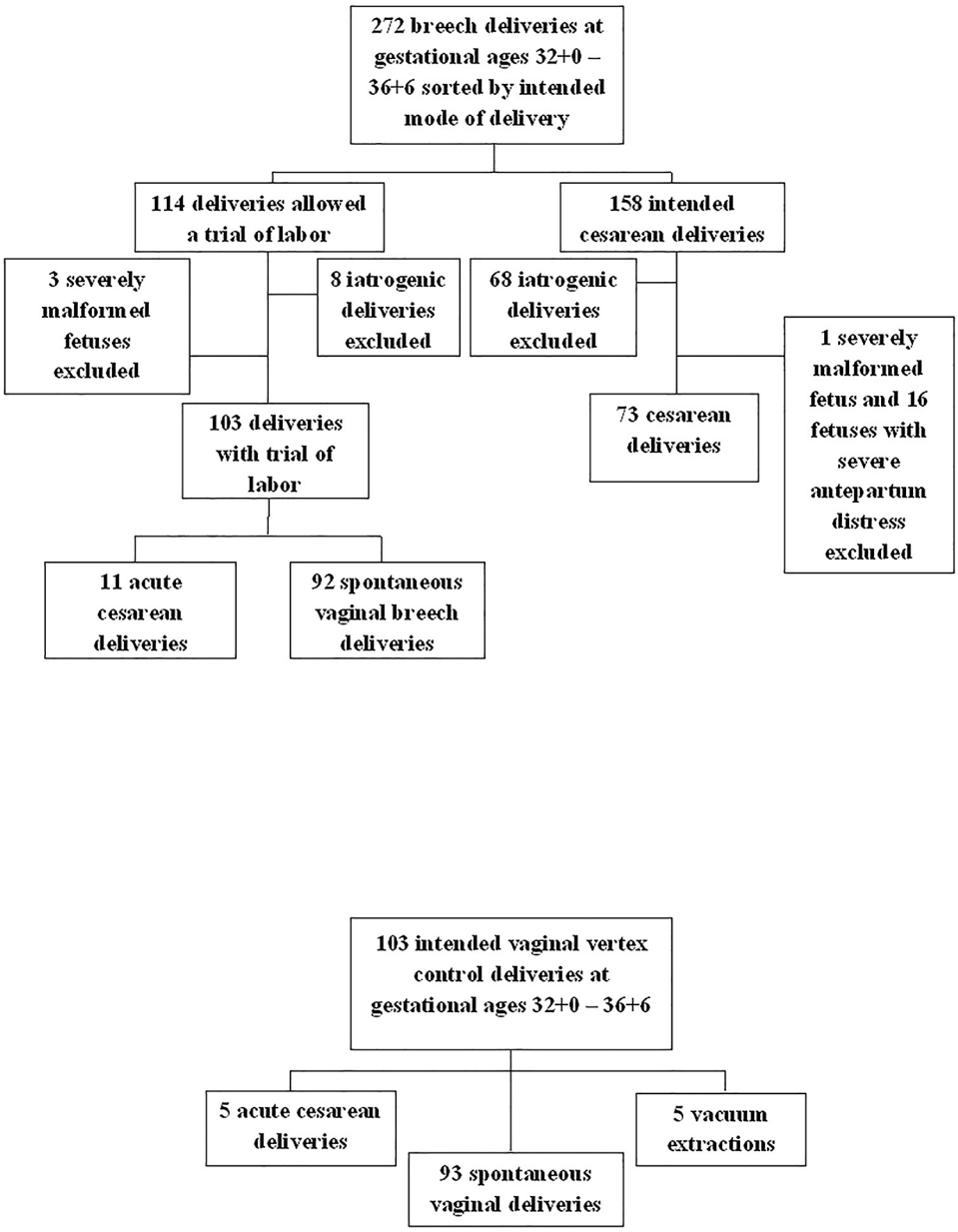

Fig. 1. Intended and actual modes of preterm breech and vertex control deliveries.

34^{+0} to 36^{+6} gestational weeks and included 84 deliveries in the BTOL group, 55 in the BCS group, and 86 in the vertex TOL group. In addition to subgroup analysis, logistic regression analysis was performed on all breech deliveries with spontaneous labor to identify risk factors for the need of neonatal intensive care.

The study hospital is a tertiary center with 5 000 deliveries annually, including all deliveries from nearby communities as well as high-risk deliveries (such as very preterm deliveries and those with fetal anomalies) from secondary centers located more peripherally. Gestational age was confirmed by ultrasound in the early pregnancy in the state-provided general ultrasound screening program. When the risk for premature labor was established before 35^{+0} gestational weeks, two doses of intramuscular betamethasone were administered with an interval of 24 h to accelerate lung maturation, unless the delivery advanced despite tocolytic agents or was urgent due to fetal or maternal factors. Magnesium sulphate was administered intravenously in threatening eclampsia. Terbutaline, atosiban, progesterone derivatives and transdermal nitroglycerin were used in different forms and combinations in attempt to delay the delivery before 35 completed gestational weeks, if fetal or maternal complications did not warrant delivery.

The mode of delivery was chosen by obstetric indications, and maternal preference was taken into account when clinically possible. Two or more previous cesarean sections were considered contraindications for vaginal delivery, as well as any presentation other than frank, complete or incomplete breech. Vaginal deliveries of breech infants were managed by obstetricians, and vertex vaginal deliveries by midwives, unless complications other than prematurity warranted obstetrician intervention. Emergency cesarean section could be performed within 10 min, although most of the operations were not this urgent.

Pediatric and anesthetic services as well as neonatal intensive care were continuously available. Following hospital protocol, all neonates with gestational age less than 35 weeks or birthweight less than 2000 g are routinely admitted to the neonatal ward. Criteria for neonatal intensive care unit (NICU) admission included gestational age less than 33 weeks, birthweight less than 1500 g or the need for respiratory support or cardiovascular monitoring. Infants weighing less than −2 standard deviations of expected fetal weight [14] were considered small for gestational age. Neonatal outcome measures included Apgar score, umbilical artery pH, neonatal death, admission to NICU, intubation and neonatal morbidity. Respiratory morbidity included problems that warranted additional care or monitoring, ranging from transient apneas and need of oxygen therapy to severe respiratory distress syndrome and mechanical ventilation. NICU admission was used as surrogate marker for adverse neonatal outcome in order to conduct logistic regression analyses.

Statistical analyses were performed using SPSS for Windows version 22.0. Quantitative data were described as median, minimum and maximum values. Categorical values were described in percentages. The differences between the BTOL group and BCS group were analyzed, as well as differences between the BTOL and vertex TOL groups. Chi-square and Mann-Whitney *U* test were used, as appropriate. Odds ratios (OR) and their 95% confidence intervals (CI) were calculated using binary forward logistic regression. *P* values of less than 0.05 were considered significant, and all *p* values are two-tailed.

Ethical approval

The study protocol was approved by the Pirkanmaa Hospital District's ethical committee (decision R12236, 13th November 2012).

Results

Demographic data of the groups are summarized in Table 1. Infants in the BTOL group were smaller at birth than vertex TOL controls. No differences in antepartum maternal morbidity was seen between the groups with the exception of uterine and genital anomalies, which were less common in the BTOL group compared to the BCS group, but more common in the BTOL group than in the vertex group. In the BTOL and vertex groups, the most common indication for an acute cesarean delivery was intrapartum asphyxia (n = 7 in the BTOL group and n = 4 in the vertex group), whereas the most common indication for a cesarean delivery in the BCS group was mother's choice (n = 34), and the operation was acutely performed because of spontaneous onset of labor.

Neonatal mortality was not observed. Apgar scores at the age of one minute were comparable between the breech groups but more

Table 1
Background data of preterm breech deliveries with spontaneous onset of labor by intended mode of delivery and compared to vertex controls. Tampere University Hospital, 2003–2015.

	Breech				p value (BTOL vs BCS)	Vertex		p value (BTOL vs vertex)
	Trial of labor (BTOL) n = 103		Planned CS (BCS) n = 73			Trial of labor n = 103		
	n or median	% or range	n or median	% or range		n or median	% or range	
Gestational age at delivery	35^{+6}	32^{+2}, 36^{+6}	35^{+4}	32^{+0}, 36^{+6}	0.282	35^{+5}	32^{+0}, 36^{+6}	0.682
Birthweight	2540	1505, 4035	2470	1260, 3670	0.249	2680	1820, 3650	0.034
Small for gestational age	7	6.8	9	12.3	0.208	2	1.9	0.088
Had received antenatal corticosteroids	30	29.1	29	39.7	0.149	32	31.1	0.761
Mode of delivery								
- Vaginal	92	89.3	0	0	<0.001	98	95.1	0.118
- Acute CS	11	10.7	59	80.2	<0.001	4	3.9	0.061
Mother's age (years)	29	19, 42	30	17, 44	0.102	30	20, 42	0.379
Primiparous	66	64.1	45	61.6	0.742	65	63.1	0.885
Smoking during pregnancy	14	14.1	7	10.1	0.441	16	16.0	0.714
Diabetes[a]	18	17.5	15	20.5	0.607	22	21.4	0.481
Hypertensive conditions	6	5.8	5	6.8	0.782	4	3.9	0.517
Uterine or genital anomalies	8	7.8	13	17.8	0.043	1	1.0	0.017

[a] Pregestational or gestational diabetes.

