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CESAREAN SECTION - SHORT TERM MATERNAL COMPLICATIONS RELATED TO THE MODE OF DELIVERY

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ABSTRACT

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Cesarean section. – short term maternal complications related to the mode of delivery

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Cesarean section (CS) is the most common major surgery performed on women worldwide. CS can save the life of the mother or the fetus, but is associated with the typical complications of any major surgery: hemorrhage, infection, venous thromboembolism and complications of anesthesia, sometimes leading to maternal death.

Recently there have been several reports from well resourced countries on increased severe maternal morbidity and even mortality. Increased rates of CS, obesity and older mothers may explain this rise.

The aim of this thesis is to study the rates and risk factors of short term maternal complications associated with CS. Also, we compared maternal morbidity by mode of delivery and over time.

The complication rates were assessed in a prospective study involving 2496 CS performed in the 12 largest delivery units in Finland in 2005. The rates of severe complications were studied by mode of delivery in a register-based study comparing national cohorts in 1997 and 2002. The impact of several risk factors on severe maternal morbidity by mode of delivery was studied in a register-based study of all singleton deliveries in 2007-2011.

In the prospective study, 27% of the women who underwent CS had one or more intraoperative or postoperative complications during their hospital stay, and 10% had a severe complication. In the register-based study the incidence of life-threatening maternal complications was 7.6 in 1000 deliveries. The incidence was lowest for vaginal delivery (VD), followed by instrumental VD and elective CS, and highest in emergency CS. An attempt of VD, including the risks associated with emergency CS, seems to be the safest mode of delivery, even for most high-risk women.

Key words: Cesarean section, vaginal delivery, maternal complications

TIIVISTELMÄ

Nanneli Pallasmaa

Keisarileikkaus. Synnytystavan vaikutus äidin synnytyskomplikaatioiden esiintyvyyteen

Synnytys- ja naistentautioppi, Turun Yliopisto, Turku, Suomi
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Keisarileikkaus on maailmassa yleisin naisille tehty suuri leikkaus. Keisarileikkaus voi pelastaa äidin tai lapsen hengen, mutta siihen liittyy tyypilliset suuren kirurgisen toimenpiteen riskit: verenvuoto, infektio, syvä laskimotukos ja anestesiakomplikaatiot, jotka toisinaan johtavat kuolemaan.

Viime vuosina on useissa kehittyneissä maissa raportoitu vakavien äitikomplikaatioiden ja myös äitiyskuolleisuuden lisääntyneen. Keisarileikkausten sekä ylipainoisten ja iäkkäiden synnyttäjien lisääntynyt osuus saattaa selittää ilmiötä.

Tämän väitöskirjatutkimuksen tavoite on selvittää äitien keisarileikkauksiin liittyviä välittömiä komplikaatioita ja niiden riskitekijöitä. Tutkimus selvittää myös komplikaatioiden esiintyvyyttä eri synnytystavoissa ja eri vuosina.

Keisarileikkauksiin liittyviä komplikaatioita ja niiden riskitekijöitä selvitettiin prospektiivisessa tutkimuksessa joka kattoi 2496 keisarileikkausta 12 synnytysyksiköstä vuodelta 2005. Vakavien synnytyskomplikaatioiden esiintyvyys eri synnytystavoissa selvitettiin rekisteritutkimuksessa, jossa aineistona olivat kaikki yksisikiöiset synnytykset vuosina 1997 ja 2002. Useiden riskitekijöiden vaikutusta vakavien komplikaatioiden esiintyvyyteen eri synnytystavoissa selvitettiin rekisteritutkimuksessa, jonka aineistona olivat kaikki yksisikiöiset synnytykset 2007-2011.

Prospektiivisessa tutkimuksessa esiintyi 27%:lla keisarileikatuista naisista vähintään yksi komplikaatio leikkauksen tai sen jälkeisen sairaalahoidon aikana, ja 10%:lla komplikaatio oli vakava. Rekisteritutkimuksessa henkeä uhkaavia komplikaatioita ilmeni 7.6 synnytyksessä tuhannesta. Esiintyvyys oli matalin alatiesynnytyksissä, korkeampi instrumentaaliavusteisissa alatiesynnytyksissä ja suunnitelluissa keisarileikkauksissa, ja korkein päivystyskeisarileikkauksissa. Alatiesynnytyksen yritys, sisältäen päivystyskeisarileikkauksen riskit, oli turvallisin synnytystapa myös useimmille korkean riskin ryhmiin kuuluville naisille

Avainsanat: Keisarileikkaus, alatiesynnytys, synnytyskomplikaatiot

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ABBREVIATIONS

aOR	adjusted OR
BMI	body mass index
CS	Cesarean section
DVT	deep venous thrombosis
ICD-10	International statistical classification of diseases and related health problems
IDM	insulin dependent diabetes mellitus
MMR	maternal mortality rate
NCSP	Nordic classification of surgical procedures
NICU	neonatal intensive care unit
OR	odds ratio
PE	pre-eclampsia
PPH	post partun hemorrhage
RR	risk ratio
THL	National institute for health and welfare (Terveyden ja hyvinvoinnin laitos)
UKOSS	United Kingdom obstetric surveillance system
UTI	urinary tract infection
VD	vaginal delivery

LIST OF ORIGINAL PUBLICATIONS

I Pallasmaa N, Ekblad U, Gissler M. Severe maternal morbidity and the mode of delivery. Acta Obstet Gynecol Scand 2008; 87(6):662-668.

II Pallasmaa N, Ekblad U, Aitokallio-Tallberg A, Uotila J, Raudaskoski T, Ulander V-M, Hurme S. Cesarean delivery in Finland: maternal complications and obstetric risk factors. Acta Obst Gyn Scand 2010; 89: 896-902.

III Pallasmaa N, Alanen A, Ekblad U, Vahlberg T, Koivisto M, Raudaskoski T, Ulander V-M, Uotila J. Variation in cesarean section rates is not related to maternal and neonatal outcomes. Acta Obstet Gynecol Scand 2013; 92:1168-1174.

IV Pallasmaa N, Ekblad U, Gissler M, Alanen A.The impact of maternal obesity, age, pre-eclampsia and insulin dependent diabetes on severe maternal morbidity by mode of delivery –a register-based cohort study. Manuscript.

1. INTRODUCTION

Cesarean section (CS) is the most common surgical procedure performed on women worldwide. It can save the life of the mother and newborn, but is also known to have the typical complications of any major surgery: hemorrhage, infection, venous thromboembolism and complications of anesthesia, sometimes leading to maternal death. Advances in medical care, antimicrobial and antithrombotic prophylaxis have improved the safety of CS. During last decades, many obstetricians perceive the risks related to CS as being so low, that they are willing to perform a CS on relative medical indications, and even without medical indications. Some obstetricians emphasize the risks related to vaginal delivery (VD) - the risks of neonatal asphyxia and trauma and the risk for obstetric tears- to justify the liberal use of CS.

During the last years, there have been several studies comparing severe maternal morbidity in different modes of delivery, and also comparing the risks related to elective CS with attempted VD (Liu et al. 2007, Villar et al. 2007, Kuklina et al. 2009, van Dillen et al. 2010, Farchi et al. 2010). Attempted VD contains the risk of ending up with emergency CS or instrumental VD. Emergency CS is related with a 1.1-2.3-fold higher morbidity than elective CS (Rasmussen et al. 1990, Allen et al. 2003, Burrows et al. 2004, Koroukian 2004). The compound morbidity of an attempted VD depends on how many of the women finally deliver in the planned manner.

Factors increasing the risk of ending up in CS and increasing the risk for complications related to a delivery have been examined in several studies. Risk factors identified by most studies are obesity and advanced maternal age, increasing the risk for CS and CS-related complications.

Recently there have been several reports from well-resourced countries on increased severe maternal morbidity and even mortality (Deneux-Tharaux et al. 2006, Samuelsson 2007, Kuklina et al 2009, Schutte et al. 2010). The causes are unclear, but increased CSs, increased obesity and an increased proportion of women giving birth in advanced age are among the causes suspected.

The present study was planned to examine the maternal complications related to CS in a high-standard health care system and to determine the risk factors predisposing to complications. Maternal complications were studied prospectively from 2496 CSs performed in 12 hospitals. The CS rates and their possible association with maternal and neonatal outcomes in these 12 hospitals were also studied. The incidences and incidence trends of severe complications by delivery mode were studied in a register based study comprising all singleton births in Finland in two separate year cohorts,

1997 and 2002. The impact of several risk factors on severe maternal morbidity was studied separately for all delivery modes in a register based study on all singleton births in 2007-2011.

2. REVIEW OF THE LITERATURE

2.1. History of cesarean section and development of modern operative obstetrics

Probably the very first documented evidence of cesarean birth is a legal text dating to the era of Hammurabi (1795-1750 BC), describing the birth of a male child "pulled out of the womb" of a deceased woman (Lurie 2005). The name *sectio caesarea* was first used by the French obstetrician Guillimeau in 1598. At that time, the operation was used to deliver live babies from dead mothers (O´Sullivan 1990).

There are three different explanations about the origin of the name of the operation. In 715 BC, the King of Rome, Numa Pompilius, codified the Roman laws. According to the law, it was forbidden to bury a dead pregnant woman before the fetus was excised. If the child was alive, it was called a "caeson". This law, Lex Caesaris or Lex Caesarea, is assumed to be the origin for the name of the procedure "cesarean section" (O´Sullivan 1990, Lurie 2005, Todman 2007).

It has also been stated, that Julius Caesar has been delivered by this method, and gave the name for the operation. This is considered unlikely, because his mother is known to have been alive during Julius Caesars adulthood. During his reign about 100 BC no woman is known to have survived the operation. A third explanation is that the name is simply derived from the Latin verb *caedare*, to cut. The word "section" is also derived from the latin verb *secare*, to cut (O'Sullivan 1990).

Hippocrates (460-377 BC) was the first physician who attempted to improve obstetrics. He wrote about difficult labor, but the practical side of midwifery was in the hands of midwives, which were uneducated and knowledge was based on experience. In early Christian times, some physicians, e.g. Soranus (AD 98-138) in Rome, wrote textbooks to instruct midwives. Still, there is no mention of cesarean section in Soranus' work *Gynaecology* or in the texts by Hippocrates (O'Sullivan 1990).

From the second to sixteenth century, rational medicine gave way to superstition, and the teachings of Hippocrates and others were forgotten. Female pelvic anatomy was not understood until Vesalius in his *De Corporis Humani Fabrica*, published in 1543, describes the female anatomy in detail. This was a foundation for operative obstetrics emerging in the 1700s and 1800s.

After the 1500s, physicians became interested in obstetrics and reports of cesarean deliveries were published in different countries. The operation was usually performed after the woman had been several days in labor and after several attempts by several midwives

and physicians to help her. The first operation reported in a medical journal was performed in 1610 by Jeremias Trautmann of Wittenberg. At that time, the mother always died within a short time, sometimes after some weeks. After Dr. Trautmann's operation, the baby survived but the patient died on the twenty fifth postoperative day (O'Sullivan 1990).

The first known cesarean birth in England in which the patient survived was performed in 1793. During the 1800s, maternal mortality related to cesarean section was nearly 90%. The abdominal incision was lateral, vertical or semilunar. The uterine incision was made in the front, at the side, in the fundus or even in the posterior wall, and was never sutured. The abdominal wall was closed by three or four sutures. The mothers died immediately of postpartum hemorrhage or later of infection (O'Sullivan 1990).

In 1876 an Italian obstetrician Edoardo Porro (1842-1902) described an operation consisting of subtotal hysterectomy after delivery of the baby. This stopped the primary hemorrhage and decreased the risk for a sepsis, but fertility was lost (O'Sullivan 1990, Todman 2007). This technique evoked worldwide interest. In 1881, Harris published a literature review of 50 cases of operations modo Porro: maternal mortality was 58% and fetal survival 86%, which were major improvements to previous results (Todman 2007). The technique was soon adopted in several countries in Europe and USA. In 1881 Sanger described a procedure, where the uterine incision was sutured. This technique reduced hemorrhage and sepsis and preserved the uterus.

Some other important steps in preventing maternal death due to CS were anesthesia by Jackson and Morton in 1846 in Boston, aseptic techniques by Semmelweiss in 1861, who started the practise of handwashing before operations in Vienna, and antisepsis by Lister in 1867, who introduced carbolic spray to keep the atmosphere above the wound free from bacteria (Todman 2007).

In 1926, James Munro Kerr introduced the transverse uterine incision instead of the longitudinal incision in USA. This form of incision had the advantages of less hemorrhage and a lower risk of uterine rupture in future pregnancies (Lurie 2005). In the beginning of the 1900s, it became more popular to make the abdominal incision transversally while the fascia was incised longitudinally. In 1900, a German gynecologist Pfannenstiel introduced the technique of incising also the fascia transversally, to have a more secure closure and less postoperative pain (Todman 2007).

From the early1900s, blood transfusions became available in specialist units. Sulphonamides in 1935 and penicillin in 1941 reduced the risk of sepsis and maternal death related to deliveries.

With these advances, maternal mortality related to CS dropped to 5-10% by the end of the 1800s, and to 0.1% by 1950 (O Sullivan 1990, Lurie 2005, Todman 2007). Towards the

end of the 20th century, maternal mortality related to birth has dropped to 6-13/ 100 000 maternities in high resource countries, but is still 3-4 times higher related to CS than to VD (Deneux-Tharaux et al. 2006, Callaghan 2012).

In the early 1900s, DeLee of USA, the foremost academic leader in obstetrics of his time, implemented an attitude that most pregnancies are potentially abnormal and must be managed by experts in order to achieve good results. Obstetrics became a specialty practiced by surgeons (Cyr 2006). In the latter half of the1900s, specialist units were increasing and pregnant women chose often to have birth in hospitals. The units were staffed by a consultant surgeon or an obstetrician, and soon also by consultant anesthesiologist. Operative obstetrics became a part of the functions of a modern hospital. The rate of CS rose concomitantly with an active policy of interventions. The need for interventions rose in pace with increased inductions, an established definition of prolonged labor and electronic fetal monitoring. In many countries "defensive obstetrics" became a common phenomenon, increasing rate of CS because of fear of litigation related to claimed negligence of fetal safety (O Sullivan 1990).

2.2. Indications for cesarean section

Before the 1800s, CS was performed only after the death of the mother to give the baby a chance to survive (O´Sullivan 1990, Lurie 2005). In the 1800s CS was sometimes performed for maternal reasons for obstructed labor, usually after the labor had been going on for several days. By the early 1900s, CS was performed for placenta previa, eclampsia, difficult labor and sometimes even at the mother´s request (Cyr 2006). As mortality has declined, the indications for CS have shifted more to the benefit of the neonate.

In the late 20th century and during the recent years, the main indications for a CS have been protracted labor, (suspected) fetal distress, malpresentation of the fetus, placental abnormalities and maternal reasons (Kolås et al. 2003, Stjernholm et al. 2010). Since focus has been increasingly put on fetal wellbeing, breech presentation has become a common indication for a CS, particularly after publication of theTerm Breech Trial by Hannah et al. (Hannah et al. 2000). Although the transverse lower uterine segment incision has led to a substantially lower risk of uterine rupture in subsequent deliveries compared to earlier techniques, a uterus scarred by previuos CS has become one of the most common indications for CS in many countries (MacDorman et al. 2008, Fitzpatrick et al. 2012).

Towards the end of the 20th century, a new indication emerged and increased the rate of CS in many countries: CS without medical indications or CS for maternal request. This has lead to controversies among obstetricians, with some accepting this policy and some not. Although there is evidence of higher maternal morbidity and even mortality related to CS compared to VD, many patients and even obstetricians consider it safe enough to

be performed even without any specific indication (Habiba et al. 2006, Gunnervik et al. 2008).

For the low-risk group of women with no indication for a CS, the rate of CS has been rising, and is estimated to be about 7% of all CS in the US in the early 2000s (Bailit et al. 2004, Menacker et al. 2006, MacDorman et al. 2008). Still, a US survey showed that a much smaller proportion of all women were interested in a non-indicated CS in the early pregnancy, suggesting that this trend is partly driven by the obstetricians themselves (Menacker 2006).

CS because of fear of delivery has become a common indication for CS, especially in the Nordic countries. In Finland, where there is more than ten years of experience of active management of fear of delivery to support parents and to avoid unnecessary CS, in average 1% of all deliveries are CS performed for this indication (Rouhe et al. 2007). In Sweden the indication "fear of childbirth or maternal request" has increased from 0.6% to 3.9% of all deliveries from 1992 to 2005 (Stjernholm et al. 2010). To which extent "fear of delivery" overlaps the indication "maternal request" used in many countries is not known, but a Swedish study on the subject showed, that 43% of women requesting a CS showed a clinically significant fear of delivery (Wiklund et al. 2008).

Table 1. Indications for elective and emergeny cesarean sections in 2005 in Sweden (Karolinska University Hospital, Stockholm).

Indications for emergency caesarean sections	**per 100 CS**
Presumed fetal compromise	44.2 %
Prolonged labor	29.7 %
Maternal compromise (e.g. severe pre-eclampsia)	7.7 %
Fetal malpresentation	15.9 %
Prematurity	2.3 %
Uterine rupture	0.2 %
Indications for elective caesarean sections	**per 100 CS**
Breech/ transverse lie	21.4 %
Uterine factor (uterine incision, ≥prev.CS)	16.0 %
Narrow pelvis	2.9 %
Psychosocial (fear of childbirth / maternal request)	38.5 %
Maternal disease	8.2 %
Multiple pregnancy	2.6 %
Fetal factor (fetal disease, macrosomia)	3.1 %
Previous sphincter injury	7.3 %

(Stjernholm et al. Acta Obstet et Gynecol Scand 2010)

2.3. The ideal CS rate

All obstetricians agree with the statement that the ideal CS rate is the rate with the least complications for both mother and neonate. However, different birth attendants and health care providers perceive the same risks differently (Cyr 2006, Liu et al. 2007).

The famous obstetrician J.W.Williams (1899-1931) maintained a CS rate of 0.9% in his hospital in Baltimore in 1900-1921. After Williams, during the late 1940s, Plass, who had trained under Williams, believed that 4-5% was close to the ideal rate of CS (Cyr 2006).

A lack of adequate obstetric care and access to necessary interventions in case of complicated labor causes maternal and fetal morbidity and death. Obstetric fistulae after obstructed labor are a common problem in the developing world (Wall 2006). At the population level, the recommended minimum necessary CS rate to avoid death or severe morbidity to the mother is currently estimated to be 1-5% (Gibbons et al. 2010). Neonatal outcomes tend to improve up to a CS rate of 10%. It has also been shown, that neonatal and maternal morbidity is not reduced when the CS rate exceeds 15%; rather, a higher CS rate is associated with higher mortality and morbidity in mothers and neonates (Althabe et al. 2006, Villar et al. 2006, MacDorman et al 2006, Goldenberg et al. 2007, Gibbons et al. 2010).