Table 2
Neonatal outcomes of premature breech deliveries with spontaneous onset of labor by intended mode of delivery and compared to vertex controls. Tampere University Hospital, 2003–2015.

	Breech				p value (BTOL vs BCS)	Vertex		p value (BTOL vs vertex)
	Trial of labor (BTOL) n = 103		Planned CS (BCS) n = 73			Trial of labor n = 103		
	n or median	% or range	n or median	% or range		n or median	% or range	
One minute Apgar score					0.138			<0.001
- 7 or more	73	70.9	60	82.2		96	93.2	
- 4–6	18	17.5	10	13.7		6	5.8	
- 3 or less	12	11.7	3	4.1		1	1.0	
Five minute Apgar score					0.697			0.151
- 7 or more	94	91.3	67	91.8		100	97.1	
- 4–6	8	7.8	6	8.2		2	1.9	
- 3 or less	1	1.0	0	0		1	1.0	
Umbilical artery pH	7.25	7.03, 7.46	7.32	7.08, 7.40	<0.001	7.26	7.08, 7.45	0.318
Child admitted to NICU	17	16.5	17	23.3	0.261	8	7.8	0.055
Intubation	2	1.9	1	1.4	0.773	2	1.9	1
Respiratory morbidity[a]	11	10.7	7	9.6	0.814	7	6.8	0.324
Neonatal infection[b]	2	1.9	2	2.7	0.726	0	0	0.155
Hypoglycemia	15	14.6	16	21.9	0.207	17	16.5	0.700
Days in NICU or neonatal ward	12	1, 47	11	1, 34	0.316	10	1, 34	0.039

[a] Respiratory problems warranting additional care or monitoring.
[b] Positive blood culture.

often low in the BTOL group compared to the vertex TOL group. No difference was observed between the groups at the age of five minutes. Median umbilical artery pH was lower in the BTOL group compared to the BCS group, whereas no difference was observed between the BTOL and vertex TOL groups. Umbilical artery pH values below 7.00 were not detected in the study population. Compared to the vertex group, rate in NICU admissions was twofold in the BTOL group and almost threefold in the BCS group, although the differences between the breech groups and between the BTOL group and vertex group did not reach statistical significance. One infant in the BTOL group had seizures and one in the BCS group and two in the vertex TOL group were diagnosed with grade 1 intracerebral hemorrhage. Details of neonatal outcome are described in Table 2. No differences in maternal complications or puerperal infections were observed between the groups, excluding median blood loss, which was less severe in the BTOL group than in the BCS group. Maternal complications are detailed in Table 3.

Univariate risk factor analyses for the need of neonatal intensive care among all breech deliveries with spontaneous labor are shown in Table 4. Multivariable analysis identified lower gestational age ($p < 0.001$, OR 0.24, 95%CI; 0.16–0.38) and being small for gestational age (p = 0.018, OR 7.39, 95%CI; 1.40–39.03) as independent risk factors for the need of neonatal intensive care. Intended mode of delivery was not associated with the need for neonatal intensive care in univariate or multivariable analyses.

Subgroup analyses of spontaneous onset deliveries according to gestational age

Analysis of the moderately preterm cohort showed no differences in Apgar scores between the breech groups, but compared to the vertex TOL group Apgar scores at the age of both one and five minutes were more often low in the BTOL group. In the late preterm cohort, infants in the BTOL group had low Apgar score more often at the age of one minute compared to both the BCS group and to the vertex TOL group, but no differences were observed between the groups at the age of five minutes. Admittance to NICU, respiratory morbidity and length of pediatric care were similar in all groups in both cohorts. See Table 5 for details of subgroup analyses according to gestational age.

Comment

The protective effect of cesarean delivery on the breech fetus is controversial [15], especially in the case of premature breech birth. Herbst and associates analyzed all preterm breech deliveries in Sweden within a 12-year period and demonstrated that cesarean

Table 3
Maternal outcomes of premature breech deliveries with spontaneous onset of labor by intended mode of delivery and compared to vertex controls. Tampere University Hospital, 2003–2015.

	Breech				p value (BTOL vs BCS)	Vertex		p value (BTOL vs vertex)
	Trial of labor (BTOL) n = 103		Planned CS (BCS) n = 73			Trial of labor n = 103		
	n or median	% or range	n or median	% or range		n or median	% or range	
Median blood loss	350	150, 1450	500	150, 2100	<0.001	350	100, 1800	0.978
Blood loss ≥1500 mL or transfusions	4	3.9	5	6.8	0.379	2	1.9	0.407
Puerperal infection[a]	4	3.9	6	8.2	0.221	2	1.9	0.407
Surgical complication								
- Relaparotomy	1	1.0	0	0	0.399	0	0	0.316
- Curettage	1	1.0	1	1.4	0.806	1	1.0	1
- Bowel or bladder lesion	0	0	2	2.7	0.091	0	0	
Any of above	8	7.8	11	15.1	0.124	5	4.9	0.390

[a] Excluding mastitis and respiratory infections.

Table 4
Univariate analyses of spontaneously onset breech deliveries according to neonatal outcome. Tampere University Hospital, 2003–2015.

	Primary neonatal outcome of spontaneously onset breech deliveries				p value univariate analysis	OR univariate analysis	95% CI univariate analysis
	Normal n = 142		Admitted to NICU n = 34				
	n or median	% or range	n or median	% or range			
Gestational age (weeks)	36 + 0	32 + 2, 36 + 6	33 + 0	32 + 0, 36 + 2	<0.001	0.248	0.161–0.380
Trial of labor	86	60.6	17	50.0	0.263	0.651	0.307–1.381
Small for gestational age	8	5.6	8	23.5	0.003	5.154	1.775–14.968
Hypertensive condition	8	5.6	3	8.8	0.494	1.621	0.406–6.464
Diabetes[a]	25	17.6	8	23.5	0.428	1.440	0.584–3.551

[a] Pregestational or gestational diabetes.

delivery reduced neonatal mortality in very preterm infants; however, this could not be substantiated with deliveries after 28 gestational weeks [16]. Similarly, by analyzing the Perinatal Registry of the Netherlands from 2000 to 2011, Bergenhenegouwen and associates concluded that planned cesarean delivery could reduce neonatal mortality and morbidity in preterm breech deliveries, but their data did not exhibit statistically significant differences in deliveries after 32 completed gestational weeks [17]. Older studies have shown benefits from cesarean delivery [18,19], but obstetrical and neonatal care has improved and thus the results may not be directly applicable to contemporary practice. Evidence regarding the optimal mode of very preterm breech delivery is conflicted [20–23]. As stated in the 2013 Cochrane review, which examined the optimal mode of preterm delivery regardless of fetal presentation [2], the need for more data is essential. Moreover, not all studies on the mode of delivery take maternal morbidity into consideration [16,17]. However, cesarean section increases maternal mortality and morbidity compared to vaginal delivery [24], and the excess morbidity is substantial especially in very preterm deliveries [25]. In addition to short-term morbidity, prior cesarean delivery increases complications in subsequent pregnancies [26].

Our data of 176 breech and 103 vertex preterm deliveries showed that although infants born by trial of vaginal delivery in breech presentation exhibited lower umbilical artery pH values compared to infants born by intended cesarean section, pH values lower than 7.00 were not observed, and there was no difference regarding low five-minute Apgar score or morbidity. There was no neonatal mortality and severe morbidity was rare in all groups. In comparison

Table 5
Subgroup analyses of spontaneously onset premature breech deliveries by intended mode of delivery and compared to vertex controls, in two cohorts according to gestational age. Tampere University Hospital, 2003–2015.

	Breech deliveries at 32^{+0}–33^{+6} weeks				p value (BTOL vs BCS)	Vertex controls		p value (BTOL vs vertex)
	Trial of labor (BTOL) n = 19		Planned CS (BCS) n = 18			Trial of labor n = 17		
	n or median	% or range	n or median	% or range		n or median	% or range	
Birthweight	2015	1505, 2430	1800	1260, 2615	0.207	2190	1820, 2780	0.124
Small for gestational age	2	10.5	5	27.8	0.181	0		0.169
One minute Apgar score					0.992			0.020
- 7 or more	12	63.2	11	61.1		17	100.0	
- 4–6	5	26.3	5	27.8		0		
- 3 or less	2	10.5	2	11.1		0		
Five minute Apgar score					0.734			0.045
- 7 or more	15	78.9	15	83.3		17	100.0	
- 4–6	4	21.1	3	16.7		0		
- 3 or less	0		0			0		
Umbilical artery pH	7.25	7.05, 7.37	7.32	7.08, 7.40	0.040	7.30	7.18, 7.40	0.085
Child admitted to NICU	11	57.9	12	66.7	0.582	6	35.3	0.175
Respiratory morbidity[a]	7	36.8	3	16.7	0.167	2	11.8	0.083
Days in NICU or neonatal ward	21	6, 47	22	4, 34	0.772	19	8. 34	0.093
	Breech deliveries at 34^{+0}–36^{+6} weeks				p value (BTOL vs BCS)	Vertex controls		p value (BTOL vs vertex)
	Trial of labor (BTOL) n = 84		Planned CS (BCS) n = 55			Trial of labor n = 86		
	n or median	% or range	n or median	% or range		n or median	% or range	
Birthweight	2650	1870, 4035	2630	1720, 3670	0.616	2760	1915, 3650	0.059
Small for gestational age	5	6.0	4	7.3	0.757	2	2.3	0.234
One minute Apgar score					0.040			0.002
- 7 or more	61	72.6	49	89.1		79	91.9	
- 4–6	13	15.5	5	9.1		6	7.0	
- 3 or less	10	11.9	1	1.8		1	1.2	
Five minute Apgar score					0.709			0.690
- 7 or more	79	94.0	52	94.5		83	96.5	
- 4–6	4	4.8	3	5.5		2	2.3	
- 3 or less	1	1.2	0	0		1	1.2	
Umbilical artery pH	7.25	7.03, 7.46	7.33	7.13, 7.38	<0.001	7.25	7.08, 7.45	0.795
Child admitted to NICU	6	7.1	5	9.1	0.677	2	2.3	0.138
Respiratory morbidity[a]	4	4.8	4	7.3	0.534	5	5.8	0.759
Days in NICU or neonatal ward	11	1, 31	8	1, 21	0.185	8	1, 18	0.158

[a] Respiratory problems warranting additional care or monitoring.

to vertex controls, breech infants displayed low one-minute Apgar score more often, but median cord pH was comparable, and no excess morbidity was observed. Additionally, vaginal delivery was accomplished equally often in breech and vertex deliveries that were allowed a trial of labor. This may reflect the importance of strict selection criteria in order to achieve safe vaginal delivery in breech presentation.

The main weakness of our study is the relatively small sample size. However, in our opinion, using data from a single center minimizes the bias from varying management and recording policies. Furthermore, our data permitted very consistent evaluation of deliveries case by case, thus enabling uniform data and the exclusion of antepartum fetal distress cases in which the mode of delivery was not the main determinant of neonatal outcome. In addition, to maintain the study's validity for practical obstetrics, only cases with clear antepartum fetal distress were excluded, and those with milder complications included (for example intrauterine growth restriction without evidence of acute fetal emergency). Studies by groups led by Bergenhenegouwen and Herbst impress with their sample size, but due to the registry-based data, individual assessment of morbidity is challenging. In addition, our subgroup analysis in small cohorts offers data for the practicing obstetrician deciding the mode of delivery.

The retrospective design is prone to confounding as cesarean section is likely to be performed more often in pregnancies with risk factors that may also contribute to adverse neonatal outcome. To control confounding, fetuses with antepartum distress were excluded as well as iatrogenic deliveries, as the condition necessitating premature delivery may affect both fetal and maternal outcome. After exclusions, maternal morbidity did not differ between the groups, nor the prevalence of intrauterine growth restriction. Furthermore, as gestational age significantly contributes to infant mortality and morbidity, we chose to present a subgroup analysis of moderately and late preterm cohorts with spontaneous onset, which produced similar results regarding main outcomes.

In conclusion, our data demonstrated that allowing a trial of labor in selected preterm breech deliveries after 32 completed gestational weeks did not increase neonatal morbidity or mortality. Careful selection of mothers eligible to trial of labor is essential, but a policy of routine cesarean delivery for the premature breech fetus between 32^{+0} and 36^{+6} weeks could not be recommended based on this study. The study hospital has a strong tradition of vaginal breech deliveries, and the high-resource setting allows quick and efficient obstetric and pediatric interventions should complications arise. These results are applicable in similar settings. Further research is needed to form protocols for management of preterm breech delivery, and centers offering vaginal breech delivery should evaluate their own results in order to offer safe care.

Conflicts of interest

The authors declare no conflicts of interest.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.ejogrb.2018.03.054.

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Maternal Experiences of Vaginal Breech Delivery

Elli Toivonen, MD, Outi Palomäki, MD, PhD, Heini Huhtala, MSc, and Jukka Uotila, MD, PhD

ABSTRACT: Background: *The optimal mode of breech birth remains controversial. In Finland, a trial of vaginal delivery is possible if strict selection criteria are met. As clinical practice in managing vaginal breech birth differs from that in normal delivery, the birth experience may also be different. This cohort study compares the childbirth experience between term breech and vertex deliveries.* **Methods:** *Intended vaginal term breech births from 2008 to October 2012 were included, and for every breech delivery, a vertex control was selected. The proportions of deliveries ending in a cesarean section and of mothers who had given birth vaginally before were equal in both groups. Three hundred eight mothers were sent the childbirth experience questionnaire and 170 returned it.* **Results:** *The birth experience does not differ between breech and vertex births, except for aspects with respect to the choice of birthing position. Indications of an even more positive experience were observed in the breech group, with the exception of the choice of analgesia, but these were not statistically significant. Primiparity, emergency cesarean section, infant birth trauma and prolonged hospital stay were identified as risk factors for a negative birth experience.* **Conclusion:** *The birth experience of vaginal breech birth seems to be at least as positive as the vaginal vertex birth experience. (BIRTH 41:4 December 2014)*

Key words: *birth experience, breech birth, trial of vaginal delivery*

Introduction

Breech presentation occurs in about 3–4 percent of term deliveries (1). In the absence of an absolute indication for cesarean section (CS), the optimal mode of delivery remains controversial, as studies both encouraging and discouraging a trial of vaginal delivery have been published (2–7). In Finland, in the case of a normal pregnancy and lack of medical contraindications, a trial of vaginal birth is an option if strict selection criteria are met. The most important criterion is the mother's wish to proceed with vaginal birth (8). The obstetrician provides the mother with medical information, but the choice is also heavily based on expectations and assumptions independent of scientific evidence. This approach is very different compared with a vertex birth, in which a vaginal delivery is the standard. In recent years, the rates of CSs have, contrary to most countries, decreased in Finland (9), but the proportion of planned CSs among breech births has increased (10). During recent years, every third mother giving birth to a breech infant in our hospital has been both eligible and willing to attempt vaginal delivery (10).

The care administered for breech births also differs from that for uncomplicated deliveries: in Finland, an obstetrician, not a midwife, delivers the fetus, although the midwife is present during the whole childbirth and takes care of the family before and after childbirth. Amniotomy is avoided, episiotomy recommended, and

Elli Toivonen is a Doctoral student in the School of Medicine at the University of Tampere; Outi Palomäki and Jukka Uotila are Senior Consultants in the Department of Obstetrics and Gynecology at the Tampere University Hospital; and Heini Huhtala is a Lecturer (Biostatistics and Epidemiology) in the School of Health Sciences at the University of Tampere, Tampere, Finland.

Address correspondence to Elli Toivonen, MD, School of Medicine, University of Tampere, 33014 Tampere, Finland.

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the threshold for conversion into an operative delivery remains low. Analgesia is offered similarly to uncomplicated births, but the birthing position is limited to the traditional half-sitting position.

Because of the clinical, social, and emotional differences to a vertex birth, the birth experience of mothers giving birth to a baby in breech presentation may differ from that of mothers giving birth to a vertex baby. Two studies have inquired into the birth experiences of mothers who have given birth to an infant in breech presentation, but the comparisons were made only in groups of intended method of delivery and no vertex controls were included (11,12). One study from Jamaica probed the breech birthing experiences of both mothers and medical staff (13), but the setting differs from the medically advanced Western health care system. In vertex deliveries, attempted vaginal deliveries ending in an emergency intervention have been shown to produce a more negative birth experience compared with spontaneous vaginal deliveries and elective CSs (14). Actual delivery by CS has also been associated with secondary fear of labor (15,16) and preferring CS as the method of delivery in subsequent pregnancies (17).

The childbirth experience questionnaire (CEQ) was developed in Sweden to assess the four major dimensions of the birth experience. It has been shown to reflect the multidimensional birth experience adequately (18).

This observational cohort study aims to compare birth experiences between breech and vertex deliveries and to identify the risk factors for an unsatisfactory birth experience.