A WHO consensus conference stated that no region should have a CS rate above 10-15% (WHO 1992). A recent survey on the global availability of CS studied the CS rates in 137 countries covering approximately 95% of all births worldwide in 2008. A CS rate under 10% was considered to be too low and a rate over 15% was considered to mean overuse of CS. The study concluded that 3.2 million additional CS were needed in 54 countries and that 6.2 million unnecessary CS were performed in 69 countries (Gibbons et al. 2010). The authors estimate that 18.5 million CSs are performed every year in the world. Approximately 10% of the countries in the world have a CS rate of 10-15%. (Gibbons et al, World Health Report 2010).

The reasons for rising CS rates have been widely studied. In a study from Canada the investigators estimated the contribution of changes in maternal characteristics and obstetric practice to the increased CS rates (Joseph et al. 2003). The authors concluded that changes in CS rates are a consequence of changes in maternal characteristics, and that obstetric practice has altered due to these changes. On the other hand, many studies show that changes in maternal characteristics explain only a part of the changes in the CS rates, and the main explanation lies in the changes in obstetric practice (Källen et al. 2005, Parajonthy et al. 2005).

The CS rate varies widely among the high-resource countries in the world. Since the 1970s the CS rate has increased from <10% in all high-resource countries to the present

>30% in the US and many European countries (The European Perinatal Health Report 2010, Center for Disease Control and Prevention, 2011, USA). Two basic methods have been used in the literature to compare the CS rates between hospitals or countries with different obstetric populations,. The "standard population" method compares the CS rates between similar populations. The Robson Ten Group Classification System, where CS-rates are compared within similar Robson-groups (for example group 1: nulliparous, single cephalic, ≥37 weeks, in spontaneous labor) is a widely used tool for comparisons between hospitals or countries (Robson 2001). Another method is the multiple logistic regression method, which takes into account several risk factors within the studied population and estimates an adjusted CS rate for different delivery units (Bailit et al. 2003).

In the Nordic countries, the rate of CS has been lower than in most parts of Europe and the USA, and quite stable during last decades. At the same time the maternal and neonatal morbidity- and mortality rates in the Nordic countries are among the lowest in the world. The European Perinatal Health Report shows, that the CS rate in Europe was under 20% only in the Netherlands, Slovenia, Finland, Sweden, Iceland and Norway in 2010 (European Perinatal Heal th Report 2010).

2.4. Tehniques of cesarean section

Because of the risk for CS-related intraoperative and postoperative complications, it is important that the surgical technique employed is optimal to minimize morbidity not only during the index delivery but also with respect to future pregnancies and deliveries (Walsh 2010). Although there are several studies comparing different techniques for different surgical steps in the CS, there is no widely accepted technique for performing a CS. Numerous approaches have been described and the techniques vary from surgeon to surgeon (Walsh 2010). The Cochrane Collaboration has published a review on the techniques for cesarean section.

The main techniques used today are the Pfannenstiel technique, where sharp dissection is used when opening the tissue layers, and the Joel-Cohen technique, where only the skin is incised sharply and the rest of the tissue layers are dissected bluntly with the fingers. Closure of the myometrium is a main difference between the techniques. In Pfannestiel technique, the uterine incision is closed with two layers of continuous sutures, while in the Joel-Cohen method it is closed with interrupted sutures in one layer. The Misgav-Ladach technique is a modification of the Joel-Cohen technique, using single-layer locking continuous suture for uterine closure. Both peritoneal layers are closed with continuous sutures in the traditional Pfannentiel method, while they are left unsutured in the other methods. Staples are often used for skin closure, except in the Misgav-Ladach technique where the skin is closed with two or three mattress

sutures (Hofmeyr et al.2008). Many obstetricians use a modification adopting features from several techniques.

Cesarean sections are categorised according to the degree of emergency. Elective CS (pre-labor, planned) is a CS performed on a scheduled time. The decision to operate is often made several days but at least 24 hours earlier. Emergency CS is performed within a few hours to 30 minutes after the decision, most often for a prolonged labor or suspected fetal distress, often but not always after the onset of labor. A crash-emergency CS in performed within a few minutes after the decision, usually for immediate threat of fetal asphyxia.

There is no consensus on the time limits for each type of CS. In UK a four-step classification system for the urgency of CS has been adopted in many obstetric units. In this system, Grade I CS is performed when there is an immediate threat to the life of the woman or fetus, grade 2 when there is evidence of maternal or fetal compromise, which is not immediately life threatening, and grade 3 when there is no maternal or fetal concern but early delivery is required and grade 4 is elective CS (Cerbinskaite et al. 2011). The techniques for elective and emergency CS do not differ essentially except for the skin incision which is made longitudinally in a crash-emergency CS and usually transversally in other CS. The deeper the fetal head has descended in the pelvis and the more the cervix had dilated, the more technical difficulties are met and the higher is the risk for intraoperative complications (Nielsen et al. 1984, Rasmussen et al. 1990, Häger et al. 2004).

2.5. Maternal complications related to delivery

The incidence of maternal complications related to deliveries reported in different studies vary according to how complications are defined, the method of collecting data and the period of follow up. The follow-up time may be during the hospital stay (Häger et al. 2004, Liu et al. 2007), to 30 days (Opøien et al. 2007), to six weeks (van Dillen et al. 2010) and even up to one year after delivery (Källen et al. 2005). Many of the delivery related complications, especially infections and thromboembolic events, occur after the discharge from hospital (Källen et al. 2005, Opøien et al 2007).

Retrospective studies using register data often report a lower incidence of complications than studies collecting data prospectively, or studies using patient hospital records for collecting data. There are also some studies where data is collected retrospectively from all possible sources, including nurse diaries. In a study by Hillan, where the nurses notes where also examined, the rate of complications related to CS was 90.5% (Hillan 1995).

2.5.1. Cesarean section compared to vaginal delivery

Several studies have compared the outcomes between elective CS and VD in an attempt to address the question, whether CS without strict medical indications is justified or not. The results vary particularly by the group compared to elective CS: spontaneous VD, all VDs (instrumental VDs included), intended VD (instrumental VD and emergency CS included), or after induction of labor or after a previous CS.

In all studies comparing maternal morbidity between elective CS and spontaneous VD the total complication rate is higher in elective CS. (Krebs et al. 2003, Burrows et al. 2004, Koroukian et al. 2004). Of the specific complications, only obstetric trauma is more common in VD than in CS. A Canadian register-based study compared maternal morbidity in elective CS with spontaneous onset labor in a population of 18 435 deliveries and showed a similar maternal morbidity rate for elective CS as for spontaneously onset labor (including deliveries that ended up in emergency CS). The total maternal morbidity rate was 7.0% for elective CS and 8.4% for spontaneous onset of labor. In this study 8.0% of the women had a CS in labor and 19.6% an instrumental VD (Allen et al. 2003). Severe morbidity was not studied separately. In this study, only febrile morbidity and wound infection occured more often in elective CS than in attempted VD (Allen et al. 2003).

Studies specifically on severe maternal morbidity show that elective CS is, without exceptions, related to significantly higher morbidity rates than VD or attempted VD (Liu et al. 2007, van Dillen et al. 2010, Farchi et al 2010, Kuklina et al.2009).

A summary of studies on maternal complications related to different delivery modes is seen in **Table 2**.

2.5.1.1. Obstetric tears, urine and anal incontinence

The typical complications related to VD are obstetric tears exposing women to pelvic organ prolapse, urinary and anal incontinence. The incidence of anal sphincter injury in VD varies by study from 0.6% to 7.8% and is higher for instrumental VD (Burrows et al. 2004, Dandolu et al. 2005, Laine et al. 2009). The reported rate of subsequent flatus incontinence is 8-61% and of fecal incontinence 0-20% (Sultan et al.1999, Kairaluoma et al. 2004, Pinta et al. 2004).

Problems of anal incontinence occur also in women having had only CS without labor and even in women without pregnancies, although this is significantly less frequent (Hannah et al. 2002, Lal et al. 2003). In a British study 4%, 6% and 8% of women had new symptoms of anal incontinence after elective CS, emergency CS and spontaneous VD, respectively (Lal et al. 2003). In that study, the total CS rate was 13%, instrumental VD rate 8% and the rate of third degree tears 0.6% (Lal et al. 2003). In a Finnish study

Table 2. Studies on maternal complications related to CS and VD

Authors		Study design	Complication rate	Complication type	Follow-up time	Risk factors	Emergency CS vs elective.CS
Nielsen et Hökegård 1984, Sweden	1978-1980 n=1319 CS CS rate 18%	Prospective Complications related to CS	11.6% (minor 9.5%, major 2.1%)	Minor: blood transfusion 1.2% minor lacerations 6.4% injuries to the infant without sequelae 0.2%, difficulty in delivering the infant 1.6% Major: injury to the bladder 0.2%, tear in cercix and vagina 0.5%, bilateral bleeding from aa.uterinae 0.5% , extensive lacerations 0.8%, intestinal injury 0.1%, injury to the infant with sequelae 0.1%		In emerg. CS: station of present.part, emerg.CS, preterm, rupt. of membr., prior. surgery, prior CS, skill of the operator In elect.CS no specific risk factors	Emergency CS 18.9% Elective CS 4.2% RR 4.5
Rasmussen et Maltau, 1990, Norway	1979-1985 n=898 CS CS rate 9.9%	Retrospective, one center Complications related to CS	total compl.rate 29.3% 8.5% intraop, 23.1% postop 90% minor, 9% severe, 1% life-threatening	Intraoper: bladder injury , lacerations,injury to aa.uterinae, hysterectomy, injury to the bowel, difficult delivery, bleeding needing transfusion, injury to the istmus, injury to the infant without sequelae Postoper: Infection 22.3% (sepsis 0.6%, pneumonia 0.4%, re-op. for inf. 0.1%, wound inf. 11.7%, UTI 9.1%, endometritis 1.7%. Tromboembol. 0.6%, ileus 0.4%		onset of labor, rupture of membranes, fetal head below spines, gest.weeks <37	em/el: Intraoper.compl. RR 1.8 Postop. compl. RR 2.5%
Hillan 1995, Scotland	ear of data collection not given n=619 CS rate 16%	Retrospective Patient records and midwifery notes Complications related to CS	Total complication rate 95.5% (one or more complications)	Fever 58%, transfusion 3.4%, Infectious morbidity 22.8%: UTI 11%, wound infection 7%, urinary retention with catheter >48 hours 5%, endometritis 4%, spinal headache 4%, pneumonia 4% Serious complications 4.7%: laparotomy 1.0%, paralytic ileus 0.6%, complete wound dehiscense 0.5%, DVT 0.2%, sepsis 0.6%	Hospital stay		More complications in emergency CS
van Ham et al. 1997, Netherlands	10 years, 1983-1992 n= 2647 CS	Retrospective, one center Complications related to CS	Intraoper. compl 14.8% Postop. morbid 35.7%: minor31.2% major 4.5%	Intraop: hem.≥1000 7.3% uterine lacer 10.1% bladder lesion0..8% lesion a.ut/bowels etc 0.5% Postop.minor: fever 24.6% hem 1000-1500 4.0% hematooma3.5% uti 3.0% thromboflebitis2.5% WI 2.0% endometritis 1.1% Ileus 1.5% bladder paralysis 0.9% Postop major hem≥1500 2.4% re-laparotomy 1.6 pelvic infection 1.5% thrombosis 1.5% pneumonia 0.3% sepsis 0.3%		Resident vs. consultant: intraoper. compl. 15.9% vs. 13.1%	Elective CS:minor compl. 23.7% major compl: 2.6% Emergency CS: minor compl. 34.0%, major compl.5.2% em/el: major. RR 1.4 minor: RR 2.0
Bergholt et al. 2003, Denmark	1995-1996 n=929 CS CS rate 11.9%	Prospective Medical records Intraoperative complications.	Intraoperative complications 12.1%	cervical laceration 3.6% , corporal lacer. 0.3%, vaginal lacer. 1.2%, bladder lacer.0.5%, bowel lacer. 0, blood loss≥1000ml 9.2%, transfusion 1.0%, uterine rupture 0.3%, hysterectomy 0.2%		Unexperienced operator, previous CS, low station of the presenting part of the fetus, birth weight, maternal age	Emerg CS 14.5%, elect CS 6.8% RR 2.1

Authors		Study design	Complication rate	Complication type	Follow-up time	Risk factors	Emergency CS vs elective.CS
Krebs et Lan-ghoff-Roos 2003, Denmark	1982-1995 (n=15 441) elective CS rate 48.6%, VD rate 15.3%, emergency CS rate 36.1%	Population-based retrospective cohort study Primiparas delivering singleton breech at term		MINOR: Anemia or hemor-rhage:VD 6.0%, elective CS 5.7%, emergency CS 7.0%. Puerperal fever/pelvic infection: VD 0.5%, el.CS 1.5%, em.CS 2.3%. Wound infection: VD 0.7%, el.CS 0.9%, em.CS 1.8%. Bladder injury: VD 0, el.CS 0.1%, em.CS 0.2%. MAJOR: Thromboembolism: VD 0, el.CS 0.1%, em.CS 0.1%. Rupture of the anal sphincter: VD 1.7%, el.CS 0, em.CS 0.			em..CS/el.CS: anemia or hemor-rhage: RR 1.1 Puerp.fever: RR 1.2 Wound infection RR 1.4 Thromboembolism: RR 1.3
Häger et al. 2004, Norway	1998-1999 (7 months) n=2751 CS CS rate 13.4%	Prospective 24 delivery units	21.4%	Iintraoperative compl. 7.9% Hemorrhage ≥1000 7.9% Blood transfusion 4.3% Infection 7.0% (WI 2.3%, UTI2.6%, endometr 2.0% re-oper.5%		Cervical dilation Birth weight >4500 No effect: age, bmi	Elect CS 16.3% Emerg CS 24.1% em/el: RR 1.5
Burrows et. al. 2004, USA *TOL=trial of labor	1995-2000 n= 32 834 (all deliveries) CS rate 17.2% instr. VD 22.3%	register-based, also medical records reviewed VD vs. CS (spont.VD/instr.VD/ repeat elect. CS/ primary el.CS/ TOL after prior CS/ primary CS after TOL*		3rd-4th degree lacer 7.8% in spont VD, 22.3% in operat. VD endometritis: VD 0.4%. elect CS: 2.8%, emerg CS:8.5% Pneumonia: VD. 0.1%, elect CS 0.4%, em.CS:0.2% Transfusion: VD 0.2%, elect CS 0.5%, em CS 1.0% intraop.compl. 0.4%	hospital stay		em/el Endometritis+pneum: VD 0.5%, el.CS 3.2%, em CS 8.7% RR 2.7 Transf: VD 0.2, el CS 0.5% , em CS 1.0%, RR 2.0
Koroukian, 2004, USA	1991-1996 n= 168736 singleton deliv. no medical conditions	register-based, ICD-9 CS rate 18.4% el cs vs. vd		Elect.CS vs. VD, Relative risk: Major puerp.inf:2.87/0.83 ,RR3.8 Thromboemb. 0.19/0.06, RR3.5 Anesth.compl. 0.39/0.09, RR 4.4 Hemorrh 1.5/2.4, RR 0.6 Transfusion 0.07/0.06, RR 1.2 obst.trauma 1.1/6.9, RR 0.2 surg.wound compl. 3.0/0.25,RR12.5	60 days after delivery		Elect.CS vs. em.CS, RR Major puerp.inf 1.5 Thromboemb.2.4 Anesth.compl. 0.9 Hemorrh 1.3 Transfusion 5.3 Obst.trauma 0.5 Surg.wound com-pl. 1.2
Källen et al. 2005, Sweden	1990-2001 n=1 029 075 women CS rate 10.9 -90 CS rate 16.6 2001	Retrospective Birth Register National	total compl.rate not reported	Transfusion VD 1.3/1000 CS 4.6/1000 Hemorrh >1500 VD 0.8% CS 2.9% Sepsis/endometritis VD 4.2/1000 CS 14.3/1000 Thromboemb. VD 0.47/1000 CS 1.73/1000 Re-oper 2.8/1000	364 days		
Hadar et al. 2011, Israel	2007-2009	Case-control study Review of patient files, women who underwent a CS 100 women with complications, 100 women without complications	total compl. rate 5.7%	Endometritis 3.6% Wound infection 1.8% Wound hematoma 1.2% Blood loss >1000ml 12%	Hospital stay	Surgeon experience (OR 2.4), intra partum CS (OR 2.1)	OR 2.1
Karlström et al 2013, Sweden	CS without medical indication, n=5877 Spont. onset of labor , n=13 774 (em.CS rate 6.1%)	Register-based, ICD-10 el Cs vs VD em CS vs VD el CS vs em CS		Hemorrhage :el CS 9.9%, em CS 10.9, VD 5.0% Infections el CS 2.5%, emCS 3.0%, VD 1.0%	Hospital stay		em/ el: Hemorrhage: RR 1.1 Infections: RR 1.2

comparing the variation in anal sphincter injury rates between Finnish delivery units, the incidence of anal sphincter injury was 0.7% -1.3%, and a high CS rate did not protect from anal injury (Pyykönen et al. 2013). Also in the large study by Villar et al, involving 120 institutions, the CS rates were not associated with rates of third or fourth degree perineal lacerations (Villar et al 2006).

In the Term Breech Trial by Hannah et al. maternal and fetal outcomes were compared in breech deliveries by the intended mode of delivery. The long term maternal outcomes reported 3 months after the delivery showed, that there were no significant differences between the study groups regarding overall morbidity (planned CS versus planned VD). In the planned CS and planned VD groups urinary incontinence occurred in 4.5% and 7.3%, pain in 27.3 % and 25.0%, gas incontinence in 10.7% and 9.7%, and fecal incontinence in 0.63% and 1.1% of the women, respectively (Hannah et al. 2002). The CS rate was 90.9% in the planned CS group and 43% in the planned VD group.

In a Danish study comparing elective CS for breech, emergency CS and VD, also the long time consequences of deliveries were studied. In a population of 15 441 women, there was no significant relation with mode of delivery and hospitalization for prolapsed organs or urinary incontinence. The incidences were 0.6%, 0.6% and 0.5% for VD, elective CS and emergency CS, respectively, and no hospitalization for fistulae or anal incontinence was detected within the follow-up period of 5-18 years after the first delivery (Krebs et al. 2003).

2.5.1.2. General complications

In a prospective Norwegian study on complications related to CS (n= 2751) predefined types of complications were collected during hospital stay and it was found that 21.4% of the women had one or more complications. The complication rate increased with increasing cervical dilation; it was 16.8% at 0 cm and 32.6% at 9-10cm of cervical dilatation (Häger et al. 2004). In a Dutch study, where maternal complications related to CS were collected retrospectively from patient records (n=2647), the total incidence of postoperative complications was 35.7%. In addition, 14.8% of these women had one or more intraoperative complications. 4.5% of the women had a major complication (van Ham et al.1997). In a Norwegian study on CS covering the years 1979-1985 (n=898) 29.3% of the women sustained one or more complications during or after the operation, and 3% had a severe complication (severe intraoperative complications, thromboembolic events, sepsis, pneumonia and re-operations (Rasmussen et al. 1990). In a large study from Germany on puerperal complications in different delivery modes, the total puerperal complications rate was 20.2% in CS and 11.8% in VD (Simoes et al 2005).