Materials and Methods

The study protocol and the materials to be sent to mothers were approved by the local ethical committee. The patient records of Tampere University Hospital from January 2008 to October 2012 were searched for term breech deliveries. As the CEQ has been created to evaluate the vaginal birth experience, only intended vaginal deliveries were included in the study. In the breech group, the intended way of delivery was mainly chosen before labor during the last weeks of pregnancy. If the breech presentation was diagnosed only at admission to the labor unit, the maternal wish and medical aspects were evaluated immediately. To avoid distractions caused by a more recent birth experience, those who had given birth again were excluded from the study. The range of the delivery dates of the study population was selected to cover the past 5 years to achieve a sufficiently large study population.

For every breech delivery, a vertex control was searched from the delivery room records as the next delivery recorded after the breech birth. To reduce the confounding impact of the method of delivery, we chose the vertex controls so that both groups had the same number of operative deliveries. As the first delivery and also a previous CS have been linked to a more negative birth experience (19), we chose as many mothers who had not previously given birth vaginally (despite the history of previous CSs) for the control group.

Because of the rather large study population, the birth experience was assessed by a questionnaire mailed to the mothers. We chose to use the CEQ, which reflects the birth experience in several dimensions despite being rather quick and easy to answer. It was developed in Sweden, where both the cultural environment and obstetric practice are similar to those in Finland. The questionnaire consists of 22 items, of which 19 are answered on a 4-point Likert scale and three on a visual analogue scale. The items are grouped in four domains covering the mother's own capacity (perceived personal control, self-efficacy, and coping), professional support, perceived safety, and participation during the birth experience. Every answered item is given points from 1 to 4, higher points indicating more favorable experience, and domain score being the mean of the item scores of that domain.

The study population comprised 308 women, 154 in each group. They were sent the CEQ, which had been translated into Finnish by two independent Swedish-to-Finnish translators with a final Finnish-to-Swedish back-translation. The Finnish version was approved by the creators of the original questionnaire. The mothers were also sent instructions and an informed consent form to sign. The forms and instructions were sent to the mothers in December 2012 and again, to those who had not returned the questionnaire, in February 2013. One hundred and seventy women returned the questionnaire, 97 (57.1%) of them had given birth to breech infants and 73 (42.9%) to vertex infants. Thus, the response rate was 55.2 percent. Of the 170 answered questionnaires, three were only partially completed. All the domain scores could be calculated for 167 responses, and at least two domain scores for every response. The medical data were obtained mainly from the mother's medical records, including information on the newborn child. If the child had health problems, the pediatric records were also examined. All the analyses were performed in an intention-to-treat mode as all the participants were included, regardless of the actual mode of delivery.

To identify the risk factors by logistic regression analysis, we defined the birth experience as negative if

the domain score for every domain was in the lowest quartile.

All statistical analyses were performed using SPSS for Windows, version 21.0 (Armonk, NY, USA). Quantitative data are expressed as means or medians with minimum and maximum values or SD. The comparisons of categorical variables are described by frequencies and percentages. The Mann-Whitney and chi-square tests were used as appropriate. A $p < 0.05$ was considered statistically significant. Logistic regression analysis was done and the results presented as odds ratios (OR) and 95% confidence intervals (CI).

Results

Of the respondents to the questionnaire, 135 mothers (76 in the breech delivery group and 59 in the vertex delivery group) had actually given birth vaginally. Twenty-one mothers (21.6%) in the breech group and 14 mothers (19.2%) in the vertex group had undergone CS. This difference between groups was not statistically significant. There existed no difference between the groups in the frequency of induction of labor, but oxytocin augmentation was used significantly more often in breech births. Episiotomy was made significantly more often in breech births, and there existed no difference between the groups in analgesia. The mean duration of a completed vaginal birth was significantly longer in the vertex group (mean duration 10 hr and 7 min, median 9 hr 45 min) than in the breech group (mean and median duration 8 hr and 25 min, $p = 0.037$). Detailed background information by group is shown in Table 1.

The breech infants had low 1-min Apgar scores significantly more often, but the difference between Apgar scores at the age of 5 min was not significant. The need for neonatal intensive care was similar in both groups, as was treatment or monitoring in the pediatric ward. Birth traumas were more common in breech births, but six out of eight of these were bruises or small abrasions, and the incidence of severe traumas was low and did not differ between the groups. There existed one case of clavicular fracture in both groups and one infant in the breech group suffered from Erb's palsy and damage to the phrenic nerve. Maternal complications were as common in both groups. There existed more infectious complications among breech births, but the difference was not statistically significant. The occurrence of severe bleeding (> 1,000 mL) or the need for transfusions did not differ between the groups. There existed only one case of grade III perineal tear (in the vertex group) and no grade IV tears. Fetal and maternal outcomes are detailed in Table 2.

Table 1. Characteristics of Mothers Attempting a Vaginal Delivery with the Fetus in Breech or Vertex Position in a Tertiary Care Unit in Finland, 2008–2012

	Breech deliveries n = *97* *No. (%) or mean [range]*	*Vertex deliveries* n = *73* *No. (%) or mean [range]*	p
Primiparous	62 (63.9)	45 (61.6)	0.761
Previous CS's	3 (3.1)	3 (4.1)	0.722
Mean maternal age (yr)	29.6 [20–40]	30.0 [19–42]	0.582
Mean gestational age at delivery (wk+days)	39+6 [38+0–42+3]	40+2 [37+2–42+3]	0.019
Mother's gestational illness	15 (15.5)	14 (19.2)	0.524
Preeclampsia	2 (2.1)	1 (1.4)	0.734
Gestational diabetes	8 (8.2)	8 (11.0)	0.549
Attempted cephalic version	45 (48.4)		
Breech presentation not known before labor	22 (22.9)		
Mode of delivery			
Vaginal	76 (78.4)	59 (80.8)	0.693
Emergency CS	17 (17.5)	11 (15.1)	0.669
Rush emergency CS	4 (4.1)	3 (4.1)	0.996
Labor induction	17 (17.5)	13 (17.8)	0.962
Oxytocin augmentation	81 (83.5)	35 (47.9)	<0.001
Episiotomy	61 (63.5)	21 (30.4)	<0.001
Neuraxial analgesia	65 (67.0)	48 (65.8)	0.864
Amniotomy	5 (5.2)	6 (8.2)	0.421
Labor over 12 hr	19 (20.7)	20 (29.0)	0.222

The first domain in the CEQ assesses the mother's own capacity (Table 3). Domain scores did not differ between the groups. Mothers in the breech group tended more often to feel strong and happy during labor and birth and thought they handled the situation well. However, these differences were not statistically significant.

The second domain determines professional support and comprises five items. The total domain score did not differ between the groups. The breech group felt slightly less often that their midwives did not devote enough time to them, but this difference was not statistically significant. Otherwise, the items were answered very similarly in both groups.

The third domain measures perceived safety and comprises six items. The total domain score did not differ between the groups. Those mothers who gave birth to a breech baby more often reported positive memories of childbirth, but this difference was not statistically significant.

The fourth domain, participation, comprising three items, focuses on whether the mother felt she had a say in deciding the birthing position and pain relief method. The breech group reported significantly more often that they were not given a say on whether they could be up and about or lie down. They also felt significantly more often that they were not given a say in deciding the birthing position. In addition, the breech group had a nonsignificant tendency to report more often that they did not have a say in the choice of pain relief. The total domain score was lower in the breech group.

Using our definition of a negative birth experience, 14 out of 167 birth experiences, nine in the breech group and five in the vertex group, were negative. The difference between the groups in the prevalence of a negative birth experience was not statistically significant ($p = 0.591$), and the breech position did not predispose mothers to a negative birth experience. Primiparous mothers were more likely to have a negative birth experience (OR 8.6, CI 1.10–67.60, $p = 0.040$). A delivery ending in a CS was also more likely to produce a negative experience (OR 3.3, CI 1.08–10.42, $p = 0.037$). If the infant suffered from

Table 2. Infant and Maternal Outcomes of Breech and Vertex Presentation Deliveries in a Finnish Tertiary Hospital, 2008–2012

	Breech deliveries n = *97* *No. (%) or mean [range]*	*Vertex deliveries* n = *73* *No. (%) or mean [range]*	p
INFANT			
Mean birthweight, *g*	3,380 [2,430–4,350]	3,580 [1,950–4,800]	0.004
Apgar 1 min			
< 4	11 (11.3)	0	0.011
4–6	11 (11.3)	8 (11.0)	
>6	75 (77.3)	65 (89.0)	
Apgar 5 min			
< 4	2 (2.1)	0	0.461
4–6	3 (3.1)	2 (2.7)	
> 6	92 (94.8)	71 (97.3)	
Mean umbilical artery pH	7.24 [6.95–7.47]	7.26 [7.07–7.48]	0.219
Umbilical artery pH < 7.10	6 (6.7)	4 (6.2)	0.884
Any illness or need for monitoring	29 (29.9)	21 (28.8)	0.873
Birth trauma	8 (8.2)	2 (2.7)	0.131
Severe trauma	2 (2.1)	1 (1.4)	0.734
Admission to NICU	5 (5.2)	2 (2.7)	0.433
MATERNAL			
Bleeding over 1,000 mL or transfusions	8 (8.2)	5 (6.8)	0.734
Severe perineal tear	0	1 (1.4)	0.248
Puerperal infections*	11 (11.3)	3 (4.1)	0.090
Procedure complications			
Surgical	1 (1.0)	1 (1.4)	0.839
Anesthetic	1 (1.0)	1 (1.4)	0.839

**Excluding mastitis.*

birth trauma, the odds ratio was 5.7 (CI 1.29–25.11, $p = 0.022$). There was no statistically significant association between a negative birth experience and the total duration of vaginal birth, but a prolonged second stage of labor was shown to increase the risk (OR 1.04, CI 1.002–1.08, $p = 0.038$). It was also observed that the risk of a negative birth experience increased the more days that had to be spent in hospital before (OR 1.59, CI 1.03–2.45, $p = 0.035$) and after childbirth (OR 1.53, CI 1.10–2.14, $p = 0.012$). No statistically significant association was observed between a negative birth experience and maternal complications, infections, severe bleeding or transfusions, or an illness in the child. Nor did the birth experience appear to be affected by whether or not the breech presentation was known before delivery.

Discussion

This study of 170 births suggests that a trial of vaginal delivery when the fetus lies in breech presentation produces as good a childbirth experience as vertex vaginal birth. Indications of an even more positive experience with a breech birth were observed in some aspects, but these were not statistically significant. Mothers' feelings about their own capacity, professional support, and safety differed little from those whose babies were born in vertex presentation. Mothers in the breech group tended to feel happy and strong more often, which can possibly be attributed to having actively chosen vaginal delivery. This choice may also be reflected in the very first item in the questionnaire, concerning the expectations and actual labor, as more

Table 3. Responses to the Childbirth Experience Questionnaire (CEQ)* by Mothers Attempting Vaginal Delivery in a Finnish Tertiary Hospital in 2008–2012

	Breech deliveries n = *97* *[mean] or % agreement*	*Vertex deliveries* n = *73* *[mean] or % agreement*	p
DOMAIN I: Own capacity	[2.64]	[2.55]	0.366
Labor and birth went as I had expected	55.7	65.8	0.559
I felt strong during labor and birth	69.1	58.9	0.342
I felt capable during labor and birth	63.9	61.6	0.937
I was tired during labor and birth	60.8	65.8	0.665
I felt happy during labor and birth	69.1	49.3	0.052
I felt that I handled the situation well	85.4	82.2	0.640
Experienced level of pain†	58.3	65.8	0.488
Experienced level of control†	51.5	54.8	0.853
DOMAIN II: Professional support	[3.40]	[3.42]	0.880
My midwife devoted enough time to me	90.7	83.3	0.280
My midwife devoted enough time to my partner	84.4	85.9	0.960
My midwife kept me informed about what was happening	81.3	86.1	0.805
My midwife understood my needs	83.5	81.9	0.945
I felt very well cared for by my midwife	91.8	91.7	0.990
DOMAIN III: Perceived safety	[2.95]	[3.01]	0.667
I felt scared during labor and birth	51.5	47.9	0.904
I have many positive memories from childbirth	69.8	61.1	0.407
I have many negative memories from childbirth	42.7	37.5	0.920
I have depressing memories from childbirth	29.2	25.0	0.902
The team's medical skills made me feel secure	78.4	84.7	0.688
Experienced level of security†	72.2	76.7	0.849
DOMAIN IV: Participation	[2.28]	[2.81]	<0.001
I felt I could choose whether I could be up or lie down	37.5	62.5	0.005
I felt I could choose my birthing position	20.8	42.3	<0.001
I felt I could choose my pain relief	81.1	83.3	0.266

*Data are shown in means (domain scores) and in percentages of responses totally or mostly agreeing with the item. Note that the CEQ is primarily answered in a 4-point scale. *All items from the CEQ, © Copyright 2011 Dencker, Taft, Bergqvist, Lilja & Berg. †These questions were answered in a VAS scale. Percentages of mothers who felt much pain, control or security (VAS > 60) are shown.*

mothers in the breech group did not feel that their labor had gone as they had expected. Professional support was perceived similarly in both groups. More mothers in the breech group reported having positive memories of the birth, but, on the other hand, there also were more mothers in that group reporting very negative experiences. The less favorable experiences of participation may be influenced by clinical practice, as the birthing position is limited in breech birth. Because of the structure of the questionnaire, we could not determine whether this feel actually produces a less positive birth experience or not. Other differences between the management protocols of breech and vertex deliveries did not seem to affect the birth experience. Surprisingly, more mothers in the breech group reported feeling that they had not had a say in the choice of analgesia, although they also reported feeling less pain during childbirth. More attention should be given to allowing mothers to choose the pain relief method they desire.

Although the controls were carefully chosen to minimize the bias, the breech group differs crucially from the vertex group in that the former may choose whether they wish to try vaginal birth or not, and have to go through a rigorous decision process, as depicted in a recent study (20). Mothers expecting breech babies and suffering from fear of childbirth probably chose planned CS as the method of delivery. A study from Hong Kong showed that mothers in general seem to consider vaginal breech birth unsafe and prefer elective CS as the method of delivery (21). On the other hand, as the delay between the birth and the questionnaire was in some cases long, and those who had given birth again were excluded, the study population may overrepresent those mothers who developed secondary fear of childbirth after the delivery and, therefore, did not want another pregnancy. This concern may be seen especially in Domain III, as a few mothers reported having very negative memories and feeling depressed when thinking about the birth.

The risk factors for a negative birth experience were primiparity, infant birth trauma, emergency CS, and prolonged second-stage labor. Risk factors that have been previously identified, such as oxytocin augmentation, overall prolonged delivery or labor induction (19), were not statistically significant in our data. This implication might be because of the lower threshold to switch from a vaginal delivery to a CS with a breech presentation. Prolonged hospital stay before or after delivery may reflect maternal or infant health problems and thus produce a more negative birth experience. Mothers staying in hospital longer may need extra support.

Although in our hospital the proportion of vaginal breech deliveries is high by international standards, to achieve a sufficiently large study population, we had to include births going back several years. We are aware that this accomplishment may be reflected in the responses. A study from Sweden has shown that although a mother's recall of labor pain becomes, on average, more positive over time, the perception of the overall birth experience may become more negative (22). To avoid the bias that would have been caused by the effects of more recent birth experiences, the mothers who had given birth again were ruled out of the study. On the other hand, this elimination meant that mothers who had had a very negative, perhaps even traumatizing, experience may have been overrepresented. Another point of interest concerning the study methods is that to avoid the confounding effect of actual mode of delivery, we chose to match the vertex deliveries, too, according to the actual mode of delivery. Since the proportion of emergency cesareans that might possibly contribute to less satisfying birth experience is lower among vertex deliveries compared with intended vaginal breech deliveries (10), the average vertex birth experience may be more positive than the average breech birth experience. The breech group's answers tended to be either very positive or very negative, possibly reflecting high expectations and their fulfillment or failure. Thus, informing the mothers about the higher risk of the delivery ending in an emergency CS is crucial.

According to our results, a breech birth experience is as positive as a vertex birth experience when matched according to the actual mode of delivery, and a trial of vaginal delivery can be permitted if no medical contraindications exist.

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RESEARCH ARTICLE Open Access

Cardiotocography in breech versus vertex delivery: an examiner-blinded, cross-sectional nested case-control study

Elli Toivonen[1*], Outi Palomäki[2], Heini Huhtala[3] and Jukka Uotila[1,2]

Abstract

Background: The safety of vaginal breech delivery has been debated for decades. Although it has been shown to predispose infants to immediate depression, several observational studies have also shown that attempting vaginal breech delivery does not increase perinatal morbidity or low Apgar score at the age of five minutes. Cardiotocography monitoring is recommended during vaginal breech delivery, but comparative data describing differences between cardiotocography tracings in breech and vertex deliveries is scarce. This study aims to evaluate differences in intrapartum cardiotocography tracings between breech and vertex deliveries in the final 60 min of delivery. A secondary goal is to identify risk factors for suboptimal neonatal outcome in the study population.