There have been less studies on the complications related to VD, but in studies comparing the different delivery modes, CS is related to a higher incidence of most complications. Emergency CSs has had a significantly higher risk (1.1-2.3-fold) for complications than elective ones in almost all of these studies. (Rasmussen et al. 1990, Allen et al.2003, Burrows et al. 2004, Koroukian 2004). In some studies elective CS is related to a higher risk of complications than emergency CS (Villar 2007, Karlström 2013).

2.5.2. Severe maternal complications and maternal death

2.5.2.1. Severe maternal morbidity

Severe maternal morbidity has increased in many high-resource countries. A study from USA reports an increase in the occurrence of severe maternal complications, from 0.64% in 1998-1999 to 0.81% in 2004-2005. The authors of the study conclude that many of these complications are associated with the increased rate of CS (Kuklina et al. 2009). A Swedish study reports an increased incidence of pregnancy-related thromboembolic events from 1970-80 to 1990-99 (Samuelsson et al. 2007).

The incidence of severe maternal morbidity related to delivery was 7.1 per 1000 deliveries in the Netherlands and the case-fatality rate was 1:53 (Zwart et al 2008, van Dillen et al 2010). When severe morbidity related to delivery mode was considered specifically, the incidences were 6.4/1000 for elective CS, 8.5/1000 for emergency CS and 3.5/1000 for VD. The OR for severe morbidity in elective CS compared to attempted VD was 1.7 (95% CI 1.4-2.0) (van Dillen et al. 2010).

Liu et al. compared severe maternal morbidity in planned CS with planned VD in low-risk pregnancies, and reported one or more severe complications in 27.3 of 1000 deliveries for planned CS and 9.0 of 1000 deliveries for planned VD (Liu et al. 2007).

In the UK, the incidence of severe maternal morbidity related to delivery was 7.4 per 1000 in 1997-1998 and it was four times more often related to CS than to VD. The morbidity to mortality ratio was 1:118 (Waterstone et al.2001).The main predictors of severe maternal morbidity in the British study were age over 34, diabetes, hypertension, multiple pregnancy and emergency CS.

A summary of studies on severe maternal morbidity by the mode of delivery presented in **Table 3**.

Table 3. Studies on severe maternal morbidity related to delivery (pregnancy excluded).

	Study design and setting	Total complication rate (all deliveries) definitions, case-fatality rate	Complications in VD	Complications in elective CS	Complications in emergency CS	Planned elective CS vs. planned VD	Risk factors
Waterstone et al. BMJ .2001	Case-control study All maternity units (19) in South East Thames region 1997-1998 (one year) Maternity computer databases, laborward and postnatal ward diaries, staff reporting, medical records n= 48 865 deliveries, 588 cases of severe morbidity	Delivery related 7.4/1000 (12.0/1000 pregnancy included) 5 deaths Severe hemorrhage 6.7/1000 Severe pre-eclampsia 3.9 Eclampsia 0.2 HELLP 0.5 Severe sepsis 0.4 Uterine rupture 0.2 Morbidity to mortality ratio 118:1	Not analyzed	In any CS 4-fold risk for severe morbidity			Age 34 OR1.5 Non-white Hypertensive disorder 1.2 Emergency CS OR 4.3 Multiple pregnanc 2.2y Social exclusion 2.6 Diabetes OR 1.8 Anticonvulsive- or Antidepressant medication
Villar et al. BMJ. 2007 Eight Latin American countries	Prospective cohort study 120 health facilities in 8 countries 2004-2005, 2-3 months per institution Medical records of each woman n=97 095 follow-up: hospital stay CS-rate 33.7%, 58.5% intrapartum CS	Transfusion, hysterectomy, ICU admission, maternal death, hospital stay >7days Exclusion: multiple births, crash-emergency CS	Overall morbidity and mortality index 1.8% Death 0.1/1000 ICU 5.4/1000 Transfusion 4.4/1000 Hysterectomy 0.5/1000 Hospital stay >7days 8.8/1000 Antibiotic treatment after del. 24.6% 3rd/4th degree lacer 0.8%	Overall morbidity and mortality index 5.5% Death 0.4/1000 ICU 27.2/1000 Transfusion 9.8/1000 Hysterectomy 3.5/1000 Hospital stay >7days 25.5/1000 Antibiotic treatment after del. 62.0% Elect. CS vs. VD risk for severe maternal morbidity OR 2.3	Overall morbidity and mortality index 4.0% Death 0.6/1000 ICU 14.2/1000 Transfusion 7.1/1000 Hystercetomy 2.9/1000 Hospital stay >7days 21.8/1000 Antibiotic treatment after del. 69.6% Emerg. CS vs. VD risk for severe maternal morbidity OR 2.0		
Liu et al. CMAJ. 2008 Canada	Retrospective population-based Nationwide 1991-2005 Discharge Abstract Database Healthy women undergoing primary CS for term breech vs. planned VD n=46 766 CS + controls intra- and postpartum complications		Planned VD: 9.0/1000 Instr.VD rate 13.9%	27.3/1000	Emerg.CS rate 8.7%	Cardiac arrest OR 5.1 Wound hematoma OR 5.1 Hysterectomy OR 3.2 Major puerp.infection OR 3.0 Anesthetic compl. OR 2.3 Thromboembolism OR 2.2 Hemorrhage requiring hysterectomy OR 2.1 Hemorrhage requiring transfusion OR 0.4 Maternal mortality NS	
Zwart et al. BJOG. 2008 Netherlands	Prospective cohort study Nationwide 2004-2006 (2 years) (98 hospitals) n=371 021 (all pregnant women) Maternity computer database, ward diaries and multiple sources (Severe mat.morb. during pregnancy, del. and puerperium) substandard care in 62% follow-up: pregn, delivery-6 weeks	total 7.1/1000, ICU 2.4/1000 pregnancy included uterine rupt. 0.6/1000 eclampsia 6.2/10 000 MOH 4.5/1000 sepsis 2.3/ 10 000 thromboemb. 0.2/1000 70.7% of complications postpartum Case fatality rate 1:53 (1.9%)					Age≥35 RR1.2 BMI≥30RR 1.5 Prior CS RR 3.7 Multiple pregn. OR 4.9 CS elect OR 4.6 CS any RR 5.2 Non-western women compared to western women RR 1.3

	Study design and setting	Total complication rate (all deliveries) definitions, case-fatality rate	Complications in VD	Complications in elective CS	Complications in emergency CS	Planned elective CS vs. planned VD	Risk factors
Kuklina et al. .Obstet Gynecol. 2009 United States	Cross-sectional study Hospitalization for severe obstetric complication 1998-1999 and 2004-2005. n=32 276 863 births CS rate 21.5% in 1998-99, 30.6% in 2004-2005	6.4/1000 in the first period, 8.1/1000 in the second period Definition: severe anesthesia complic, renal failure, heart failure, puerperal cerebrovascular disorders, pulmonary embolism, pulmonary edema, ARDS, DVT, DIC, sepsis , shock, hysterectomy, transfusions, ventilation.	2004-2005: All severe complications: 3.5/1000 in VD, 5.4/1000 in Vaginal Birth after CS Pulmonary embolism 0.09/1000 Transfusion	2004-2005: All severe complications: 9.3/1000 in repeat CS 15.2/1000 in primary CS Adjustment for delivery mode made the increase in complications non-significant (increases were associated with the increasing CS rate) 2004: Pulmonary embolism: repeat CS 0.25/1000, Primary CS 0.49/1000			Maternal age Cs compared to VD
van Dillen et al. AOGS. 2010 Netherlands	Prospective cohort study Nationwide 2004-2006 (2 years) Severe maternal morbid.related to delivery n=355 841 deliveries CS Rate 14.9% em.CS 53.8% of CS Abnormal placentation,eclampsia, morbidity before delivery excluded	total 4.1/1000 Definition: per 1000 Admission to ICU 2.4 Uterine rupture 0.6 Eclampsia/HELLP 0.7 MOH (transfusion ≥4units, embolization) 4.5 Miscellaneous 0.7 _____ Hysterectomy 0.3/1000 Maternal death	attempted VD 3.9/1000 VD 3.5/1000 Hystercetomy 0.1/1000 Maternal death 3.6/ 100 00	6.4/1000 Hystercetomy 1.4/1000 Maternal death vs. VD OR 12.2	8.5/1000 Hystercetomy 1.2/1000 Maternal death vs. VD OR 7.0	OR 1.7 (95% CI 1.4-2.0)	non-western immigr OR 1.3 prev. CS: 3-fold risk
Farchi et al. AOGS. 2010 Italy	Population-based 2001-2007 All full term singletons, mat. conditions and pregn.disorders excluded, in regional hospital in Lazio n=324 883 Full term singletons Hospital discharge database in nulliparas: planned CS 22.4% CS rate in labor 32% of intend.VD	per 1000 deliv: Total: 3.4/1000 Transfusion 1.8 Hysterect. 0.7 Obst.shock 0.15 Anesth.compl. 0.21 Major puerp.inf.0.25 Thromboemb. 0.03 Rupt. of uterus 0.20				Transfusion OR 0.77 Hysterect. OR 1.30 Obst. schock OR 2.15 Anesth.compl. OR 2.2 Major infect. OR 1.5 Thromboemb. OR 2.8 Rupt. of uterus OR 0.7	

2.5.2.2. Maternal mortality

Maternal mortality is defined as the death of a woman while pregnant or within 42 days of the termination of pregnancy irrespective of the duration and site of the pregnancy for any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes. The maternal mortality rate (MMR) is defined as the

number of all maternal deaths from direct or indirect obstetric causes per 100 000 live births (Bouvier-Colle et al 2012).

Maternal death is an uncommon event in high-resource countries, and while others considers MMR to be an important indicator of health system performance even in high-resource countries (Bouvier-Colle et al. 2012), some authors see it as inappropriate for defining the quality of obstetric care because maternal death is a rare event. Some authors consider maternal severe morbidity or near- miss morbidity as a more appropriate measure of the quality of care, although the definitions of near-miss or severe morbidity vary. Many authors use the case-fatality-ratio, or severe maternal morbidity:mortality ratio, to describe how many of the near-miss incidents lead to maternal death; this might reflect the quality of care more appropriately (Waterstone et al. 2001, Zhang et al. 2005, Zwart et al. 2008).

Many maternal deaths are due to pre-existing diseases. When comparing the risk in CS and VD, several studies report an increased risk for maternal death in CS. Still, there have been controversies on the subject, and some authors claim that the results may be confounded by the indications of CS (Vadnais et al.2006). The first large study on maternal mortality comparing the risk by modes of delivery was published by Lillford et al. in 1990. Women with pre-existing medical or antenatal conditions were excluded. The risk of mortality associated with CS compared with VD after exclusion of pre-existing morbidity was 5-fold, and the relative risk of intrapartum CS compared with elective CS was 1.4 (Lillford et al. 1990).

Recently, there have been several studies where the comparison has been restricted to previously healthy mothers or where the risk has been adjusted for known risk factors (age, BMI, pre-existing disease or pregnancy disorder), and the result is consistently the same. CS is related to a 3.6 -5 fold mortality compared to VD (Lillford et al. 1990, Deneux-Tharaux et al. 2006, Schutte et al. 2007). In most studies, but not all, emergency CS contains a higher risk than elective CS. In a recent large French study on maternal deaths due to conditions during or after delivery the adjusted OR for intrapartum CS compared to prepartum CS was 1.4 (CI 0.6-3.2) (Deneux-Tharaux et al. 2006).

A Dutch study investigated the mortality related directly to the operative process of a CS. In women having elective CS for breech presentation in 2000 to 2002, there were two cases of death from massive pulmonary embolism, and two cases of death from sepsis. These were assumed to be caused directly as a complication of the operation itself, and yilded a case-fatality rate for elective CS for breech of 0.47/1000 operations (Schutte et al. 2007). A study from Norway examined the direct maternal deaths 1976-1995 and reported a maternal mortality ratio of 5.5/ 100 000 births. 71% of the cases were related to CS, and more than half were judged to be related to a complication of the operation (Andersgaard et al. 2008).

In the Netherlands, there has been a significant rise in maternal mortality from 1983-1992 to 1993-2005 from 9.7 to 12.1 per 100 000 live births. The leading cause of maternal death is pre-eclampsia, followed by thromboembolism, sudden death in pregnancy, sepsis, hemorrhage and amniotic fluid embolism (Schutte et al. 2010). An increase in maternal mortality was reported also in the United States, when the MMR in 1998-2005 (14.5/ 100 000 live births) was compared to the 20 previous years. The most frequent causes of death were hemorrhage, thromboembolic events and infection (Berg et al. 2010).

The MMR was in average 6.2 per 100 000 in Europe in 2006-2010. In Finland, the MMR was 4.7 per 100 000 live births in 2006-2010, and it has been stable since 1970 (European Perinatal Health Report 2010, Gissler 2005). The most common causes of maternal deaths in Europe are listed in Table 4.

Substandard care has been reported in 47% -80% of the cases, where severe maternal morbidity has lead to maternal death (Knight 2007, Andersgaard et al. 2008, Saucedo et al. 2013). The factors associated with severe maternal morbidity leading to maternal death in a national cohort analysis from 2003 to 2009 in UK were: age >35 years (OR 2.4), black ethnicity (OR 2.4), low sosio-economic status (OR 2.2) and obesity with BMI ≥30 (OR 2.7) (Kayem et al. 2011).

Table 4. Incidence and causes of maternal mortality in European countries (2006-2010).

Obstetric causes of maternal deaths in Europe in 2006-2010
Hemorrhage 0.87/100 000 (15% of all deaths)
Hypertensive disorders 0.72/100 000
Ectopic pregnancy and pregnancies with abortive outcome 0.62/100 000
Other thromboembolic causes 0.48/100 000
Amniotic fluid embolism 0.45/100 000
Chorionamninitis/sepsis 0.23/100 000
Uterine rupture 0.11/ 100 000
Complications of anesthesia 0.03/100 000
Other direct causes 1.12/100 000
Indirect causes 1.08/100 000

Europeristat Health Report 2010.

2.5.3. Hemorrhage

In most studies, hemorrhage is the most common cause of morbidity related to delivery. The reported incidence of hemorrhage and severe hemorrhage related to delivery varies markedly by study. This is partly explained by different definitions. The following definitions of hemorrhage have been used in the different studies: defined ICD-codes, >500ml, >1000ml, >1500ml, any transfusion of blood, transfusion of ≥4 units red

cells, fall in the hemoglobin concentration ≥40 g/l, embolization or hysterectomy for hemorrhage, re-operation for hemorrhage (Waterstone et al. 2001, Häger et al. 2004, , Zwart et al. 2008, O'Brien et al. 2010, Holm et al. 2012). The amount of hemorrhage is often estimated visually, which is known to be inaccurate, and the amount of PPH is often over- or underestimated, more often underestimated, which can cause a delay in the proper care of the woman (Prasertcharoensuk et al. 2000, Kabel et al. 2012).

Some of the variation may depend on variation in the quality of obstetric care. In a register based cohort study in California, USA, comprising 507 410 births in 1997, postpartum hemorrhage complicated 2.4% of births. The incidence varied up to 3-fold by hospitals even after adjusting for risk factors. The authors suspect that this is partly due to improper conduct of operative deliveries (Lu et al. 2005).

When hemorrhage was defined as ≥1000ml and/or a need for transfusion, the incidence was 8.6% related to CS in a Norwegian prospective study and 13% in a Swedish register-based study (Häger et al 2004, Källen et al. 2005).

Some studies report a lower incidence of hemorrhage in elective CS than in VD, but usually higher incidence of transfusions (Koroukian 2004). Still, most studies report a higher incidence of any hemorrhage in CS, even in elective CS, although hemorrhage is even more often related to emergency CS than elective CS. When the most severe forms of hemorrhage (hemorrhage leading to hysterectomy or other interventions) are studied, the incidence is 6-14-fold in all studies even for primary CS compared to VD, and still higher after a previous CS (Simoes et al. 2005, Stivanello et al. 2010, Knight et al. 2008).

Hemorrhage is often defined as severe in following cases: >1500ml, transfusion of ≥4 units red cells, fall in the hemoglobin concentration ≥ 40 g/l., embolisation or hysterectomy for hemorrhage and in case of re-operation for hemorrhage (Waterstone et al. 2001, Häger et al. 2004, Zwart et al. 2008). Severe obstetric hemorrhage (> 1500ml or transfusion) occurred in 1.1% of all deliveries in Norway in 1999-2004, 0.8 % in VD, 2.2 % in elective CS and 3.4% in emergency CS (Al-Zirqi et al. 2008). In a British study the incidence (>1500ml, ≥four units of blood, fall in HB ≥40 g/l) was 0.7% in all deliveries, more frequent in CS than in VD and most frequent in emergency CS (Waterstone et al. 2001). In Finland, the reported incidence of severe hemorrhage (defined as: measured >1500ml hemorrhage or ≥2500ml transfusion or death) was 8.8/1000 in all deliveries. This figure varied between 0.7 and 8.8 per 1000 deliveries in nine European countries (Zhang et al.2005).

2.5.3.1. Risk factors for hemorrhage

The most important risk factor for severe hemorrhage is a prior CS, which raises the risk for abnormal placentation and uterine rupture (Knight et al. 2008, Silver et al. 2005).

In a Finnish study on 171 731 women having singleton deliveries, 2.3% received blood transfusion. Previous CS, advanced maternal age, all instrumental deliveries, and any CS in the present delivery increased the risk. A previous CS increased the risk for hemorrhage also in subsequent VD compared to a women with a history of VDs only (Jakobsson et al. 2012, Holm et al. 2012).

A large population-based study from Canada included 8.5 million deliveries from 1999 to 2008. Significant risk factors for postpartum hemorrhage after adjusting for confounders were age ≥35 (OR 1.5) multiple pregnancy (OR 2.8), fibroids (OR 2.0), pre-eclampsia OR 3.1), amnionitis (OR 2.9), placenta previa or abruption (OR 7.0), cervical laceration (OR 94.0), uterine rupture (OR 11.6), instrumental vaginal delivery (OR 1.5) and cesarean delivery (OR 1.4) (Kramer et al. 2013).

2.5.3.2. Peripartum hysterectomy

Peripartum hysterectomy is an obstetric emergency situation, performed for a life-threatening hemorrhage or, occasionally, for severe infection (Forna et al. 2004). It destroys future fertility, and contains a high risk of intraoperative and postoperative complications, and may lead to maternal death (Knight 2007).

The reported incidence of peripartum hysterectomy varies from 0.3 to 5.0 per 1000 deliveries in different studies. The incidence is higher for CS than VD and higher in populations where the rate of CS is high (Shellhaas et al. 2009, van Dillen et al. 2010, Knight 2007, Joseph et al.2007, Stivanello et al. 2010, Roethlisberger et al.2010). It is also higher for women with prior CS compared to women without a prior CS (Knight et al. 2008, O'Brien et al. 2010, Stivanello et al. 2010). In a Dutch study, the incidence was 0.1/1000 for VD, 1.4/1000 for elective CS and 1.2/1000 for emergency CS (van Dillen et al. 2010). The case-fatality rate was 1:167 in the Brittish study (Knight 2007).