Methods: One hundred eight breech and 108 vertex singleton, intended vaginal deliveries at term from a tertiary hospital with 5000 annual deliveries were included. Two experienced obstetricians, blinded to fetal presentation, neonatal outcome and actual mode of delivery, evaluated traces recorded 60 min before delivery. They provided a three-tier classification and evaluated different trace features according to FIGO (1987) guidelines. Factors associated with acidemia and low Apgar scores were identified by univariate and multivariable analyses performed with binary logistic regression. Student's *T*-test and chi-square test were used, as appropriate.

Results: Late decelerations were seen in 13.9 % of breech and 2.8 % of vertex deliveries ($p = 0.003$) and decreased variability in 26.9 % of breech and 8.3 % of vertex deliveries ($p < 0.001$). In multivariable analysis complicated variable decelerations and breech presentation were identified as risk factors for neonatal acidemia and low Apgar score at the age of five minutes. Pathological trace and breech presentation were independent risk factors for low Apgar score at the age of one minute.

Conclusions: Decreased variability and late decelerations were more prevalent in breech compared to vertex deliveries. Pathological trace predicts immediate neonatal depression and especially complicated variable decelerations may signal more severe distress. Further research is needed to create guidelines for safe management of vaginal breech delivery.

Keywords: Fetal monitoring, Breech presentation, Cardiotocography, Vaginal breech delivery

* Correspondence: toivonen.elli.m@student.uta.fi
[1]School of Medicine, University of Tampere, 33014 Tampere, Finland
Full list of author information is available at the end of the article

Background

Cardiotocography (CTG), the monitoring of fetal heart rate and uterine contractions, has been used in an attempt to assure fetal well-being during labor for over forty years [1]. Despite ongoing debate on the efficacy of the method [2–5], continuous CTG monitoring has become widely used and is recommended during labor of women with high-risk conditions [6, 7]. Several rating systems for normal and abnormal CTG tracings have been developed, of which the three-tier model, also presented in International Federation of Obstetrics and Gynaecology (FIGO) guidelines in 1987 [7], is probably the most widely accepted consensus yet reached [8, 9]. However, even when following a predefined rating system, inter- and intraobserver agreement has been described to vary [9–11].

Breech presentation occurs in 3–4 % of term, singleton deliveries [12]. The optimal mode of delivery remains controversial, as retrospective studies both encouraging [13–15] and discouraging [16] attempted vaginal delivery have been published. Three randomized controlled studies of the topic have been published with contrasting results [17–19], the latest and most extensive suggesting a policy of routine cesarean delivery [17]. In our hospital, a trial of vaginal delivery is allowed if strict selection criteria are met, and the threshold to convert the mode of delivery to an emergency cesarean section (CS) is kept low during labor. Continuous CTG monitoring is recommended throughout labor to detect fetal distress [20, 21]. Mothers giving birth to a breech infant should be thoroughly informed on the contrasting research data and the choice regarding the mode of delivery should be made in collaboration of the mother and the health care provider [20]. As many mothers will choose vaginal delivery, more studies on improving the safety of vaginal breech delivery is needed, as indicated in the latest Cochrane review on the mode of delivery in breech presentation [22].

Studies on breech deliveries dated as early as the 1970's and 1980's have described frequent decelerations during the first stage of labor [23, 24] and one study observing term breech fetuses in second stage of labor described a high prevalence of variable decelerations, thought to be produced by compression of the umbilical cord [25]. Furthermore, the non-stress antepartum fetal heart rate traces of breech fetuses have been described to show decreased variability compared to vertex fetuses [26], which in turn was associated with a shorter umbilical cord. A recent study demonstrated that fetal ST-waveform analysis was also applicable in breech vaginal deliveries, although intervention was more often triggered by a preterminal CTG than ST changes in breech deliveries compared to vertex deliveries [27]. However, based on a search of MEDLINE (English language; 1961 – October 2015; search terms "Breech presentation" and "Cardiotocography"), no comparative studies concerning the differences in intrapartum CTG traces between breech and vertex deliveries have been published. As several institutions around the world still allow trial of vaginal delivery also in breech presentation, evidence-based data on safe clinical management of vaginal breech delivery is indicated.

The objective of this study was to determine whether CTG tracings at the late phase of the first stage and during the second stage of labor differ between fetuses in breech and vertex presentation. A secondary aim was to identify risk factors for suboptimal neonatal outcome in the study population.

Methods

The study protocol was approved by the Pirkanmaa Hospital District's ethical committee (decision R12236). All intended singleton vaginal term breech deliveries, ending in either spontaneous vaginal delivery or emergency cesarean section, between January 2007 and April 2009 were included in the study if the quality of the CTG tracing was deemed adequate. The control group consisted of intended vaginal vertex deliveries, ending in either spontaneous vaginal, operative vaginal, or emergency CS delivery. The groups were matched by the actual mode of delivery, either spontaneous vaginal or operative delivery. Thus the number of spontaneous deliveries was equal in the groups, and the number of acute CS in the breech group was equal to the number of acute CS's and vacuum extractions in the vertex group. The total number of deliveries in the study was 216 (108 deliveries in each group).

Two experienced obstetricians (OP and JU) evaluated the CTG traces, blinded to fetal presentation, actual mode of delivery and neonatal outcome. Only 60 min of tracing, immediately preceding either vaginal or emergency cesarean delivery, were evaluated, and thus the tracings were from the first and second stages of labor. As profound CTG changes are almost always observed immediately before birth, the decelerations of the final ten minutes of the tracing were not included in the classification unless the trace included a severe bradycardia before delivery. The obstetricians used the FIGO three-tier classification published in 1987 [7, 28] and provided their estimate on the baseline variability, presence of accelerations, late and complicated variable decelerations, and prolonged decelerations. The details of the classification of trace features can be found on Table 1 and an example of complicated variable decelerations in Fig. 1. The obstetricians also estimated the number of uterine contractions per 10 min. After independent evaluation of the traces, the obstetricians evaluated the traces together and formed a consensual interpretation, which was used in comparing the different features of the

Table 1 Classification of the fetal heart rate tracings. Based on FIGO 1987 guidelines [7, 28]

Classification	Basal heart rate (bpm)	Baseline variability (bpm)	Decelerations
Normal	110–150	5–25 Accelerations	Early uniform decelerations Variable decelerations (duration <60 s and depth of <60 bpm)
Suspicious	100–110 150–170	<5 >25	Variable decelerations (duration <60 s and depth of <60 bpm)
Pathological	>170 <100 for >3 min	<5 for >60 min Sinusoidal pattern	Complicated variable decelerations (duration >60 s or depth >60 bpm)[a] Late uniform decelerations

[a]See Fig. 1

traces between breech and vertex deliveries. Third person (ET) collected the data from the mother's medical records, which included summary information of the newborn. Pediatric records were also examined, if the child had health problems. During the study period, delayed cord clamping was not yet adapted in our hospital, and thus all the umbilical cord pH samples were taken after immediate cord clamping.

All statistical analyses were performed using SPSS for Windows version 21.0 (IBM Corp., 2012. Armonk, NY, USA). Quantitative data were expressed as means or medians with minimum and maximum values. The results of categorical variables were described by percentages. The Student's *t*-test and chi-square test were used as appropriate. Binary logistic regression analyses were performed to calculate odds ratios using forward logistic regression. A p-value of less than 0.05 was considered statistically significant. All p-values are two-tailed.

Results

There were no differences between the groups in mothers' mean age, duration of pregnancy, or in the prevalence of chronic illnesses or gestational complications, but significantly more mothers were primiparous in the breech group. Oxytocin augmentation was used more often in breech deliveries, but the difference was not statistically significant, and the presence of uterine tachysystole (defined as more than five contractions per 10 min) was similar in both groups. Unlike breech deliveries, vertex deliveries were assisted with vacuum extraction, and thus breech deliveries ended in an emergency CS significantly more often. Data concerning maternal background and labor are detailed in Table 2. The primary indication for intervention was most often suspected fetal asphyxia and did not differ between the groups (66.7 % of the interventions in the breech group and 70.8 % in the vertex group, $p = 0.755$).

Significantly more infants in the breech group had low Apgar score at the age of one minute, but at the age of five minutes there was no difference between the groups. Mean umbilical artery pH was lower in the breech group and pH 7.10 or lower was seen more often in the breech group. Conversely, no differences between the groups in admittance to neonatal intensive care unit, perinatal infections, or overall morbidity were observed. Details of the neonates are presented in Table 3.

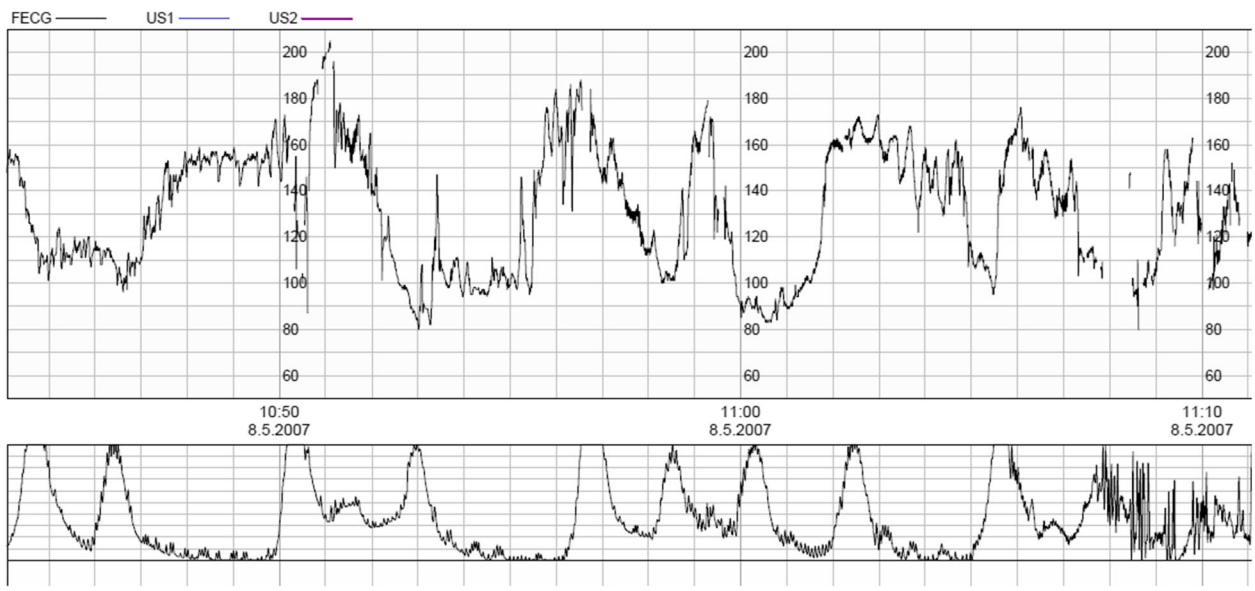

Fig. 1 An example of complicated variable decelerations, their duration more than 60 s and depth more than 60 beats per minute

Table 2 Demographic data and parameters concerning the mother and the delivery

	Breech deliveries $n = 108$		Vertex deliveries $n = 108$		*P* value
	Mean or n	% or range	Mean or n	% or range	
Maternal age (years)	28.9	18, 44	29.7	18, 46	0.224
Duration of pregnancy (weeks + days)	39 + 5	37 + 0, 41 + 6	40 + 1	37 + 0, 42 + 2	0.007
Primiparous	75	69.4	53	49.1	0.002
Chronic illness	12	11.1	11	10.2	0.825
Gestational diabetes	12	11.1	7	6.5	0.230
Pre-eclampsia	3	2.8	2	1.9	0.651
Spontaneus vaginal delivery	84	77.8	84	77.8	1
Operative delivery	24	22.2	24	22.2	1
- Vacuum extraction	None		13	12.0	<0.001
- Emergency CS	22	20.4	8	7.4	0.006
- Rush emergency CS	2	1.9	3	2.8	0.651
Induction of labor	15	13.9	23	21.3	0.153
Neuraxial analgesia	72	66.7	79	73.1	0.299
Oxytocin augmentation	82	75.9	70	64.8	0.074
Uterine tachysystole[a]	20	18.5	18	16.7	0.721

Legend: Comparison between breech and vertex intended vaginal deliveries in a Finnish tertiary hospital, 2007–2009
[a]Defined as more than five contractions per 10 min

According to FIGO classification, traces from breech deliveries tended to display pathological patterns more often compared to vertex deliveries, but the difference was not statistically significant. However, breech delivery traces displayed decreased (less than 5 beats per minute) variability more often than traces from vertex deliveries, and late decelerations were more common in the breech group. There was no difference between the groups regarding frequency of complicated variable decelerations, prolonged decelerations or any abnormal decelerations (late, prolonged or complicated variable decelerations) grouped together. Details of the trace interpretations are

Table 3 Neonatal outcomes

	Breech deliveries $n = 108$		Vertex deliveries $n = 108$		*P* value
	n or mean	% or range	n or mean	% or range	
1 min Apgar					<0.001
- Less than 4	11	10.2	3	2.8	
- 4–6	22	20.4	4	3.7	
- 7 or more	75	69.4	101	93.5	
5 min Apgar					0.408
- Less than 4	None		None		
- 4–6	4	3.7	2	1.9	
- 7 or more	104	96.3	106	98.1	
Umbilical cord pH	7.23	6.80, 7.46	7.27	7.05, 7.42	0.007
Cord pH ≤ 7.10	10	9.5	2	1.9	0.015
Cord pH ≤ 7.00	2	1.9	None		0.162
NICU admittance	4	3.7	4	3.7	1
Perinatal infection	10	9.3	6	5.6	0.299
Any illness or need for monitoring	24	22.2	16	14.8	0.161
Birthweight	3280	1935, 4350	3600	2320, 4670	<0.001

Legend: Comparison between breech and vertex intended vaginal deliveries in a Finnish tertiary hospital, 2007–2009

presented in Table 4. Further analyses of infants displaying pathological trace patterns showed that 31 of the 45 breech infants and 19 of the 32 vertex infants were delivered spontaneously ($p = .389$). Infants that had displayed pathological trace showed more often one-minute Apgar score of six or less in the breech group (40 % of infants in the breech group and 18.8 % of the infants in the vertex group, $p = .047$), but there were no statistically significant differences between the groups regarding five-minute Apgar score, incidence of low cord pH or admission to neonatal intensive care unit.

In order to study whether breech presentation, oxytocin use, pathological trace or any of the CTG features independently associate with adverse neonatal outcome in the study material, primary suboptimal neonatal outcome was defined as umbilical artery pH 7.10 or lower or five-minute Apgar score lower than 7. Using this definition, 13 infants in the breech group and 4 in the vertex group had suboptimal neonatal outcome ($p = 0.023$). Low five-minute Apgar score was associated with abnormal CTG trace; pathological in three out of four breech cases and one out of two vertex cases, and the rest two traces were defined as suspicious. Neonatal acidemia was likewise associated with pathological trace in the vertex group, as both two infants suffering from acidemia had displayed a pathological trace. However, in the breech group, acidotic cord pH was measured in seven infants with a pathological trace, two infants with a suspicious trace, and one infant with a normal trace. The infant displaying normal trace and acidotic pH was born to a healthy primiparous mother in spontaneous delivery on the 39th week of her pregnancy. Breech presentation was not diagnosed until labor, and the mother gave birth vaginally to a healthy baby weighing 3290 g, displaying cord pH 7.08, Apgar score of 7 at the age of one minute, and 9 at the age of five minutes. Further monitoring was not required.

Univariate analysis of the entire study population showed that suboptimal neonatal outcome was associated with pathological FIGO classification of CTG trace. Similarly, absence of accelerations, presence of late decelerations and presence of complicated variable decelerations as well as breech presentation were associated with suboptimal neonatal outcome. However, decreased trace variability, oxytocin augmentation, or uterine tachysystole were not significant predictors of adverse neonatal outcome. Odds ratios of univariate analyses are detailed in Table 5. Multivariable analysis revealed that complicated variable decelerations (OR 16.1, 95 % CI 2.1–124.8) and breech presentation (OR 4.1, 95 % CI 1.2–13.2) were independent risk factors for suboptimal neonatal outcome.

Immediate neonatal depression was seen in 40 infants, as 33 infants in the breech group and seven in the vertex group displayed Apgar score of less than seven at the age of one minute. Multivariable analysis showed that the factors independently associated with immediate neonatal depression were pathological trace (OR 3.2, 95 % CI: 1.5–6.7, $p = 0.002$) and breech presentation (OR 5.9, 95 % CI: 2.5–14.3, $p < 0.001$).

Uterine tachysystole was associated with pathological trace. 57.9 % of traces were deemed pathological when uterine tachysystole was found, whereas only 30.9 % of traces with normal uterine contractility were deemed pathological ($p = 0.002$). Conversely, oxytocin use did not seem to increase trace pathology, as pathological trace was seen in 38.8 % of oxytocin-augmented deliveries, compared to 28.1 % of deliveries with spontaneous labor ($p = 0.134$).