Uterine atony has previously been the leading cause for emergency obstetric hysterectomy, but with increasing CS rates worldwide, an abnormally adherent placenta has become more common, and in some studies it has become the most common cause for peripartum hysterectomy (Roethlisberger et al. 2010). It has been estimated that peripartum hysterectomies due to abnormal placentation are still increasing because of increasing rates of CS (Forna et al. 2004, Kastner et al. 2002, Imudia et al. 2009)

The risk for complications related to peripartum hysterectomy is high. In a study from the UK where national data (the United Kingdom Obstetric Surveillance System, UKOSS data) was used, bladder damage was reported in 12.2%, ureter damage in 4.5%, ovary removal in 9.0% and further surgery in 19.6% of the women who underwent peripartum hysterectomy (Knight 2007). In a study from the US, 186 cesarean hysterectomies (0.5% of all CS) were analyzed and the following complications were reported: 84% need

for blood products, 11% postoperative fever, 0.5% septic pelvic thrombophlebitis, 2.7% cuff abscess, 3.2% urinary tract infection, 3.8% exploratory laparotomy, 1.1% wound dehiscence, 0.5% DVT, 1.1% bowel injury and 1.6% maternal death (Shellhaas et al. 2009). In another large study from the US covering time from 1990 to 2002, 54.6% of the women had an infectious complication afterwards (Forna et al. 2004).

No significant differences in the frequency of complications between women who undergo total or subtotal hysterectomy have been reported (Forna et al. 2004, Knight 2007).

2.5.4. Intraoperative complications

The incidence of intraoperative complications was 14.8% in a study on 2647 CS in a university hospital in Netherlands 1983-1992. The complications included blood loss ≥1000 ml, accidental incision of the fetal skin (1.3%), lacerations of the uterine corpus (10.1%), bladder lesions (0.8%), laceration of uterine arteries or laceration to the bowels (0.5%). Complications were more common in emergency operations than elective operations and more common in women with a prior CS than among women without a prior CS (van Ham et al. 1997).

In a prospective study from Norway 2751 CS in 1998-1999 were analyzed. The combined occurrence of intraoperative complications (tissue damage that required extra suturing, bowel/bladder lesion, technical difficulties because of adhesions, and other events that were judged as a complication by the surgeon) amounted to 8.1% of the operations. The risk increased with increasing cervical dilation (19.1% at 9-10cm of cervical dilation and 4.0% at 0cm.) (Häger et al.2004).

In a prospective study on 929 CS in Denmark in 1995-1996, 12.1% of the patients had one or more intraoperative complications, more in association with emergency CS than in elective CS (14.5% and 6.8%, respectively). Uterocervical lacerations (5.1%) and hemorrhage >1000ml (9.2%) were the most common complications. Bladder laceration occurred in 0.5%, and hysterectomy was needed in 0.2% of the operations (Bergholt et al. 2003).

A prospective study on intraoperative complications in CS was undertaken in Sweden in 1978-1980, including 1319 CS. The overall complication rate was 11.6%, 9.5% were minor complications (blood transfusions, minor lacerations, minor injuries to the infant without sequelae to the infant) and 2.1% were major complications (injury to the bladder, tear in the cervix or vagina, bilateral bleeding of the uterine arteries, lacerations involving most of the corpus uteri, intestinal injury, and injury to the infant with sequelae). The complication rate was higher in emergency CS than elective CS

(18.9% vs. 4.2%). The study also showed that an experienced operator reduces the risks associated with emergency CS significantly (Nielsen et al. 1984).

In a prospective study from Norway covering the years 1979-1985, intraoperative complications occurred in 8.5% of CS. 1% of the women had a severe complication (bladder injury, bowel injury, laceration of arteries, hysterectomy because of hemorrhage) (Rasmussen et al 1990).

The risk for a bladder injury was 1.3 per 1000 deliveries in a Turkish study on 56 799 CS. The risk was highest for women with a prior CS, increased also with prior pelvic surgery, and increased in emergency procedures especially when the presenting part was deep in the pelvis (Gungorduk et al. 2010).

2.5.5. Complications of anesthesia

In a US study on anesthesia-related maternal mortality in 1991-2002 there were 1.2 anesthesia-related maternal deaths per 1,000 000 live births, comprising 1.6% of all pregnancy-related deaths. The number has decreased by 59% since 1979-1990. The leading cause of death was intubation failure or induction problems, followed by respiratory failure, high spinal or epidural block and drug reactions. 86% of these deaths were related to CS (Hawkins et al. 2011).

In a district hospital in the UK accidental dural punctures and post dural puncture headache in obstetric anesthesia was followed over a 23-year period (1993-2006). The occurrence of accidental dural punctures after epidurals in all obstetric procedures was 0.9%; 88% of these patients experienced post dural puncture headache which required an epidural bloodpatch (Sprigge et al. 2008).

In 1990-1991 data was collected in 79 obstetric units in the UK, and among 123 000 women receiving either epidural or spinal blockade in obstetric care, 1/1000 had a severe complication, post dural puncture headache not included. The complications were neuropathies of single nerves (46), unexpectedly high blockades (26), backache (21), urinary retention (8), cardiac arrest (2) and maternal death (1) (Scott et al. 1996).

2.5.6. Puerperal complications

Puerperal complications consist of infections, hemorrhage, transfusions, ileus, re-operations, urinary retention, pain, headache related to unintended dural puncture, deep venous thrombosis and thromboembolic events. The puerperium continues until six weeks after delivery, but many studies use a follow-up time of only the hospital stay, which has become shorter during the last years, and is shorter for women having VD than for women having CS.

In a Scottish study assessing postoperative morbidity after CS, only 9.5% of the women who underwent CS had no recorded morbidity in the postnatal period. In that study, not only the obstetric case records but even the midwifery notes were reviewed (Hillan 1995).

In a Dutch study the intraoperative and postoperative complications in CS over a 10-year period (1983-1992) were reviewed and it turned out that 35.7% of the women had postoperative complications. Minor postoperative complications (fever, bloodloss 1000-1500ml, hematoma and urinary tract infection) occurred in 31.2%, and major postoperative complications (bloodloss exceeding 1500ml, relaparotomy, pelvic infection, thrombosis/embolism) in 4.5% of the operations (van Ham et al. 1997). In a Norwegian prospective study on CS the overall puerperal complication rate was 11.9%, and the total complication rate was 16.3% for planned and 24.1% for unplanned CS (Häger et al 2004). In a German register-based study from 2001, the total puerperal complication rate related to CS was 22.4%; the complications included postpartum anemia, blood loss >1000ml, hysterectomy, wound infection, postpartum fever, sepsis and eclampsia (Simoes et al. 2005).

2.5.6.1. Infections

In the recent decades, the use of prophylactic antibiotics during deliveries has increased. The use of prophylactic antibiotics related to CS is widespread, especially during emergency procedures. The infection rate related to CS has decreased with the prohlylactic use of antibiotics (Hofmeyr et al. 2008). In VD the use of prophylactic antibiotics for women with vaginal colonisation with Group B streptococci has been increasing. The use of antibiotics related to operative vaginal deliveries is not a common policy.

The different rates of infections reported in different studies are partly explained by the variable observation periods. The duration of the hospital stay has become shorter during the recent years. In a Danish study on postpartum infections with a follow-up time of 30 days after delivery, the investigators noticed that 77% of postpartum infections appeared after hospital discharge. The risk of postpartum infection was five times higher after CS than after VD (Leth et al. 2009). Also in a Norwegian study on surgical site infections, 20 % of all wound infections were diagnosed during the hospital stay and 80% later, during a 30 days follow-up time (Opøien et al. 2007).

In the prospective Norwegian study by Häger et al, 7.0% of the women had an infection after CS during the hospital stay (Häger et al 2004). In a Canadian study by Allen et al. the incidence of puerperal febrile morbidity and wound infection combined was 0.6% in spontaneous VD, 2.6% in elective CS and 5.5% in CS in labor (Allen et al. 2003). In the Danish study by Krebs et al, puerperal febrile morbidity and the incidence of wound

infection combined was 1.2% in VD, 2.4% in elective CS and 4.1% in emergency CS (Krebs et al. 2003). In the US study by Koroukian, the incidence of major puerperal infection was 0.9% in VD, 2.9% in elective CS and 4.3% in emergency CS (Koroukian 2004).

In a Cochrane review covering 86 randomized trials that compared antibiotic prophylaxis with no prophylaxis for elective and non-elective CS, prophylactic antibiotics did reduce the incidence of febrile morbidity significantly (RR 0.45) both in elective and emergency CS (Smail FM et al. 2010).

2.5.6.1.1. Sepsis

Puerperal sepsis causes at least 75 000 maternal deaths every year, mostly in low-resource countries, but it is among the most common causes of maternal death even in high-resource countries (van Dillen et al. 2010, Schutte et al. 2010).

There is no uniform definition of obstetric sepsis, which make comparisons between different studies unreliable. Sepsis is defined as bacteremia confirmed by positive blood cultures, or as sepsis that progresses to a septic shock with signs of low blood pressure, low platelet count and perfusion abnormalities (Waterstone et al. 2001, Kankuri et al. 2003, van Dillen 2010). The incidence of severe sepsis was 0.4/1000 in a British study and 0.23/1000 in a Dutch study which both defined sepsis as requiring signs of organ dysfunction, hypoperfusion or hypotension (Zwart et al. 2008, Waterstone et al. 2001).

In a study on severe maternal morbidity in nine European countries, the incidence of uniformly and clearly defined sepsis (bacteremia and signs of an inflammatory body response in terms of body temperature, pulse, respiratory rate and/or white cell count) was 0.8 per 1000 deliveries in the total material, and 1.0 per 1000 deliveries in Finland (Zhang et al. 2005).

In a Finnish study on peripartum sepsis defined as laboratory confirmed bacteremia in 43 483 deliveries in 1990-98 in a university hospital, sepsis occurred in 1/1060 deliveries. Postpartum sepsis was 3.6 times more common in women delivered by CS as compared to women delivered vaginally. At the time of the study, prophylactic antibiotic treatment was not given routinely during CS or in VD to combat vaginal colonization by Group B streptococci (Kankuri et al. 2003).

In a large population-based German study the incidence of septicemia was 2.3/1000, and the RR was 8.6 in CS compared to VD for a low-risk woman (elective CS, no risk factors for infection) (Simoes et al. 2005).

In a study investigating 1 622 474 deliveries in California in 2005-2007, the incidence of sepsis was 1 per 1000 deliveries, and the OR was 1.99 for primary and 1.25 for repeat CS

compared to VD (Acosta et al. 2013). The incidence of severe sepsis was 0.5 per 1000, and the case fatality rate was 14.3%. Significant risk factors for developing a severe sepsis were primiparity (OR 2.0), IDM (OR 1.5), chronic hypertension (OR 8.5) and CS (OR 1.2) (Acosta et al. 2013). In a UK study the adjusted OR of uncomplicated sepsis was 3.2 for CS compared to VD, and 13.4 for developing a severe sepsis (Acosta et al. 2012).

2.5.6.1.2. Endometritis

The risk for endometritis is significantly higher in CS than VD, and higher in emergency operations than in elective ones. Endometritis has decreased dramatically after introduction of prophylactic antibiotics as a common policy, but is still ten times higher in CS than in women delivering vaginally (Hadar et al.2011). The total incidence of endometritis related to CS in a US study was 6.9% CS (2.7% and 9.4% in elective and emergency CS, respectively), 15 times higher than for VD (Burrows et al. 2004).

In many studies, endometritis is included in the category "major puerperal infection". In the study by Koroukian, major puerperal infection occurred in 0.9% of VD, 2.9% of elective CS and 4.3% of emergency CS (Koroukian 2004).

2.5.6.1.3. Wound infection

In a Norwegian study on surgical site infections, the total rate of wound infections related to CS was 8.9% during a 30 days follow-up time, but at hospital discharge only 1.8% (Opøien et al. 2007). The risk of wound infections increased significantly in obese women and when the operating time exceeded 38 minutes. There was no difference in wound infection rate between elective CS and emergency CS (Opøien et al. 2007).

In a study from Israel on timing and risk factors related to CS, the wound infection rate was 1.8%; it was higher after emergency CS and after CS performed by a resident compared to CS performed by a senior surgeon (Hadar et al. 2011). The incidence was 2.0% in a Dutch study, 1.0% in elective CS and 2.8% in intrapartum CS (van Ham et al 1997).

2.5.6.1.4. Other infections

Urinary tract infection (UTI) was diagnosed in 2.5-3.4% of women after elective and non-elective CS in a Dutch study by van Ham et al. (1997); the incidence was lowest in elective CS. In a Danish study on infections related to CS, UTI occurred in 1.5% after VD, 2.6% after elective CS and 3.0% after emergency CS (Leth et al. 2009).

Pneumonia was more common among women delivering by CS than by VD in a US study. The incidence was 0.1% after VD, 0.5% after elective CS and 0.7% after emergency CS. Smokers had a 2-fold risk for pneumonia compared to non-smokers (Burrows et al. 2004).

2.5.6.2. Thromboembolic events

Thromboembolic events and particularly pulmonary embolism are among the leading causes of maternal death in countries with low maternal mortality. Alterations in the coagulation system of a woman during pregnancy increase the risk of thromboembolism 4- to 6-fold compared to the non-pregnant state (James 2012). The most common risk factor for a thromboembolic event during pregnancy is CS compared to VD, and, combined with other risk factors, the risk increases even more (Jakobsen et al 2008).

In a large Swedish study on CS covering the years 1990-2001 (n= 1 029 075) the incidence of any type of thromboembolic event was 1.7 in 1000 CS, 3.7–fold compared to VD. Almost two-thirds of the cases were diagnosed after the mother and her newborn had been discharged from the delivery unit (Källen et al. 2005). The incidence of thrombosis was 1.0 per 1000 pregnancies in a Norwegian study on 613 232 pregnancies during 1990-2003. In that study, incidence was similar antepartum and postpartum. Risk factors for postpartum thrombosis were CS (adjusted OR 2.7 for planned CS and 4.0 for emergency CS), pre-eclampsia (aOR 3.8), placental abruption (aOR 2.5) and placenta previa (aOR 3.6). All maternal deaths due to thromboembolism occurred postpartum (3 of 615 cases, case: fatality rate 0.5%) (Jacobsen et al. 2008).

According to a Swedish study the incidence of venous thromboembolism had increased four-fold from the 1970s to the 1990s, but mortality in venous thromboembolism had been decreasing since 1970. The case-fatality rate for venous thromboembolism had decreased from 4.5% to 0.6%. (Samuelsson et al. 2007). In another Swedish population-based study on 1 003 489 deliveries, focusing on pulmonary embolism and stroke, CS constituted a 3.8-fold risk for pulmonary embolism and a 5.8-fold risk for stroke compared to VD (Ros et al. 2002).

In a cohort of 44 922 women delivering in a University Hospital in Texas, USA, during a three-year period, 15 women had a septic pelvic thrombophlebitis, diagnosed by computed tomographic imaging, yielding an incidence of 1:3000 deliveries. The incidence was 11-fold in CS compared to VD (Brown et al. 1999).

Besides CS, other known risk factors for DVT related to pregnancy and delivery are obesity, smoking, IDM, hypertension, pre-eclampsia, systemic lupus erythematosus,

multiple gestation, postpartum infection, postpartum hemorrhage and transfusion (Larsen et al. 2007, James 2012, Abbasi et al. 2014).

Amniotic fluid embolism is a rare and severe condition which may occur during delivery. The reported incidence is 2.5- 7.7 per 100 000 deliveries and the mortality rate is 19-38% (Abenhaim et al. 2008, Kramer et al. 2012, Stolk et al. 2012). It is associated with cesarean section (OR 5.7), maternal age over 35 years (OR 2.2), pre-eclampsia (OR 7.3), placental abruption (OR 8.0) and placenta previa (OR 30.4) (Abenhaim et al.2008). In a Dutch study the most important risk factors were high maternal age and multiparity (Stolk et al. 2012).

2.5.6.3. Other complications

Other complications related to deliveries, and more often to CS than to VD, are re-operations, re-laparotomy, wound hematoma, bowel obstruction, urinary retention and pain.

In a prospective Norwegian study on 2752 CS re-operation was needed in 1.7% after a CS performed after ≥30 weeks of pregnancy, and in 5.2% performed before 30 weeks of pregnancy (Häger et al.2004). In a retrospective study on 3380 CS re-laparotomy was needed after 0.53% of the CS: 66% due to hemorrhage, 17% to eventration and 17% to infection. Hysterectomy was needed in one case in this group (Lurie et al. 2007).

Ileus was reported after 1.5% of CS in a Dutch study, and in 0.64% in a Scottish study (van Ham et al. 1997, Hillan 1995).

Wound hematoma was recorded in 1.2% of women after CS in a study from Israel and in 3.7% of women after CS in a study from Norway (Hadar et al 2011, Häger et al. 2004).

Postpartum urinary retention is reported in 14.6% of women after VD and 24.1% of women after CS. In most cases, the problem is covert and diagnosed only when postvoiding residuals are measured. Most of these women recover within a few days, but 0.2% had protracted urinary retention (Yip et al 1997, Liang et al 2007). The risk factors for protracted urinary retention were prolonged second stage of labor and vacuum delivery. Also these women recovered fully within 28 days (Groutz A et al. 2011). With early diagnosis an overstreching of the bladder wall causing detrusor damage can be avoided.

Problems with breastfeeding were most common among women who underwent elective CS (1.2%) in a Swedish study comparing the outcomes after different delivery modes

(OR 6.8). (Karlström et al. 2013). Postsurgical fatigue and postoperative pain may restrict the woman from caring for the newborn (Lobel et al. 2007).

2.5.7. Long term complications of CS and VD

2.5.7.1. Placenta accreta

The most severe risks related to CS are complications in future pregnancies. Also, the risks increase progressively with increasing number of prior CS. (Silver et al. 2006, Knight et al. 2008). Placenta accreta (or increta/ percreta) is the most severe consequence of CS. Although it is rare, it has become more common during the recent years, which is probably due to an increased rate of CS (Knight et al. 2008).

Maternal morbidity associated with multiple repeat CS (CS without labor) was investigated in a US study. The study showed that severe morbidity increased by every CS, and the incidence of placenta accreta was 28-fold (6.7%), and that of hysterectomy 14-fold (9.0%) after 6 or more CS compared to the situation at the first CS (Silver et al. 2006).

In the UK, the UKOSS has provided important data on rare events related to pregnancy and birth. A 12 month cohort including all women giving birth in UK was studied to estimate the incidence and risk factors for abnormally adherent placenta. The incidence was 1.7 per 10 000 maternities, and a previous CS was an important risk factors (adjusted OR 14.4 (95% CI 5.6-36.9), together with other previous uterine surgery (OR 3.4), IVF pregnancy (OR 32.1), increasing maternal age in women without a previous CS (OR 1.3 for every added year) and placenta previa (OR 65.0) (Fitzpatrick et al. 2012). For a woman with at least one prior CS and placenta previa diagnosed prior to delivery, the incidence of an abnormally adherent placenta was as high as 5.8%.

2.5.7.2. Uterine rupture

Uterine rupture is a serious complication in pregnancy and delivery. It causes severe morbidity for the mother and the neonate and leads occasionally to maternal or neonatal death. The risk is higher if a woman has had two or more prior CS, if she has had a CS less than 12 months earlier or if the labor has been induced (Fitzpatrick et al. 2012). Uterine rupture is, in most cases, associated with a prior CS. In a British national case-control study, the overall incidence of uterine rupture was 0.2 per 1000 deliveries and for a woman with a prior CS 2.1/1000 in an attempt of VD and 0.3/1000 in an elective CS, respectively (Fitzpatrick et al. 2012).

2.5.7.3. Other long term complications of CS

There are several studies showing that an unexplained stillbirth in a later pregnancy is more common after a CS than after VD. In a recently made meta-analysis involving 11

studies the authors concluded that a prior CS may increase the risk of stillbirth in later pregnancies by 23% (O'Neill et al. 2013).

A prior CS was related to ectopic pregnancy with a RR of 1.3, placental abruption with RR of 2.4 and placenta previa with RR of 3.8 in a Finnish register-based cohort stydy (Hemminki et al. 1996).

Chronic pain after CS is reported in 12.3% of women 10 months after a CS, and 5.9% of them experienced pain daily or almost daily (Nikolajsen et al. 2004). Chronic pain may be the result of nerve entrapment, cesarean scar defect or pelvic adhesions (Silver 2010).

2.5.7.4. Long term risks of vaginal delivery

One of the most feared complications of VD is severe perineal tear with injury to the anal sphincter, often leading to urine and anal incontinence later in life. Although perineal tears occur only in VD, urinary and anal incontinence also occur in women who have had only cesarean deliveries, even in women with only prepartum CS (Lal et al. 2003). The risk of pelvic organ prolapse, often needing operative repair at an older age, is higher after VD than after CS, but pelvic organ prolapse occurs in women after all modes of delivery. The risk for urinary and anal incontinence increases after VD, but occurs also in women with only cesarean deliveries, and also in women with no pregnancies in their history (Hannah et al. 2002, Lal et al. 2003).

The lowest rates of anal sphincter injuries among high-resource countries are reported in Finland, where the incidence of anal sphincter tears related to VD is on average 1.0%, but varies from 0.2% to 2.1% in primiparous women in different hospitals, suggesting variable management of deliveries (Räisänen et al. 2010). In another Finnish study, where different hospitals were compared, it was shown that a high CS rate did not protect from anal sphincter injury (Pyykönen et al. 2013).

Table 5.Typical short term risks of vaginal and cesarean deliveries.

Vaginal delivery	Cesarean delivery
Obsteric tears -perineal injury -anal sphincter injury 1-8%	None **Surgical complications** -Lacerations, organ injury, re-operation
Hemorrhage	**Hemorrhage** -any hemorrhage 2-4-fold compared to VD -massive hemorrhage 6-14-fold compared to VD
Infection -perineal wound infection -endometritis -sepsis	**Infection** -wound infection -endometritis 3-15-fold compared to VD -sepsis 2-9-fold compared to VD
Thromboembolic events	**Thromboembolic events** -3-4-fold compared to VD
Mortality	**Mortality** 3.6- 5-fold compared to VD

Table 6. Typical long term risks of vaginal and cesarean deliveries.

Vaginal delivery	Cesarean delivery
Pelvic organ prolapse	Placenta previa and accreta -need for hysterectomy 4-10-fold compared to VD
Urinary incontinence	Uterine rupture in subsequent pregnancy or delivery
Anal incontinence	Preterm delivery
-occuring also after CS, but less commonly	Subfertility Stillbirth

2.6. Risk factors for delivery related complications

Obesity and maternal age are increasing worldwide, and are recognized as important risk factors for maternal complications related to deliveries. They also increase the risk of having induction of labor because of pregnancy complications, and the risk of ending up in CS in any delivery.

Emergency CS compared to elective CS increases the risk of most types of complications. In most studies, the RR for occurrence of complications in emergency CS compared to elective CS is between 1.1 and 2.5 (Häger et al. 2004, van Ham et al. 1997, Rasmussen et al. 1990). In a Swedish study from 1984 the RR was as high as 4.5 (Nielsen et al.1984). On the other hand, in a large study from eight Latin American countries, the adjusted OR for severe maternal morbidity was 2.3 for elective CS and 2.0 for intrapartum CS when compared to VD, adjusted for parity, any pathology previous to pregnancy or during the pregnancy, hypertensive disorders, bleeding in second half of pregnancy, IUGR

and other medical conditions (Villar et al.2007). The degree of cervical dilatation was linearly related to the rate of maternal complications, with a total complication rate of 16.8% at 0 cm and of 32.6% at 9-10 cm. (Häger et al. 2004).

2.6.1. Obesity

In a British study obese women had an almost two-fold risk for induction of labor (OR 1.7) (Sebire et al. 2001). Compared to normal weight women, obese women have an increased risk for having a CS. The risk relates to the degree of obesity: the OR is 1.5, 2.1 and 2.9 for overweight, obese, and severely obese, respectively (Dinatale et al. 2010). The risk of ending up in emergency CS in an attempt of VD is 2-3 fold in obese women compared to normal weight women (Sebire et al. 2001, Weiss et al 2004, Fyfe et al. 2012). The risk of ending up in operative VD was not increased among women with a BMI of 30-35, but it was increased among women with a BMI >35 (OR 1.7) in a large multicenter study of 1473 obese and 877 morbidly obese women (Weiss et al 2003).

Besides the higher risk of ending up in elective and emergency CS, obese women have more intraoperative complications because of technical difficulties (Dinatale et al. 2010). Obesity increases the risk for postpartum hemorrhage both after CS (OR 1.7) and VD (OR 2.1) (Fyfe et al. 2012). Obesity is also a risk factor for both minor and major infection (Opøien et al. 2007, Dinatale et al. 2010, Jarvie et al. 2010). In a British study, obese women (BMI>30) had an OR of 2.2 for wound infection (Sebire et al. 2001). Endometritis occurs 30% more often in obese women than in normal weight women (Burrows et al. 2004). Pneumonia is also more common in obese women than in normal weight women, possibly due to later mobilization and weaker lung function (Sebire et al.2001, Dinatale et al. 2010). In a Scottish study, obese women had twice the odds of uncomplicated sepsis (Acosta et al. 2012).

Overweight, even without pre-existing co-morbidity, increases the risk for severe maternal morbidity, and the risk increases with increasing BMI. Compared to normal weight women, a woman with BMI>30 has an OR of 1.4 and a woman with BMI >40 an OR of 2.1 for severe morbidity (Witteveen et al. 2013). Although maternal death is rare, obesity is also a risk factor for the progression of severe maternal morbidity to death (Kayem et al. 2011).

Obesity is also a known risk factor for thromboembolism. In a Danish case-control study the adjusted OR for venous thromboembolism in obese women (BMI>30) was 5.3 compared to normal weight women (Larsen et al. 2007). The increased risk for thromboembolism in obese women prevails throughout the pregnancy and puerperium (Larsen et al. 2007, Jarvie et al. 2010)

2.6.2. Maternal age

It has been shown in several studies that increasing maternal age is related to a higher rate of pregnancy complications, obstetric interventions and complications related to interventions (Temmerman et al. 2004, Kuklina et al. 2009, Biro et al. 2012, Klemetti et al. 2013).

Women aged 35 or more have an increased risk of CS. In a Finnish study from 2008 birth outcomes in primiparous women were compared by age. The CS rate was 20%, 35% and 41% in women aged <34 years, 35-39 years and ≥40 years and the rate of instrumental delivery was 15%, 17% and 20%, respectively (Klemetti et al. 2014). In an Australian study, the OR for CS was 1.9 and the OR for operative VD 1.1 for primiparous women aged ≥35 years compared with younger women.

There is an increased risk for any hemorrhage (OR 1.1-1.3) or severe hemorrhage (OR 1.1-1.5) in older mothers but the reason to this is not known (Al-Zirqi et al. 2008, Jakobsson et al 2012, Kramer et al. 2013).

A higher rate of thromboembolic events related to deliveries in women aged >35 has been reported in several studies and the OR is in the order of 1.3-1.5 for pregnant women and women giving birth aged >35 compared to younger women (James 2012).

In a study on severe maternal complications in the United States in 1998-2005, the rate of severe complications increased linearly with increasing maternal age (Kuklina et al. 2009). The risk of a severe obstetric complication of progressing to death is also increased in older mothers (Temmerman et al. 2004, Kayem et al. 2011, Saucedo et al. 2013). In a Belgian study maternal age over 35 years increased the MMR 7-fold, and in a British study the adjusted OR for maternal death was 2.4 for women aged more than 35 years, compared to younger women (Kayem et al. 2011, Temmerman et al. 2004).

2.6.3. Pre-eclampsia

Pre-eclampsia is a severe obstetric complication in itself, but also increases the risk for complications related to delivery, especially the risk for hemorrhage. PE increases the risk of hemorrhage 2-fold and the risk of severe hemorrhage 2- to 3-fold (Burrows et al. 2004, Eskild et al. 2009, Al-Zirqi et al. 2008, Kramer et al. 2013).

Because of changes in the coagulation system in women with PE, the risk for thromboembolic events is increased with an OR of 3.8 (Jakobsen et al. 2008).

2.6.4. Other risk factors

In many studies from USA and Europe socioeconomic factors are among the most important risk factors for morbidity related to delivery, and are usually taken into

account when adjusting any risks or complications for confounders (Waterstone et al. 2001, Kayem et al. 2011, Acosta et al. 2013). In Finland maternity services are free and available to all and used by all mothers, and there is a belief that socioeconomic differences do not affect delivery-related morbidity. There are some studies on the impact of socioeconomic status on pregnancy complications and on the occurrence of anal sphincter injury in Finland, but so far there are no studies on the impact of socioeconomic status on the overall morbidity related to deliveries (Räisänen et al. 2013, Räisänen et al. 2013). A non-western ethnic background appears to be a risk factor for severe maternal morbidity in Europe and in the United States according to several studies (Zwart JJ et al. 2008, Acosta et al. 2013).

Smoking has been studied as a risk factor for obstetric complications. The harmful effects of smoking on the fetus have been documented. A protective effect against severe morbidity and, in particular, hemorrhage and pre-eclampsia has been reported, but the effects have not been analyzed separately with respect to differet delivery modes (Waterstone 2001, Cnattingius et al. 1997).

Diabetes mellitus is known to cause several perinatal problems, but its relation to postpartum complications is less studied. In some studies IDM is related to a higher risk of infections, but not all. A Danish study on the impact of obesity and diabetes on the risk of infections showed that after controlling for obesity and mode of CS, gestational DM and IDM increased the risk for infections only modestly, with ORs of 1.2 (non-significant) and 1.65 (non-significant), respectively, while obesity increased the risk of infection for diabetic women during the hospital stay more than two-fold (OR 2.7 (95%CI:1.3-6.0) (Leth et al. 2011). In a study by Riley et al., women with IDM had similar infection rates as healthy women (Riley et al.1996).

The surgeon experience affects the risk of CS-related complications (Nielsen et al. 1984, Aubrey-Bassler et al. 2007). In a Canadian study, complications related to CS were compared between women operated on by general practitioners and women operated on by specialists (n= 5792). Major surgical morbidity occurred in 2.5% vs. 1.6%, transfusions need in 5.9% vs. 7.0% and severe morbidity in 3.1% vs.1.9% of the women (Aubrey-Bassler et al. 2007). An operating time ≥38 min increased the risk for surgical site infection 2.5-fold (Opøien et al. 2007). In a study from Israel, surgeon experience decreased the risk for infections related to CS. The OR was 2.4 for a CS performed by a resident compared to a CS performed by a senior surgeon (Hadar et al. 2011).

2.7. Impact of the mode of delivery on the neonate

The most feared complication of VD is neonatal asphyxia leading to neurological morbidity. It is a common belief that CS protects the neonate from cerebral palsy, but it

has been estimated, that only a small proportion, 8-28%, of the cases of cerebral palsy (CP) are associated with birth asphyxia (Stanley 1994, Visser 1996, Clark et al 2008). Most neonates who develop CP have had damaging events already antenatally (infection, hypoxia, intracranial hemorrhage) or are low-weight or pre-term at birth (Stanley 1994, Clark et al. 2008).

Fetal lacerations occur in 0.1-3.1% of CS. The risk is increased in emergency operations, in abnormal presentations and after the rupture of membranes (Haas et al. 2002, Dessole et al. 2004, Signore et al. 2008). Sometimes severe lacerations occur, needing operative repair later (Nielsen et al 1984, Dessole et al. 2004).

Vaginal delivery seems to have several features important for neonatal adaptation to extrauterine life. During vaginal delivery the mechanical pressure on the fetus during the passage through the birth canal together with activation of sodium channels that transport liquids from the lungs help the neonate to start breathing (Jain et al. 2006).

The risk for respiratory morbidity has been studied in several studies which generally have shown that the overall risk for respiratory morbidity is 2 to 4 times higher in uncomplicated term pregnancies after elective CS compared to VD (Fogelson et al. 2005, Hansen et al. 2007, Hansen et al. 2008). The risk is reduced by increasing pregnancy duration, and is significantly lower after 39 weeks of pregnancy than before that. The most common form of respiratory morbidity is transitory tachypnea, but even more severe forms of respiratory morbidity occur, such as respiratory distress syndrome, pneumothorax and persistent pulmonary hypertension of the newborn (Kolås et al.2006, Zanardo et al.2007, Hansen et al.2008, Benterud et al. 2009).

There is proof of delayed neonatal adaptation to extrauterine life in neonates born by elective CS related to glucose balance, body temperature and neurologic adaptation. This is partly explained by the catecholamine surge that occurs in neonates born vaginally. The mean serum concentrations of catecholamines are lower in infants born by CS than VD. There are differences also in the levels of some other hormones between the neonates born vaginally and by CS (Buhimschi et al. 2006). A Swedish study on maternal and infant outcome after CS without medical indications, showed increased respiratory distress with OR of 2.7 in elective CS compared to emergency CS, and the risk of hypoglycaemia doubled for infants born by CS (Karlström et al. 2013).

Recently, there have been numerous studies on the impact of the mode of delivery on the immune system of the neonate. An Italian group showed that the intestinal microbiota differs in children delivered by CS compared to children delivered by VD, and concluded that the mode of delivery has a profound impact on the composition of the intestinal microbiota in the beginning of human life. There is strong evidence suggesting that the early composition of the microbiota of neonates plays an important role for the postnatal

development of the immune system (Biasucci et al. 2008). There is growing evidence showing that altered microbial colonization after CS may affect postnatal maturation of T cells and predispose to illnesses in later life (Signore et al. 2008).

There is evidence of an increased risk of asthma, allergic rhinitis and atopy in children born by CS compared to children born vaginally (Roduit et al.2009, Pistiner 2008). In a meta-analysis of 23 studies, there was a 20% increase in the risk of asthma for children delivered by CS (Thavagnanam et al.2008). CS may also predispose children to food allergy (Eggesbo et al. 2003). Still, all studies have not identified an association between CS and childhood asthma and allergic disease. Some studies have reported an association only for emergency CS, and this raises the thought that exposure to vaginal microflora is not the only explanation for the association between CS and increased childhood asthma seen in many studies (Almqvist et al. 2012, Tollånes et al. 2008).

MacDorman et al. have examined neonatal mortality risk by mode of delivery for low-risk women having singleton, term, vertex births with no medical or obstetric risk factors in a large birth cohort of more than 8 million births and 17 412 infant deaths. “CS without labor complications” was compared to “planned vaginal delivery” including VD and CS with labor complications. The patients were adjusted for several sociodemographic and medical risk factors. The study showed that the unadjusted neonatal mortality rate for CS with no labor was 2.4 times higher than for a “planned VD”, and after adjusting for several confounding factors the OR for neonatal mortality was still 1.7 for children born by CS without labor than for children born by intended VD (MacDorman et al. 2008). The authors present no explanation for these findings.

3. AIMS OF THE STUDY

This study was designed to evaluate the risk for maternal complications related to different modes of delivery with special emphasis on complications related to CS.

The specific aims were

1) To assess the incidence and trends of severe maternal complications in different delivery modes in two different annual cohorts in a register-based study (Study I).

2) To assess the incidence of complications related to cesarean sections in Finland, and to identify risk factors that increase the complication rate in a prospective multicenter study (Study II).

3) To compare the obstetric care in 12 hospitals participating in the study. The aim was to assess the association, if any, between CS rates and maternal and fetal outcomes (Study III).

4) To assess how much certain risk factors increase the risk of severe maternal complications and to assess if the impact of the risk factors varies by mode of delivery (Study IV).

4. SUBJECTS, MATERIALS AND METHODS

The study was conducted in Turku University Central Hospital, Department of Obstetrics and Gynecology, and the Medical Faculty of Turku University. The study was started in early 2005 by collecting prospectively data on CS performed in 12 hospitals. The prospective study on events and complications related to CS was performed as a multicenter study in the 12 largest delivery units in Finland, which included all the five university hospitals and the central hospitals with more than 1500 deliveries per year. This data was used in studies II and III.

The register-based studies were conducted in co-operation with the National Institute for Health and Welfare in Finland (THL). THL maintains the Finnish Birth Registry, Hospital Discharge Registry and the Register on surgical interventions in hospitals. These registers were used in studies I and IV.

The studies were approved by the Ethics Committee on the Intermunicipal Hospital District of Southwest Finland (5/2004 § 128). The multicenter study was approved by the Social and Health Ministry of Finland (Dnro STM/280/2005). Permission to use the registers for the register-based studies was granted by the National Institute for Health and Welfare in Finland (THL).

Table 7.Summary of materials, methods and results of studies I- IV.

	Stydy design	Setting	Number of patients
Study I	Register-based cohort study	All singleton births in Finland in 1997 and 2002	110 717
Study II	Prospective study	All CS in 12 delivery units during 6 months in 2005	2496
Study III	Prospective study	All births in 12 delivery units during 6 months in 2005	19 764
Study IV	Register-based cohort study	All singleton births in Finland in 2007-2011	292 253

The statistical analyses for studies II and III were performed by the Department of Biostatistics of the University of Turku and for studies I and IV by the THL.

4.1. Register based studies (Studies I and IV)

Studies I and **IV** were based on data derived from the Finnish Medical Birth Registry and Hospital Discharge Registry provided by the National Research and Development Centre for Welfare and Health. These registers collect data on birth, death and hospital inpatient discharges, including all diagnoses and surgical procedures. All births with a pregnancy duration of ≥22 weeks or a fetus weighing ≥500g are included in the registers. In these studies, data on each woman having a singleton birth during the study period was linked between the registers to have as complete information as possible on all studied complications, risk factors and delivery mode for each birth. The information was collected during delivery and until 42 days after the delivery. We chose all maternal diagnoses (based on ICD-10 codes) and operative interventions (based on the Nordic Classification of Surgical Procedures) that indicated a severe maternal complication. For **Study IV**, we searched all recorded diagnoses and surgical interventions in 2007-2011 and included some new diagnoses and surgical interventions not included in **Study I**. The diagnoses and surgical procedures used in **Study I** and **Study IV** are seen in **Table 8**.