Table 4 Expert interpretations of cardiotocography tracings

	Breech deliveries $n = 108$		Vertex deliveries $n = 108$		*P* value
	n	%	n	%	
FIGO classification					0.150
- Normal	29	26.9	39	36.1	
- Suspicious	34	31.5	37	34.3	
- Pathological	45	41.7	32	29.6	
Decreased variability	29	26.9	9	8.3	<0.001
Accelerations	84	77.8	94	87.0	0.074
Late decelerations	15	13.9	3	2.8	0.003
Complicated variable decelerations	58	53.7	62	57.4	0.584
Prolonged decelerations	26	24.1	29	26.9	0.639
Any abnormal decelerations[a]	69	63.9	66	61.1	0.673

Legend: Comparison between breech and vertex intended vaginal deliveries in a Finnish tertiary hospital, 2007–2009
[a]Late, complicated variable or prolonged decelerations or a combination of these

Table 5 Factors associated with primary neonatal outcome

	Primary neonatal outcome							
	Normal $n = 199$		Suboptimal[a] $n = 17$		p value univariate analysis	OR univariate analysis	95 % CI univariate analysis	p value multivariable analysis
	n	%	n	%				
Pathological CTG trace in 3-tier FIGO classification	65	32.7	12	70.6	0.004	4.9	1.7–14.6	
Decreased variability	33	16.6	5	29.4	0.191	2.1	0.7–6.3	
Accelerations absent	31	15.6	7	41.2	0.012	3.8	1.3–10.7	
Late decelerations	14	7.0	4	23.5	0.027	4.1	1.2–14.1	
Complicated variable decelerations	104	52.3	16	94.1	0.010	14.6	1.9–112.3	0.008
Prolonged decelerations	49	24.6	6	35.3	0.337	1.7	0.6–4.8	
Vacuum extraction or emergency CS	43	21.6	5	29.4	0.460	1.5	0.5–4.5	
Primiparity	117	58.8	11	64.7	0.635	1.3	0.5–3.6	
Oxytocin augmentation	140	70.4	12	70.6	0.984	1.0	0.3–3.0	
Uterine tachysystole	35	17.6	3	17.6	0.995	1.0	0.3–3.7	
Breech presentation	95	47.7	13	76.5	0.031	3.6	1.1–11.3	0.020

Legend: Trace details and other obstetrical factors and their connection to primary neonatal outcome in breech and vertex intended vaginal deliveries in a Finnish tertiary hospital, 2007–2009

[a]Cord pH ≤7.10 or Apgar score at the age of five minutes <7

Discussion

This cohort study of 216 deliveries showed that the CTG tracings from deliveries with the fetus in breech presentation displayed decreased variability and late decelerations more often than tracings from vertex deliveries. Moreover, a tendency to show pathological patterns (according to FIGO 1987 classification) more often was observed, although the difference was not statistically significant. In addition, breech presentation was seen to predispose infants to low Apgar score at the age of one minute, but there was no association with low Apgar score at the age of five minutes. Mean umbilical cord pH was lower in the breech group, but the incidence of severe acidemia (pH ≤7.00) did not differ between the groups.

Several ominous trace features were associated with neonatal depression. Especially pathological trace was shown to predict suboptimal Apgar score at the age of one minute, and complicated variable decelerations predicted neonatal depression (defined as umbilical artery pH 7.10 or lower or Apgar score less than seven at the age of five minutes). Breech presentation predisposed infants to both outcomes.

In this study, the effect of primiparous mothers having more compromised labor and deliveries should be reduced, as the mode of delivery was operative equally often between the groups. However, the weaknesses of this study include analyses not being adjusted by primiparity, which may cause bias in favor of the vertex group. Additionally, due to the study design, the interpreters did not know whether the tracings represented the second stage of labor or not, which may have affected the trace interpretations. Furthermore, the last hour of tracing before the delivery does not represent the entirety of labor, and at least in some cases longer tracings may have been more informative.

Although vaginal breech delivery has been consistently shown to predispose infants to low Apgar score at the age of one minute [14, 16, 29], the implication of this parameter is of minor importance. In order to enhance the clinical significance of the neonatal parameters, Apgar score at the age of five minutes and cord pH were chosen. However, this definition has similar problems, as the case of the breech infant with mildly acidotic pH and completely normal short-term outcome demonstrates. Furthermore, as our primary outcome variable included the cord pH, the results are biased in favor of the vertex group, as breech infants display lower cord pH values [14, 29]. Still, long-term data on infant health is not readily available, and likely as a consequence, primary neonatal outcome is most often used to study obstetrical management protocols. Infants in both groups were very healthy in general: outcomes that have been used to demonstrate neonatal morbidity such as severe birth trauma, Apgar score at the age of five minutes <4, or base deficit ≥15 [17], were not present in the study population.

The sample size of this study was mainly limited by the relatively low incidence of intended vaginal deliveries. The rate of intended vaginal deliveries in breech presentation has declined also in the study hospital [29] and thus is slightly lower than in other centers producing new research data on vaginal breech deliveries [27, 30]. Including additional centers would have increased the study population, but this would have reduced the objectivity and

reproducibility of the trace interpretation, as it would have been impossible to form both independent and consensual evaluations of all the traces. In addition, including limited years and only one center, the management protocols of the deliveries were uniform and controlled.

We are aware that renewed FIGO guidelines have been introduced, but this study was conducted before those were published, which is why the 1987 guidelines were used. However, this study demonstrates the feasibility of the standardized guidelines in predicting neonatal depression also in vaginal breech delivery. Presumably the new classification will be even more reproducible and thus more effective and encourages further research. Furthermore, complicated variable decelerations are not recognized in the 2015 guidelines but instead categorized as late decelerations [31], which is appropriate also in light of this study, as they were identified as a risk factor for neonatal depression. On the other hand, the new guidelines have not yet been scientifically evaluated, and appropriate testing remains a challenge before adapting them into clinical setting.

Oxytocin use has been associated with adverse perinatal outcome in breech deliveries [32], and some institutions disfavor the use of oxytocin augmentation in breech deliveries, considering failure to progress in labor an indication for cesarean delivery [13]. In this study, neither oxytocin augmentation nor uterine tachysystole was associated with adverse neonatal outcome, which may be due to a low threshold to intervene with pathological CTG traces that in turn were associated with uterine tachysystole. However, vertex fetuses may have been, in some cases, quickly delivered by vacuum extraction when signs of fetal distress are observed in the second stage of labor, unlike breech fetuses, which were delivered by slower CS in similar circumstances. After the decision to deliver by an emergency CS is made, oxytocin infusion is discontinued and, in selected cases, tocolysis is administered, which may result in intrauterine recovery of the fetus from short-term asphyxia. This may cause the actual effect of oxytocin and uterine tachysystole on neonatal depression to be underestimated, especially in the breech group.

Although this study showed that breech presentation predisposed infants to low Apgar score at the age of one minute, another Finnish study demonstrated that vaginal breech delivery is associated with low Apgar score at the age of both one and five minutes, but the long-term health of these children is as good as that of children born vaginally in vertex presentation [33]. Some studies have demonstrated inferior immediate neonatal outcome in vaginal breech delivery [16, 17] and thus the frequent CTG pathologies may signal more frequent fetal distress. Even so, our results encourage attempting vaginal breech delivery in selected cases, as the neonatal outcome was comparable in both groups despite the higher incidence of ominous trace features in the breech group. Additionally, as pathological trace according to FIGO classification was shown to predict low Apgar score at the age of one minute and complicated variable decelerations alerted of prolonged fetal distress, continuous cardiotocography monitoring provides a tool for timely intervention in these cases. However, this is the first comparative study on cardiotocography in breech and vertex deliveries. More research is needed to form safe guidelines in managing vaginal breech delivery, should one attempt it. As the numbers of vaginal breech deliveries per institution are relatively small, multicenter studies or meta-analyses of uniform studies could provide the data needed.

Conclusion

Cardiotocography tracings from breech deliveries display decreased baseline variability and late decelerations more often than tracings from vertex deliveries, but the association of these trace features with neonatal asphyxia is not clear. Trace pathology according to FIGO 1987 classification predicts neonatal depression and especially complicated variable decelerations seem to signal fetal distress, but also breech presentation seems to be an independent risk factor for neonatal depression.

Abbreviations

BPM: Beats per minute; CI: Confidence interval; CS: Cesarean section; CTG: Cardiotocography; FIGO: International Federation of Obstetrics and Gynaecology; OR: Odds ratio

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Availability of data and materials

Pirkanmaa Hospital District's ethical committee approved the use of the dataset only for this study. Based on reasonable request to the contributing author, permission to use the dataset for further studies can be solicited from the ethical committee.

Authors' contributions

All authors designed the study. ET, OP and JU produced and gathered the data, and all authors analyzed the data and interpreted the results. All authors participated in writing the manuscript and have approved the final version. All authors agree to be accountable of the study.

Authors' information

Not Applicable.

Competing interests

The authors declare that they have no competing interests.

Ethics approval and consent to participate

The study protocol was approved by the Pirkanmaa Hospital District's ethical committee (decision R12236). As this report does not include details of individual participants, consent to publish was not needed.

Author details
[1]School of Medicine, University of Tampere, 33014 Tampere, Finland. [2]Department of Obstetrics and Gynecology, Tampere University Hospital, PL 2000, 33521 Tampere, Finland. [3]School of Health Sciences, University of Tampere, 33014 Tampere, Finland.

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