Main outcome measures	Main findings
Severe maternal morbidity (thromboembolic events, severe hemorrhage, severe infection, other) in spontaneous VD, instrumental VD, elective CS and emergency CS. Trends in maternal morbidity.	Incidence of severe complications per 1000 2002: all deliveries 7.6, sp. VD 5.2, elective CS 12.1, emergency CS 27.2. Total rate increased from 5.9 to 7.6 from 1997 to 2002.
Maternal complications during hospital stay in elective-, emergency- and crash-emergency CS. Secondary outcomes: risk factors for complications	27.2% of women had one or more complications. 10% had a severe complication. Increased degree of emergency, obesity, age, pre-eclampsia, DM, multiple pregnancy, degree of cervical dilation, rupture of membranes increased the risk significantly.
Difference in CS-rate, correlation with maternal complication rate, neonatal asphyxia rate.	CS rate varied 12.9%-25.1%, maternal complication rate 13.0%-36.5%, neonatal asphyxia 0.14%-2.8%. No correlation.
Impact of maternal obesity, age, pre-eelampsia and IDM on risk of maternal complications in VD, elective CS, emergency CS and attempted VD.	Total complication rate lowest in VD compared to elective CS and emergency CS in all risk groups. OR varied by risk group and by delivery mode.

Table 8. Diagnoses and surgical interventions in **studies I** and **IV**.

Diagnoses (ICD-10) and surgical interventions (NCSP) used as markers for severe maternal morbidity in Study I.	Diagnoses (ICD-10) and surgical interventions (NCSP) used as markers for severe maternal morbidity in Study IV.(number of cases during 2007-2011)
Thromboembolic disease I26.9, I80.1, I80.29, I80.8, I80.9, O87.1, O88 Hemorrhage with coagulation disorderO67.0 Infections K65.0, K65.9, O85 Intestinal obstruction K56 Uterine rupture O71.0, O71.1, Uterine inversion O71.2 Operative interventions _ Nordic Classification of Surgical Procedures Hysterectomy (total and subtotal) LCC10 Subtotal hysterectomy LCD00 Total hysterectomy MCW00 Hysterectomy related to a delivery MCA30 Cesarean section and subtotal hysterectomy MCA33 Cesarean section and total hysterectomy Reoperations MWA00 Repair of wound dehiscence in obstetric surgery MWC00 Reoperation for deep infection in obstetric surgery LWA00 Repair of wound dehiscence in gynecological surgery LWE00 Reoperation for deep hemorrhage in gynecological surgery LWF00 Reoperation for insufficiency of anastomosis or suture in gynecological surgery LWW96 Other reoperation in gynecological surgery MWE00 Reoperation for deep hemorrhage in obstetric surgery MWW96 Other reoperation in obstetric surgery JAH00 Explorative laparotomy JAH96 Other explorative abdominal operation JAK00 Laparotomy and drainage of peritoneal cavity	O87.1 DVT in puerperium (41) O87.3 DVT in sinus durae in puerperium (9) O88 Obstetric embolism (22) I26.0, I26.9 Pulmonary embolism (110) I63.6 DVT in cerebral vein, causing infarctation (16) I80.1 DVT in v. femoralis (21) I80.20 DVT in v.iliaca (15) I80.29 DVT in other vein (29) I81 DVT in vena portae (5) I82.80 DVT in v. subclavia (5) I82.88 DVT in other vein (32) I82.29 DVT in vena cava (11) O67.0 Hemorrhage with coagulation disorder (22) O75.1 Obstetric schock (6) O71.0, O71.1 Uterine rupture (286) O71.2 Uterine inversion (10) O85 Puerperal sepsis (1887) O74.0 Pneumonia, aspiration (9) J80 ARDS (9) J81 Pulmonary edema (7) K65.0, K65.9 Peritonitis (14) K56 Intestinal obstruction (56) PC7NT Embolisation of a.uterina (38) PDT21 Embolisation of a.iliaca interna (15) PG1PT Exstensive embolisation (6) PDC21 Ligation of a.iliaca interna (3) PDC22 Ligation of a.iliaca externan (1) MBB10 Tamponade of uterus (34) LCC10 Subtotal hystercetomy (9) LCD00 Total hysterectomy (14) LCD96 Other hysterctomy (2) MCW00 Hysterectomy related to a delivery (57) MCA30 Cesarean section and subtotal hysterectomy (46) MCA33 Cesarean section and total hysterectomy (20) MWA00 Repair of wound dehiscence in obst. surgery (114) MWC00 Reop. for deep infection in obstetric surgery (30) LWA00 Repair of wound dehiscence in gyn.surgery 11 kpl LWE00 Reop. for deep hemorrhage in gyn.surgery (28) LWF00 Reop. for insufficiency of anastomosis or suture in gynecological surgery (15) MWE00 Reop. for deep hemorrhage in obstetric surgery (173) MWW96 Other reoperation in obstetric surgery (23) JAH00 Explorative laparotomy (52) JAH01 Explorative laparoscopy (19) MCW96 Peripartum laparotomy (23) Severe hemorrhage: O67.0, O75.1, LWE00, LWF00, MWE00, JAH00 (selected cases), LCC10. LCD00, LCD96, MCW00, MCA30, MCA33, PC7NT, PDT21, PG1PT, PDC21, PDC22, MBB10. (selected cases of hysterectomy performed because of infection) Infection: O85, O74.0, MWC00, K65.0, K65.9, (selected cases of JAH00)

In **Study I**, two separate year cohorts 5 years apart were investigated to see if there was any change in the incidence of severe maternal complications. The year 1997 was chosen as the first study year, and a five year interval was assumed to be appropriate for evaluating any trends in incidences. The number of births in this study was 110 717. The complications found were divided into the following groups: thromboembolism (deep venous thrombosis, pulmonary embolism, amniotic fluid embolism), hemorrhage (hysterectomy because of hemorrhage, reoperation because of hemorrhage, and obstetric coagulation disorder), major infection (sepsis, peritonitis, reoperation because of infection), and other (re-operation, uterine rupture, uterine inversion). The following delivery modes were examined: spontaneous vaginal delivery (including vaginal breech delivery), instrumental vaginal delivery, elective cesarean section and non-elective cesarean section. For the purpose of planning a delivery, we also compared elective CS to attempted VD. Attempted VD included all vaginal deliveries and non-elective CS.

The incidences were counted as number of patients having one or more of the defined complications per 1000 deliveries. The differences in the incidence of all complications and of each type of complication between the two study years and between the different modes of delivery were analyzed with the t-test for relative proportions. The incidences of complications were studied by each mode of delivery, and Risk Ratio (RR) with 95% intervals was calculated for each outcome by mode of delivery with spontaneous VD as the reference. RR was also calculated for elective CS using attempted VD as the reference. The difference in the incidence of complications by mode of delivery and by year was considered significant at a level of $p<0.05$. The long term risks of CS were analyzed by calculating RRs for peripartal hysterectomy, placenta previa and uterine rupture in women with and without prior CS.

In **Study IV** we studied the impact of several risk factors on severe maternal morbidity by mode of delivery. A five-year cohort of women (2007-2011) was studied, which gave us an adequately sized population for dividing into subgroups (n=292 253). The incidences were assessed for all severe complications and separately for severe infection and severe hemorrhage. The following risk groups were studied: women with BMI 30 or more, women aged 35 or more, women with pre-eclampsia and women with IDM. The aim was to investigate if the risk for severe complications was increased (or decreased) within a specific risk group compared to women without these risks in a similar manner for all delivery modes.

The impact of the risk factors on the risk for severe maternal complications was studied for vaginal deliveries, elective CS, emergency CS and attempted VD (including VDs and emergency CS). The ORs and 95% confidence intervals for the risk factors in all deliveries and separately in CS, VD and attempted VD were calculated by logistic

regression analysis. The ORs were adjusted for BMI and age of the woman, maternal smoking, existing IDM, existing PE and parity.

4.2. Prospective studies (studies II and III)

Data on all CS performed in 12 hospitals was collected prospectively from January 1 to June 30, 2005. All the five University Hospitals in Finland and seven of the central hospitals (with more than 1500 deliveries per year) participated. All hospitals invited to the study agreed to participate. Each hospital had a contact person, a senior consultant or a registrar, who had the responsibility to collect information on all CS performed on designated report forms (appendix 1). The report forms contained information on the medical and obstetric history of the woman, on the index pregnancy and delivery, indication for the CS, the operation itself (degree of emergency, experience of the operator, events related to anesthesia, intraoperative events), and maternal recovery during the hospital stay. The incidence of complications was assessed for all CS and for elective CS, emergency CS and crash emergency CS separately. The following conditions were included as complications: hemorrhage ≥1500ml, need for blood transfusion, intraoperative complications (organ injuries, lacerations), complications related to anesthesia, hysterectomy and other re-operations, sepsis, endometritis, wound infection, urinary tract infection, pneumonia, pulmonary edema, deep venous thrombosis and bowel obstruction.

Data on 2496 CS was obtained, and data coverage was 85% (51%-100% in different hospitals). During the study period, there were 28 278 deliveries and 4646 CS in Finland, and the study hospitals had 69% of all deliveries and covered 69% of all CS in Finland.

In **Study II** the following risk factors for complications were analyzed: type of CS, pre-eclampsia, maternal BMI, maternal age, preterm delivery, previous abdominal surgery other than CS, type 1 diabetes, multiple pregnancy, rupture of membranes, degree of cervical dilatation and smoking. The incidences of complications in connection with all CS and separately in elective CS, emergency CS and crash-emergency CS were calculated. The ORs for different risk factors were calculated by logistic regression to determine their impact on the risk for overall complications and severe complications separately. The risk factors whose independency turned out to be significant by univariate logistic analysis were analyzed further by multivariate logistic regression analysis. Multivariate analysis was performed separately for each type of complication. The factors analyzed by multivariate analysis were emergency CS vs. elective CS, PE, BMI, age and gestational weeks.

The same data on CS from 12 hospitals was used as the study material in **Study III**. The CS rates in different hospitals were compared. The actual CS rate in each hospital was adjusted for the following obstetric factors known to increase the risk for CS: maternal

age≥ 35 years, birthweight ≥4500g, breech presentation, multiple pregnancy, preterm delivery (<37 weeks of pregnancy), induction of labor, previous CS, post-term pregnancy and primiparity. This was done to assess if variation in the population characteristics explained the variation in CS rates. BMI was not recorded in the registers at the time of the study. Because the prospectively collected detailed data contained information on CS only, we used data derived from the Birth Registry and Hospital Discharge Registry for characterizing the obstetric population of each hospital. Data on the incidences of risk factors, the CS rates within each risk group and the total CS rate in each hospital covering the whole obstetric population (n=19 764) were presented as frequency data, not as individual deliveries. Therefore, a logistic regression analysis could not be made. We planned an applied adjustment where we assessed the CS rate in different risk groups in each hospital, and then calculated the adjusted CS rate by assuming that the distribution of risk factors was similar for each hospital.

The detailed data on maternal complications related to CS was available from the prospectively collected material, and the complication rates in the different hospitals were adjusted to the risk factors in each hospital by logistic regression to examine if the variation in the incidences of risk factors explained the variation in maternal complication rates. The maternal complications included are the same as used in **study II**.

The neonatal outcomes were derived from the Hospital Discharge Registry provided by the THL. The prospectively collected data included information on neonatal umbilical artery pH values at birth of all neonates delivered by CS, but also data on neonatal outcomes related to VD was needed for comparison. The data on umbilical artery pH values was incomplete in the national registers at the time of the study. We used neonatal admission to the neonatal intensive care unit (NICU) with ICD-10 diagnoses P21.1 (mild or moderate birth asphyxia) and P21.0 (severe birth asphyxia) as a closest available estimate for the occurrence of neonatal asphyxia.

Finally, we looked for a possible association between the CS rates and maternal and neonatal complications.

5. RESULTS

5.1. Register-based studies (Studies I and IV)

The CS rate was 15.3% and 16.1% for singleton deliveries in 1997 and 2002, respectively. The proportion of emergency CS was 48% and 46%.

The total incidence of severe maternal complications related to delivery was 5.9 per 1000 deliveries in 1997 and 7.6 per 1000 deliveries in 2002 (**Study I**). It was lowest for spontaneous VD, higher in instrumental VD and elective CS and highest in emergency CS (**Table 9** and **Table 10**). The incidence increased significantly from 1997 to 2002 ($p<0.001$). The increase was particularly high for major infections in all delivery modes and for hemorrhage in non-elective CS. When comparing the complication rate in elective CS with attempted VD (including emergency CS), the RR was 1.8 (95% CI 1.4-2.4) in 1997 and 1.9 (95% CI 1.5-2.4) in 2002. The risk of peripartum hysterectomy, placenta previa and uterine rupture was 5.3-, 3.0- and 8.5-fold, respectively, for women who had and who had not had a previous CS.

Study IV covered the study period 2007-2011. The CS rate among singletons was 15.8% and the proportion of emergency CS was 61% of all CS. The proportion of emergency CS varied markedly by risk group, and was 9.7% of all deliveries in the whole obstetric population. It was 15.6% for women with BMI ≥30, 12.7% for women aged ≥35 years, 53.1% for women with PE and 41.2% for women with IDM. Of all women delivering a baby in 2007-2011, 11.5% had a BMI ≥30, 18.2% were aged ≥35 years, 0.8% had PE and 0.6% had IDM.

During the time period of 2007-2011 the incidence of any severe maternal complication was 12.8 in 1000 deliveries. The incidence was lowest in VD, higher in elective CS and highest in emergency CS. When comparing elective CS to attempted VD the adjusted OR for a severe maternal complication was 1.4 (95% CI 1.2-1.6). The total complication rate was higher in all of the studied risk groups than in women without these risks, but the OR varied by risk group and by delivery mode (**Table 11**). Attempted VD was the safest mode of delivery for all women in the risk groups except for women with PE who had a similar risk in attempted VD and elective CS. The risk for thromboembolic events increased in all the risk groups compared with women without these risks.

Table 9. Incidence of severe maternal complications in 1000 by mode of delivery (**studies I** and **IV**). Diagnoses and interventions as in **Table 8**.

	Number of singleton deliveries	CS-rate (emergency CS % of all CS)	Instrumental VD rate	**All deliveries**	VD	Elective CS	Emergency CS	Attempted VD
1997	57 149	15.3% (48%)	5.4%	**5.9**	4.3	9.9	19.6	5.5
2002	53 568	16.1% (46%)	6.3%	**7.6**	5.5	12.1	27.2	7.2
2007*	57 127	16.0% (59.7%)	8.2%	**8.6**	6.9	13.9	20.5	8.3
2007-2011**	292 23	15.8% (61.0%)	8.6% (2010-2011)	**12.8****	10.2**	18.0**	31.6**	12.4**

**The year cohort 2007 was examined separately with the same diagnoses and interventions as in study I for comparison. **In the cohort of women 2007-2011 there were some additional diagnoses and interventions, see Table 8.*

Table 10. Incidence (per 1000 deliveries) of severe infections and severe hemorrhage by mode of delivery (**Studies I** and **IV**).

	Severe infection					**Severe hemorrhage**				
	All deliveries	VD	Elective CS	Emergency CS	Attempted VD	**All deliveries**	VD	Elective CS	Emergency CS	Attempted VD
1997	**3.3**	3.0	2.6	7.6	3.3	**1.1**	0.4	4.9	5.7	0.8
2002	**4.5**	4.1	4.5	8.2	4.5	**1.5**	0.4	4.5	10.7	1.2
2007*	**6.1**	5.5	7.3	11.0	6.1	**1.1**	0.4	3.3	4.8	0.9
2007-2011**	**8.1**	7.8	7.0	11.0	8.1	**1.4****	0.6**	4.6**	5.9**	1.2**

**The year cohort 2007 was examined separately with the same diagnoses and interventions as in study I for comparison. **In the cohort of women 2007-2011 there were some additional diagnoses and interventions, see Table 8.*

Table 11. Incidence (per 1000 deliveries) of severe complications in different risk groups by mode of delivery. Singleton births in 2007-2011, n= 292 253.

	All women n=292 253	BMI ≥30 n=33 464	Age ≥35 n=53 048	Pre-eclampsia n=2362	Insulin dependent DM n=1778
All deliveries	1.3	1.6	1.3	2.3	1.6
Vaginal deliveries	1.0	1.1	0.9	1.6	0.7
Elective CS	1.8	2.3	1.9	2.0	1.7
Emergency CS	3.2	3.6	3.3	3.1	2.7
Attempted VD	1.2	1.5	1.2	2.4	1.5
Total CS rate within the group	*15.8*	*23.3*	*21.2*	*59.1*	*58.5*
Emergency CS rate	*10.3*	*15.6*	*12.7*	*53.1*	*41.2*

5.2. Prospective studies (studies II and III)

The CS rate in the study hospitals was 16.6% of all deliveries during the study period. The proportion of elective CS was 45.6% (35.7-61.1%) of all CS, and that of crash-emergency CS 7.9% of all CS (3.7-15.4%). About 25% of the emergency CS and 15%

of the crash-emergency CS were performed before onset of labor. 1.7% of all CS were performed after a failed trial of vacuum extraction. Spinal anesthesia was used in 44%, combined spinal-epidural in 37%, epidural alone in 8% and general anesthesia in 11% of the operations. Antimicrobial treatment was used in 51% of all CS (25% elective, 70% emergency and 90% crash-emergency CS). Antithrombotic prophylaxis was used in 4% of CS. The operator was a registrar with less than 2 years of experience in 23%, a registrar with more than 2 years of experience in 45% and a senior consultant in 30% of CS. More than one operator was involved in 2% of the CS. The mean operating time was 40 (13-150) minutes for elective CS, 38 (14-250) minutes for emergency CS and 39 (14-250) minutes for crash-emergency CS. Women undergoing emergency CS were significantly younger, more often nulliparae, had more often preterm delivery, hypertensive disorder and pre-eclampsia, and were more often smokers than women undergoing elective CS.

27% of the women had one or more complications related to the CS during their hospital stay, and 10% had one or more severe complications **(Table 12**). Complications were more common in emergency CS than in elective CS, and most common in crash-emergency CS ($p<0.001$). The distribution of different complications is shown in **Table 12.**

10.5% of all women had an infectious complication, more often after emergency procedures than elective ones. Seven women had sepsis (0.3%), four of which were related to elective CS. Pneumonia occurred in four women (0.2%), all after emergency CS. Endometritis occurred in 5.5% and wound infection in 3.2% of the women. Endometritis was more frequent after emergency CS than after elective CS (8.4% vs. 1.9%, $p<0.001$), whereas wound infections occurred at similar rates in elective and emergency CS. A re-operation was needed in 1.5% (n=37), twelve of which were laparotomies (for hemorrhage, ureter or bowel repair). Re-operations were equally common after elective and emergency operations. Pulmonary edema occurred in seven patients, four of whom had pre-eclampsia, one with eclampsia. Six patients had a deep venous thrombosis (0.3%) during the hospital stay, three of them complicated by pulmonary embolism and one by septic pelvic thrombophlebitis. In addition to these, one woman died of pulmonary embolism at home 12 days postpartum, and was therefore not included in the analysis.

Emergency CS increased the risk for overall complications with an OR of 1.8 (1.5-2.2) and for severe complications with an OR of 1.9 (1.4-2.5) compared to elective CS by multivariate logistic regression analysis. Obesity increased the risk for overall complications (OR 1.4: 1.1-1.8) and infections (OR 1.8: 1.3-2.4). Pre-eclampsia increased the risks for hemorrhage (OR 1.8: 1.2-2.7), puerperal complications (OR 1.8: 1.3-2.5) and severe complications (OR 2.2: 1.5-3.2). An increase in maternal age of every 5 years increased the risk of intraoperative complications (OR1.5: 1.2-1.8), re-operations (OR 1.6: 1.2-2.2) and severe complications (OR 1.2: 1.1-1.4).

In addition to the risk factors analyzed with logistic regression, we studied the impact of several other risk factors. Smoking did not have a significant effect on the incidence of any complications, but there were more smokers among the women needing a crash-emergency CS (14.1%) than in the group needing emergency CS (12.2%) or in the elective group (8.9%) (p=0.015). Smokers also had more thromboembolic events than non-smokers (0.79% vs. 0.24%), but the numbers were not statistically significant due to small numbers of cases.

Previous intra-abdominal surgery (other than CS) increased the risk for hemorrhage and intraoperative complications. Advanced cervical dilatation increased the risk for intraoperative complications and infections. IDM increased the risk for puerperal infections, 21.6% vs. 11.0% (p=0.018) in women with and without IDM, respectively.

Table 12. Incidence of maternal complications (%) by type of cesarean section. 2496 cesarean deliveries in Finland (**study II**).

	All CS (n=2496)	Elective CS (n=1141)	Emergency CS (n=1159)	Crash-emergency CS (n=196)	Emergency and crash-emergency CS combined (n=1355)	P-value*
All complications	**27.2**	**21.3**	**30.5**	**42.4**	**32.2**	p<0.001
Severe complications	10.4	7.1	11.7	25.0	13.2	p<0.001
Hemorrhage †	8.4	5.8	9.0	20.4	10.6	p<0.001
Introperative complications	4.4	3.0	4.6	12.2	5.7	p<0.001
Complications of anesthesia	4.3	4.2	4.9	1.6	4.4	p=0.764
Puerperal complications -	20.2	14.8	23.8	29.6	24.6	p<0.001
infections‡	10.5	7.6	14.5	12.8	14.2	p<0.001

* Elective CS compared to combined group of emergency CS and crash-emergency CS
†Hemorrhage > 1500ml and/or blood transfusion
‡Endometritis, wound infection, urinary tract infection, sepsis, pneumonia

Table 13. Incidence of severe complications per 100 cesarean deliveries (2496 CS).

Hemorrhage >1500 ml	5.0 (n=125)
Transfusion	6.4 (n=159)
Re-operations	1.5 (n=37)
Organ injury	0.5 (n=13)
Sepsis	0.3 (n=7)
Thromboembolic events	0.2 (n=6) +1
Pulmonary edema	0.3 (n=7)
Bowel obstruction	0.3 (n=7)
Pneumonia	0.2 (n=4)
Hysterectomy	0.2 (n=6)
Inversio uteri	0.04 (n=1)
All severe complications (Women having one or more severe complications)	**10.4**

Table 14. Incidence of infections per 100 cesarean deliveries (2496 CS)

Endometritis	5.5 (n=136)
Wound infection	3.2 (n=81)
Urinary tract infection	1.4 (n=35)
Sepsis	0.3 (n=7)
Pneumonia	0.2 (n=4)
All infections	**10.5 (n=263)**

In **Study III**, the CS rate varied significantly among the 12 study hospitals (12.9%-25.1%). This variation levelled some when the CS rates were adjusted for risk factors (maternal age, fetal birth weight ≥4.5kg, breech, multiple pregnancy, preterm pregnancy, induction of labor, previous Cs, post term pregnancy, primiparity) and the difference between the highest rate and the lowest rate sank from 12.2% to 8.0%.

The incidence of maternal complications varied from 13.0% to 36.5% and the incidence of severe complications from 4.6% to 15.4% in the different hospitals. After adjustment of the complication rates for risk factors known to increase the risks (degree of emergency of the operation, maternal age, maternal BMI, gestational age, pre-eclampsia, IDM and multiple pregnancy), the rates decreased in four hospitals (0.2-0.9%), increased in six hospitals (0.1-1.3%) and remained unchanged in two hospitals. The maternal complication rates did not correlate with the CS rate.

The incidence of NICU admission for asphyxia varied from 0.2% to 3.1%. Higher than average rates occurred in hospitals with a high CS rate as well as in hospitals with a low CS rate. Of the five hospitals with a CS rate ≤15%, four had lower than average rates of asphyxia.

6. DISCUSSION

In perinatal medicine the basic principle is not to harm the mother or the fetus. Sometimes their interests may be in conflict. CS can save the mother or the neonate from severe injury when performed in a timely manner on the basis of correct indications but has potential adverse effects that may affect the mother or the neonate. Pregnancy itself and VD entails risks, as well. The goal in obstetrics is to deliver as safely as possible.

At the same time as evidence- based medicine is practiced in most areas of medicine today, the management of deliveries and the use of the most frequent major surgical operation on women vary widely from hospital to hospital (Aron et al. 1998, Bailit et al. 2006, Pallasmaa et al.Study III).

6.1. Methodological considerations and study limitations

The literature review is not a proper systematic review with specific search criteria on the literature on complications related to deliveries. Because of the broad topic, I have restricted the studies referred to in the literature review to the most essential ones. The choices I made may bias the results referred to, but not intentionally. Regarding the studies on severe maternal morbidity, all studies on severe maternal morbidity by delivery mode were, however, included.

6.1.1. Register based studies

The Finnish Birth Register is known to be complete and of high quality, and is therefore a useful source for clinical research (Gissler et al. 1995, Langhoff-Roos et al 2013). Practically all pregnant women use the free municipal maternal services, and data on the previous obstetric history and diagnoses and interventions during hospital stay are comprehensively recorded in the Hospital Discharge Registry and the Birth Registry. Although some individual data is lost in a register-based study, such a study allows studying a large population and events that are less common (Räisänen et al. 2013).

In **Study I**, the complication rates were not adjusted for any confounding factors, which is a clear weakness. If risk factors increasing the occurrence of severe complications were more common among women having either type of CS, this would cause bias in the safety evaluation of VD vs. CS. However, despite this theoretical drawback, the results are in line with other studies that have adjusted data for several confounding factors.

Study I was designed to investigate short term maternal complications in a cohort of women. The long term complications related to previous CS were secondary outcomes

and analyzed as in a case-control study, not according to the preset, original design of the study.

The validity of these results depends on the reliability of the registers and the appropriateness of the diagnoses that are included in the analysis. The incidence of complications in the register-based study (**Study I**) was slightly lower, but close to the incidences compared to the same complications in the prospective study. A fair concern is whether the diagnoses in **study I** are appropriate. They may not all be of the same degree of seriousness, but each of them are severe and may lead to maternal death.

The definition of emergency CS in **studies I** and **IV** may cause some bias when estimating the risks of attempted VD. There is no clear consensus on the time limits when a CS is categorized as an elective or an emergency CS in cases where labor has not started. In a register-based study, the obstetrician in charge decides the category according to his judgement. The CS is usually categorized as an emergency procedure, if the decision to operate has been made within 8-12 hours from the time when the operation was performed. In the most severe cases of PE and other sudden severe pregnancy complications (such as placental abruption), with extensive risks for severe complications, the decision to perform a CS is often made promptly, and the operation is categorized as an emergency CS, but VD has never been attempted. On the other hand, placenta previa is related to a high risk of complications, especially severe hemorrhage and eventually hysterectomy, but unless there is acute bleeding, these cases are included in the category of elective CS. In **study II** the categorization was made on the basis of a questionnaire, where elective CS was defined as a CS where the decision to operate had been made more than 12 hours earlier and with the membranes unbroken. Unfortunately, the questionnaire in **Study II** did not include a precise question on labor; there was only data on the extent of cervical dilation and of rupture of membranes. This is a weakness in the questionnaire.

To make a reliable comparison between the delivery modes, only women without pre-existing medical conditions and without pregnancy disorders should be included. Such a comparison has been made in some studies, and the results are in line with ours (Liu et al. 2007, Farchi et al. 2010). Some other studies on severe maternal morbidity by mode of delivery use adjustments for risk factors, and also these results are in line with ours (Villar et al. 2007, Kuklina et al. 2009). A previous CS affects the risk for complications, both in CS and in VD (Holm et al.2012, Jakobsson et al 2013, Silver et al. 2005). In **studies I** and **IV**, all women with singleton deliveries were included. Adjustments for several factors were made in **study IV**, but not for prior CS, which is a limitation.

6.1.2. Prospective studies

In **Study II** data coverage was 85% of all CS performed in the study hospitals during the study period. Thus, the average coverage is good, but it varies from 51% to 100% in the

different study hospitals. This may cause a bias in the results, if complication rates differ from average more in the hospitals with a low coverage than in high coverage hospitals. The total complication rate varied from 13 % to 33%, but the complication rate did not vary by data coverage. The average complication rate was 29% in hospitals with data coverage less than 80% (two hospitals), 26% in hospitals with data coverage 80-98% (four hospitals), and 27% in hospitals with data coverage above 98% (six hospitals). Nor did the complication rate correlate with the CS rate of the hospital.

In **Study III,** the analyses were made with two different data sources which caused some problems. The data on maternal complications related to CS and the risk factors increasing these risks were derived from the prospectively collected detailed data. This data allows the use of logistic regression analysis to adjust the complication rates of different hospitals with respect to the risk factor incidences. To determine whether the variation in complication rates between the hospitals was explained by differences in the obstetric population, we also needed data on women delivering vaginally. This data was obtained from the Birth Registry, but only as frequencies and incidences, and this did not allow us to perform logistic regression analysis for adjusting the rates. Therefore, we planned a simplified method of adjusting the CS rates for the risk factors. In this method, we could not control for the fact that some women may have had several risk factors. If overlapping was more common in some hospitals, this would bias the result.

Another limitation in **Study III** was the definition of asphyxia, which can be criticized. We checked the umbilical artery pH values of the neonates recorded in the registers in each hospital. Also the 5 minute Apgar score values <7 and <5 were checked. At the time of the study, umbilical artery pH values were not comprehensively recorded in the Birth Registers. Defining asphyxia by Apgar scores is also known to be unreliable (Hogan et al 2007). Although the threshold to admit neonates to NICU with diagnoses P21.0 and p21.1 may vary in different hospitals, the ICD-10 definition requires that not only low Apgar scores but also symptoms of asphyxia must exist to use this diagnosis, and it has been used in other studies (Bailit et al. 2002).

6.2. Comparison with other studies

The reported incidence of general complications related to CS in **study II** (27%) is similar to several other studies. Häger et al. reported an incidence of 21.4% in a prospective study similar to **study II** (Häger et al. 2004). Van Ham et al. reported an incidence of 35.7% in a retrospective study of data derived from patient records. Some studies report much lower incidences, and they are often register-based. Allen et al. reported that total morbidity related to elective CS was 7.0%, and to emergency CS 16.3% based on a provincial population-based database in Canada (Allen et al. 2003). In a study from Denmark using Medical Birth Register as a source of data, the morbidity rate was

8.3% in elective CS, 11.4% in emergency CS and 8.9% in VD when injury to the anal sphincter was included (Krebs et al 2003).

The incidence of hemorrhage related to CS varies in different studies. The rates in **study II** (8.4% in all CS) are in line with the results of studies with similar study setting , 7.9% in the study by Häger et al. and 9.9% in elective CS and 10.9% in emergency CS in the study by Karlström et al. (Häger et al. 2004, Karlström et al. 2013).

The frequency of blood transfusions related to CS in **study II** was higher (6.4%) than in most other studies. Especially some register-based studies report rates as low as 0.2-0.5% in elective CS and 0.6-1.0% in emergency CS (Burrows et al. 2004, Liu et al. 2007). It is possible, that data is lost in the registers of register-based studies. According to a register-based Finnish study, the transfusion rate in all deliveries was 2.3% in 2008, and the OR for needing a transfusion was 2.5 for any CS before adjustment for confounders, and 1.8 when adjusted, which comes close to the incidence in our prospective study (study II) (Jakobson et al. 2012). This also demonstrates the high quality of the Finnish registers. Evidently also the threshold to use blood transfusions is different in different hospitals and obstetric cultures.

Some studies report a lower incidence of hemorrhage in elective CS than in VD or an attempted VD, but the need for blood transfusion is higher in CS than in VD in these studies (Koroukian 2004). There are some studies that report even a transfusion rate higher in attempted VD compared to elective CS (Allen et al. 2003, Farchi et al 2004, Liu et al. 2007, Holm et al. 2012). In these studies, any amount of transfusion is included. In all studies, the most severe forms of hemorrhage (hemorrhage leading to hysterectomy, other surgical interventions or coagulation disorders) are more commonly related to CS, even elective CS (Knight et al. 2008, Forna et al. 2004, van Dillen et al. 2010).

Comparing the incidence of severe complications between elective CS and attempted VD the OR was 1.9 in 2002 in **study I**, without adjustments for confounders. In **study IV**, the ORs were adjusted for BMI, maternal age, smoking, IDM, PE and parity, and the OR for elective CS compared to attempted VD was 1.4. These figures are in line with other studies on severe maternal morbidity (van Dillen et al. 2010).

Infections occurred after 10.5% of CS in our prospective study (**study II)** during hospital stay. Häger had similar rates (7%) in a similar study setting (Häger et al 2003). Allen reported a puerperal febrile morbidity rate of 0.6% in VD, 2.6% in elective CS and 5.5% in emergency CS in a register-based study (Allen et al. 2003).

The incidence of septic infections is higher in our study than reported in most other studies. In the prospective study (**Study II**) the incidence of sepsis related to CS was 2.8/1000. In the questionnaire, the criteria to the use of this diagnosis were not specified.

In the register-based studies, where women with ICD-10 code O85 (puerperal sepsis) were included, the incidence was 3.3/1000 and 4.4./1000 in 1997 and 2002, respectively, and 6.5/1000 in 2007-2011. Rates up to 1.0-2.3/1000 have been reported in previous studies (Simoes et al. 2005, Acosta et al 2013). The rate of puerperal sepsis has been defined in two earlier studies from Finland and it was 1/1000 (Kankuri et al. 2003, Zhang et al. 2005). In these studies, a positive blood culture was required to use the diagnoses. It is possible, that the diagnosis O85 is used too easily in Finnish hospitals, only based on clinical symptoms without confirmation from a blood culture, maybe explaining the discrepancy in the incidence of sepsis between the register-based studies using the diagnosis O85 as a marker for sepsis and the studies requiring a positive blood culture to use the diagnosis. In our register-based studies the risk for sepsis was similar in VD and elective CS and only slightly higher in emergency CS. In other studies sepsis is more often related to CS than to VD (Kankuri et al. 2003, Simoes et al. 2005 Acosta et al. 2012, Acosta et al. 2013).

The use of antimicrobial prophylaxis varied in different hospitals in **study II**. Prophylaxis was used in 51% of CS, more often in emergency CS than in elective CS. In VD, the use of antimicrobial prophylaxis for women with vaginal colonization with group B Streptococci has increased during the recent years, but it is not used commonly for other reasons. The incidence of sepsis has increased from 1997 to 2002 and further to 2007 in all delivery modes (Table 10).

In Finland CS is usually performed by one surgeon alone, in contrast to the practice in many other countries, where there are usually two operators, and the registrars seldom operate alone. In **Study II,** there was more than one operator in only 2% of CS, despite the fact that the operator was a registrar with less than 2 years of experience in 23% of the CS. The occurrence of complications related to emergency CS was slightly higher when the operator was a registrar with little experience, but the difference was not significant (data not shown). A study assessing the effect of the learning curve on the outcome of CS reported that after starting to perform CS independently, the outcomes in terms of operating time and hemorrhage levelled off after 15 operations. There was not any statistically significant differences in the other outcomes or in postoperative complications (Fok et al. 2006).

There is no final consensus on an appropriate CS rate in a specific population, nor a consensus on an acceptable complication rate related to deliveries. Therefore, in **Study III**, average rates of CS were used as reference values to define low and high rates. The maternal complication rates of each hospital were also compared to the average complication rate. The average values may not be the ideal values. Rather, we could regard the lowest rates with good outcomes as the optimal values.

The relation between CS rates and maternal and neonatal outcomes has been studied earlier. In the study by Bailit et al, maternal and neonatal outcomes were best in hospitals where CS rates where within the rates expected after adjustment for risk factors (Bailit et al. 2002, Bailit et al 2006). In the study by Villar et al. on maternal and neonatal outcomes related to the CS rate in 120 institutions in Latin America, adverse maternal and neonatal outcomes were associated with increased CS rates (Villar et al 2006).

6.3. Comparison of the different modes of delivery

The risks of emergency CS are perceived so high by some investigators that elective CS is considered to be safer than attempting a VD with the possibility of ending up in an emergency CS. Several studies have compared the risks in elective CS and emergency CS. In most studies, the risk for complications related to emergency CS compared to elective is CS 1.1- to 2.5-fold (Häger et al. 2004, van Ham et al. 1997, Rasmussen et al. 1990). In the present studies both general and severe maternal complications were twice as common in emergency CS compared with elective CS.

There are numerous confounding factors influencing the outcomes in obstetrics. Adverse outcomes can be a result of inappropriate management of deliveries as well as the mode of delivery itself. Adverse outcomes can also be related to pregnancy complications or maternal characteristics. If emergency interventions are performed too liberally or if they are conducted improperly, the complications in the group of intended VD increase. If interventions are not made in a timely manner, the rate of complications increase. Sometimes the conclusions made of the outcomes in different delivery modes may be based on false premises. The results may be true in the setting of the study, but not be generalisable to other settings.

Since the outcomes of CS are often affected by the indication which has led to the operation, conclusions on the safety of CS or VD cannot be made directly by comparing the outcomes of these deliveries. A randomized controlled trial comparing the outcomes of planned vaginal and planned cesarean delivery in healthy women without coexisting medical conditions could give answers regarding the safety of each delivery mode, but this is not possible for ethical reasons. (Wax 2006, Signore et al. 2008, Souza et al. 2010). Different estimates and adjustments have been used to address this question. Women undergoing elective CS for breech presentation with no other maternal or fetal reason for the CS than the fetal presentation and CS on maternal request have been used as a surrogate for planned CS (Hannah et al. 2002, Krebs et al. 2003, Karlström et al. 2013). As the risk for complications in spontaneous VD is lower than in any CS, the compound risk of attempted VD is directly related to the proportion of women ultimately delivering in the planned manner and the proportion of emergency procedures, both instrumental VD and emergency CS.

If we had a reliable way to predict which of the women attempting VD will end up in emergency CS, the rate of complications could be reduced by choosing an elective CS for these women. Several efforts have been made to make prediction models but useful models for obstetric practice have not emerged (Grobman et al 2009, Metz et al. 2013, Uyar 2009). We do not know what is the optimal proportion of emergency CS in an average western population.

In Finland, the total CS rate has been stable, between 15.0% and 16.2%, for singleton births since 1995, but the proportion of emergency interventions has increased. The emergency CS rate was 7.4%, 7.5% and 9.7% of all deliveries in 1997, 2002 and the study period of 2007-2011, respectively. The instrumental VD rate was 5.4%, 6.3% and 8.6% (Birth Registry). The same trend is seen in many other countries, perhaps explaining partly the increase in maternal morbidity (Rossen et al. 2010).

In the future, it is important to establish the reasons for the increase in maternal morbidity if outcomes are to improve. The tools may be to avoid unnecessary CS, and maybe other interventions as well. We also need to investigate how CS can be made safer, e.g. by improving surgical techniques. We need to investigate if antimicrobial and antithrombotic prophylaxis is used as recommended. Improving obstetric skills may improve the safety of deliveries. To decrease the rates of advanced age and obesity is not possible for obstetricians, but identifying the high-risk patients may help in making deliveries safer for these women.

7. SUMMARY AND CONCLUSIONS

The incidence of severe maternal delivery related complications and the change in the rates during a time period of five years was studied in all delivery modes in a register based study on year cohorts 1997 and 2002. The incidence and risk factors for intraoperative and postoperative complications related to CS were studied prospectively in 12 delivery units. The rates of maternal complications and neonatal asphyxia were compared between these 12 hospitals which had different CS rates. The association between maternal risk factors and severe maternal delivery-related complications by intended and actual mode of delivery was studied register based in a five-year cohort of singleton deliveries.

The main findings are:

1. The register-based incidence of severe maternal complications was 5.9 in 1000 deliveries in 1997 and increased to 7.6 in 1000 deliveries in 2002. Maternal morbidity was lowest in VD, higher in elective CS and highest in emergency CS. Elective CS was associated with a 1.8-1.9-fold risk of severe maternal complications compared with attempted VD.

2. In a prospective study, 27% of women had one or more complications at CS, and 10% had a severe complication. Significant risk factors were: emergency CS, obesity, increasing maternal age and pre-eclampsia.

3. The CS rate, the maternal complication rate at CS and the neonatal asphyxia rate varies significantly between the different Finnish hospitals. The differences in the CS rates were unrelated to the maternal complication rates and neonatal asphyxia rates. Lower than average asphyxia rates were seen in four and lower than average maternal complication rates in three of the five hospitals with a CS rate of 15% or less.

4. Women with BMI above 30, an age above 35 years, pre-eclampsia and diabetes mellitus are at increased risk of severe maternal complications. The impact of these risk factors varies by mode of delivery. Attempted VD is the safest mode of delivery in all risk groups except in women with pre-eclampsia.

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APPENDIX 1.

SYNNYTYSKOMPLIKAATIOTUTKIMUS

KEISARILEIKKAUS -KYSELY

1. Synnytyssairaala: _____

2. Potilaan sos. turvatunnus: _____

3. Leikkauspäivämäärä: _____

4. Synnyttäjän ikä: _____ v. 5. Paino: _____ kg (raskauden alk.) 6. Pituus: _____ cm

YMPYRÖI SOPIVA VAIHTOEHTO / VAIHTOEHDOT JA TÄYTÄ PYYDETYT KOHDAT

7. Aikaisemmat synnytykset:

1) spontaani alatiesynn: ____ kpl
2) imukuppi/pihtisynn: ____ kpl
3) päivystyskeisarileikkaus: ____ kpl
4) elektiivinen keisarileikkaus ____ kp

I

8. Aikaisemmat kaavinnat: ____ kpl (vuotohäiriöihin, keskenmenoihin, raskauden keskeytyksiin tai synnytyksiin liittyen) ___ ei tietoa

9. Aikaisemmat leikkaukset (vatsanalueen leikkaukset, tyrät, suonikohjut): mitä leikattu:

_____

__ei tietoa

10. Synnyttäjän perussairaus (0 – useampi vaihtoehto):

1) diabetes (White luokka ____)
2) verenpainetauti
3) veren hyytymishäiriö tai aiemmin sairastettu veritulppa
4) munuaissairaus
5) astma
6) kilpirauhasen toiminnan häiriö
7) muu, mikä: _____
8) en tiedä / osaa sanoa

11. Raskauden aikana esiintyneet häiriöt:

1) raskaudenaikainen verenpaineen nousu
2) pre-eklampsia
3) raskausdiabetes
4) sikiön kasvuhäiriö
5) muu, mikä:_____

12. Tupakointi: 1) ei 2) kyllä, _____savuketta/vrk

13. Raskauden aikainen lääkitys: _____

_____

14. LEIKKAUS:

Merkitse ympyröimällä minkä tyyppinen keisarileikkaus kyseessä:
1) elektiivinen keisarileikkaus (päätös leikkauksesta tehty yli 12 t aikaisemmin ja lapsivesi on tallella)
2) päivystyskeisarileikkaus
3) hätäkeisarileikkaus

15. Leikkausindikaatiot (ympyröi 1-2 tärkeintä)
1) uhkaava sikiön asfyksia
2) pitkittynyt synnytyksen avautumisvaihe
3) pitkittynyt ponnistusvaihe
4) supistusheikkous
5) ahdas lantio /dysproportio fetopelvina
6) tarjontahäiriö, mikä: _____
7) sikiön perätila
8) aiempi keisarileikkaus, n= ____
9) kohturuptuura
10) verenvuoto : 1) ablatio placentae 2) muu syy, mikä:_____
11) etinen istukka
12) äidin sairaus, mikä: _____
13) synnytyspelko
14) äidin leikkaustoive
15) muu syy, mikä : _____

16. Raskauden kesto leikkauspäivänä: _____rv ____pvää

17. Sikiöiden lukumäärä
1) 1
2) 2
3) 3 tai useampia

18. Onko synnytystä yritetty käynnistää
1) kyllä
2) ei

19. Käynnistysmenetelmä (1 tai useampia):
1) diskisio
2) oksitosiini
3) Cytotec
4) muu, mikä:_____

20. Käynnistyksen syy:
1) yliaikaisuus
2) äidin tai sikiön infektio(epäily)
3) epäily sikiön ahdinkotilanteesta
4) äidin sairaus tai tila
5) makrosomiaepäily
6) muu syy, mikä: _____

21. Kohdunsuu avautunut ennen leikkausta
1) alle 4cm
2) 4-8cm
3) yli 8cm
4) ponnistusvaihe alkanut
5) yritetty imukuppi/pihti –ulosauttoa

22. Lapsivesi mennyt ennen synnytystä:
0) ei
1) alle 12 t
2) 12 – 24 t
3) 24 – 48 t
4) yli 48 t

23. Synnytyksen aikana kuumetta yli 38 1) ei
2) kyllä.

24. Synnytyksen aikana antibioottihoito 1) ei
2) kyllä, mikä: _____

25. Antibioottihoidon syy, : 1) rutiininomainen leikk.aikainen infektioprofylaksia
jos ab-hoito ollut 2) Streptococcus Agalactiae -profylaksia
käytössä 3) äidin infektio tai sen epäily
4) muu syy, mikä: _____

26. Onko Streptococcus Agalactiae –näyte otettu 1) ei
2) kyllä, näyte ____pos ____neg

27. Synnytyksen aikainen muu lääkitys: _____

_____

28. Onko synnytyksen aikana ollut käytössä 1) KTG-seuranta
2) STAN-seuranta

29. Lapsen syntymäpaino: _____g.

30. 5 min Apgar pisteet 1) 0
2) 1-3
3) 4-6
4) 7-10

31. Napasuonen pH, jos määritetty:____arteria-pH ____vena-pH
BE (Base excess): _____

32. Leikkauksen kesto _____min (viilto – ihon sulku loppu)

33. Leikkaaja: 1) erikoistuva , alle 2 v alalla
2) erikoistuva, yli 2v alalla
3) erikoislääkäri

34. Onko seuraavat kudoskerrokset suljettu erikseen:
1) rakkolambo: 0) ei 1)kyllä
2) peritoneum : 0) ei 1)kyllä
3) lihaskerros (fascian ja peritoneumin välissä): 0) ei 1)kyllä
4)subcutis: 0) ei 1)kyllä

35. Leikkausviilto:

1) phannenstiel
2) alakeskiviilto
3) muu, mikä:_____

36. Ihon sulku:

1) sulamattomat knopit
2) sulava intrakutaaniommel
3) sulamaton intrakutaaniommel
d) muu, mikä: _____

37. Leikkauksen aikainen komplikaatio (0 – useampia):

a) ei
b) verenvuoto yli 500ml
c) virtsarakkovaurio
d) uretervaurio
e) suolivaurio
f) viiltohaava lapsen ihoon
g) kohdun poisto
h) muu, mikä: _____

Tarkempi kuvaus komplikaatiosta (tarvittaessa) : _____
_____

38. Todettiinko leikkauksen aikana placenta accreta (tai percreta)?
1) ei
2) kyllä

39. Tromboosiprofylaksia

1) ei
2) kyllä, mikä:_____

40. Leikkauksenaikainen ja sen jälkeinen verenvuoto yhteensä:

1) alle 500 ml
2) 500 -1500 ml
3) yli 1500 ml, kuinka paljon: _____ ml

41. Leikkauksenaikainen tai heräämössä tapahtunut verensiirto

1) ei
2) kyllä, _____yksikköä punasoluja
3) muita verituotteita, mitä _____

_____

ANESTESIA

42. Käytetty anestesiamuoto:

1) spinaalianestesia
2) epiduraalianestesia
3) yleisanestesia
4) muu, mikä: _____

43. Anestesiaan liittyviä komplikaatioita

1) ei
2) kyllä, minkälaisia:_____

44. Onko synnyttäjä ollut synnytyksen jälkeen tehohoidossa?
1) ei
2) kyllä, _____ vrk

Tarvittaessa tarkennuksia: _____

POSTOPERATIIVINEN TILANNE (LAPSIVUODEOSASTOLLA)

Ympyröi ja täytä (0 – useita vaihtoehtoja)

45. Onko osastohoidon aikana esiintynyt:

1) anemia (Hb alle 100)
2) verensiirto (vuodeosastolle siirtymisen jälkeen) _____yks
3) haavainfektio : 1) punotus ja märkäerite, vaatinut antibioottihoidon 2) . . . märkäkertymä/abscessi, joka purkautunut tai avattu
4) leikkausalueen hematooma: jouduttu avaamaan ____kyllä ____ei
5) virtsatieinfektio (uricult yli 10 E5)
6) epäselvä kuumeilu yli 38 astetta
7) kohtutulehdus (kuume / märkäinen vuoto / kohdun aristus/kohonnut CRP)
8) sepsis. Jos alkuperä tunnettu, mikä se on: _____
9) antibioottihoito: mikä:_____. Aloitettu _____ postop.pvänä.
10) syvä laskimotromboosi: todettu _____postop.pvänä
11) keuhkoembolia: todettu _____ postop.pvänä
12) virtsaretentio (vaatinut katetrointia)
13) veripaikan vaatinut spinaalipäänsärky
14) postop. ileus/suolenvetovaikeuksia (vaatinut iv-nestehoidon leikkauksen jälkeen)
15) re-operaatio, syy: _____
16) postoperatiivinen vuoto
17) muu ongelma, mikä: _____

46. Osastohoidon aikana saatu lääkitys (muu kuin antibiootti): _____

_____

47. Hoitopäiviä synnytyksestä kotiuttamiseen ____kpl (synnytyspäivä on ensimmäinen hoitopäivä, kotiutuspäivä viimeinen)

48. Hoitopäiviä ennen synnytystä:____vrk, syy: _____
(synnytyspäivää ei lasketa mukaan)

VASTASYNTYNYT

49. Onko lapsi ollut keskola / tehohoidossa

1) ei
2) kyllä, _____vrk
3) lapsi menehtynyt alle 7vrk:n iässä, syy: _____
4) lapsi synytynyt kuolleena, syy: _____

50.Syy keskola/tehohoitoon (yksi tai useampia):

1) verensokeriongelmat
2) infektio
3) hengitysvaikeudet
4) asfyksiaongelmat
5) muu, mikä: _____

KIITOS VASTAUKSESTANNE

APPENDIX 2.

STUDY ON COMPLICATION RELATED TO DELIVERY

QUESTIONNAIRE FOR CESAREAN SECTIONS

1.Name of the hospital: _____

2. Identification number: _____

3.Date of the CS: _____

4.age: _____ yrs 5. weight: _____ kg (prepregnancy.) 6. height: _____ cm

CIRCLE THE BEST OPTION/OPTIONS AND FILL IN

7.Pregnancy history:

1) spontaneus vaginal delivery (n): ____
2) vacuum/forceps (n): ____
3) emergency cesarean delivey (n): ____
4) elective cesarean delivery (n) ____

8.Dilatation and curettage (n): ____ (because of irregular bleeding, miscarriage, legal abortion or after delivery) ___ not known

9. History of operations (abdominal area, hernias, varicoses): type of operation_____:
not known: _____

10. Medical history of the parturient (0 – many options):

1) diabetes (White class ____)
2) hypertension
3) coagulation disorder or history of thrombosis
4) renal disease
5) astma
6) thyroid disease
7) other: ___, spesify_____
8) do not know / can not say

11.Pregnancy related disorders (index pregnancy):

1) gestational hypertension
2) pre-eclampsia
3) gestational diabetes
4) intrauterine growth retardation
5) other, specify:_____

12. Smoking: 1) no 2) yes, _____cigarettes per day

13. Medication during the pregnancy (index pregnancy): _____

_____

14. OPERATION:

Circle the type of operation:
1) elective CS (decision made more than 12 hours before operation and no PROM)
2) emergency CS
3) crash-emergency CS

15. INDICATIONS FOR CS (circle 1-2 most important)
1) suspected fetal asphyxia
2) prolonged I stage of delivery
3) prolonged second stage
4) uterine inertia
5) fetopelvic disproportion
6) dystocia because of abnormal presentation/position: _____
7) breech presentation
8) repeated CS , n= ____
9) uterine rupture
10) hemorrhage : 1) placental abruption 2) other , specify:_____
11) placenta previa
12) chronic disease of the mother , spesify: _____
13) fear of child birth
14) maternal request of CS
15) other, specify : _____

16.Gestational age at operation: _____wks ____days

17. number of fetuses
1) 1
2) 2
3) 3 or more

18. induction ?
1) yes
2) no

19. method of labor induction (1 or more):
1) breaking the membranes
2) oxytocin
3) Cytotec® (misoprostol)
4) other , specify:_____

20. indication of the induction:
1) prolonged pregnancy
2) infection (mother or fetus), suspected
3) suspected fetal asfyxia
4) maternal disease
5) macrosomia of the fetus or threatening macrosomia
6) other indication, specify:: _____

21. cervix dilated before the CS
1) less than 4cm
2) 4-8cm
3) > 8cm
4) second stage
5) trial of vacuum / forceps

22. Membranes ruptured before CS
0) no
1) < 12 h
2) 12 – 24 h
3) 24 – 48 h
4) > 48 h

23. Temperature during the delivery >38 C
1) no
2) yes.

24.Antibiotics during the delivery
1) no
2) yes, specify: _____

25. Indication for the use of antibiotics:
1) routine prophylaxis during the operation
2) GBS prophylaxis
3) maternal infection or suspicion of infection
4) other indication, specify: _____

26. GBS tested
1) no
2) yes, result ____positive ____negative

27. Other medication during the delivery: _____

_____

28.CTG during the delivery
1) CTG-recording
2) +STAN®-recording

29. Birth weight: _____grams.

30. 5 min Apgar score
1) 0
2) 1-3
3) 4-6
4) 7-10

31.Umbilical artery/vein pH, in case taken
arterial-pH_____ venous-pH_____
BE (Base Excess): _____

32. Duration of the operation (skin open – skin closed) _____ min

33. Operation performed by:
1) registrar, < 2 yrs of specialization
2) registrar > 2 yrs of specialization
3) specialist

34. Following tissue layers closed separately:
1) urinary bladder peritoneum:
0) no 1) yes
2) peritoneum :
0) no 1)yes
3) muscular layer (between fascia and peritoneal layer)
0) no 1)yes
4)subcutaneous layer:
0) no 1) yes

35.Skin incision: 1) phannenstiel
2) middle line
3) other:_____

36. skin closure:
1) non absorbable stiches
2) absorbable intracutan continuous
3) nonabsorbable intracutan
d) other: _____

37. Complication after the CS (0 – more):
a) no
b) hemorrhage over 500ml
c) bladder injury
d) injury to the ureter
e) bowel injury
f) fetal laceration
g) hysterectomy
h) other, specify: _____
Describe the complication if needed: _____
_____

38. Was an abnormally attached placenta (accreta /percreta) noticed during the operation?
3) no
4) yes

39. Was antithrombotic prophylaxis used?
1) no
2) yes, spesify:_____

40.Hemorrhage during and after the operation:

1) less than 500 ml
2) 500 -1500 ml
3) more than 1500 ml, estimated: _____ ml

41. blood transfusion during the operation and in the the recovery room

1) no
2) yes, _____units blood
3) other blood products, specify _____

_____

ANESTHESIA

42.: The type of anesthesia used

1) spinal blockade
2) epidural blockade
3) general anesthesia
4) other: _____

43. Complications related to the anesthesia

1) no
2) yes, specify:_____

44.Has the patient been to the intensive care unit after the delivery?

1) no
2) yes, _____ days

If necessary, further details: _____

Postoperative care (at the postpartum ward)

Circle and fill (0 – several options)

45. Has there been any of the following during the postpartum follow-up

1) anemia (Hb less than 100)
2) blood transfusion (at postpartum ward) _____units of red cells
3) wound infection : 1) local erythema and discharge from the wound, antibiotics needed 2) abscess, which was opened or broke up
4) Hematoma at operation site: needed evacuation____yes ____no
5) urinary tract infection (uricult more than 10 E5)
6) fever over 38 C
7) endometritis (fever / infectious discharge / uterine tenderness /elevated CRP values)
8) sepsis (if known what was the cause, specify_____
9) antibiotic treatment: specify:_____. Started at postoperative day _____.
10) deep venous thrombosis: diagnosed at postoperative day_____
11) pulmonary embolism: diagnosed at postoperative day _____
12) urinary retention (needed bladder catheter)
13) spinal headache – blood patch needed
14) postop. ileus/ or other bowel problems (there was a need for intravenous fluid after the operation)
15) re-operation, diagnosis: _____
16) postoperative hemorrhage
17) other problems, specify: _____

46. other medication during the postpartum ward (other than antibiotics): _____

_____

47. Hospital stay after the delivery (days (n)____ (the day of delivery counted and also the day of going home)
48. Hospital stay before the delivery (days, n):____,Reason for hospital stay:_____
(the day of delivery notincluded)

NEONATE

49. Was there need for neonatal intensive care unit treatment

1) no
2) yes , _____days (n)
3) neonatal death under 7 days after birth, diagnosis: _____
4) stillborn, diagnosis: _____

50.The reason for neonatal intensive care treatment (one or more reasons):

1) problems of blood glucose balance
2) infection
3) respiratory problems
4) fetal asphyxia
5) other, diagnosis: _____

Thank you for answering !