Approach to infants born before gestational week 26:
Method of delivery, complication risks and health of the preterm neonate
by
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Abstract

Background: The survival of the preterm neonate has increased because of the use of antenatal corticosteroids. Accordingly, the gestational age limit of neonatal survival is lowered. Several reports show improved survival of extreme preterm neonates, though with relatively high rates of moderate and severe disability compared to those born at a gestational age above 24 weeks. The method of delivery has been claimed to be important for the survival of the extreme preterm neonate. The frequency of maternal complications is increased by caesarean section compared to vaginal delivery. The number of complications is related to gestational age. In the period 2005-2014 40 % of the neonates admitted to the Neonatal Intensive Care Unit (NICU) at Oslo University Hospital, Rikshospitalet, were born before gestational week 26, and 50 % of those born in week 24 and 25.

Objective: The aim of this study was to give a literature review on complication rates following caesarean section with specific emphasis on the relation to gestational age at delivery and on survival and future health prospective of preterm neonates with specific focus on extreme prematurity. Secondly, to examine the method of delivery for the neonates born before gestational week 26.0 admitted to the NICU at Oslo University Hospital, Rikshospitalet with specific focus on the indication for caesarean section.

Methods: Literature search was made in UpToDate and PubMed. The material for the selected 99 patients in the time period 2005-2010 was collected from Neonatalprogrammet at the NICU, Rikshospitalet. The information from NNK was further used to look at the mother’s medical record in DIPS.

Conclusion: Complications occur in 1 out of 5 women with CD. The proportion is higher in emergency than elective CD, and the risk is higher if the procedure is performed late compared to early in the delivery process. Low gestational age has previously been shown to be a risk factor for complications, and complication rates as high as 45% has been reported in CD performed before gestational age 28.

Frequent complications following preterm birth include respiratory distress syndrome, intra cranial hemorrhage, bronchopulmonary dysplasia and retinopathy of prematurity. The more immature the infant is at birth, the more frequent these complications occurs and the more serious they are. Lifelong sequelae may in some cases be the result from these complications. The prognosis for premature neonates has improved over the recent 20 years. The mortality among extreme premature neonates has decreased dramatically during the last 20-25 years. A survival rate of 20-30 % was reported for these neonates in the 1980s. Today this number has increased to 60%.

According to our examination of neonates born before week 26, there were performed C-section in 37 of 99 pregnancies, 94,5 % were unplanned. Indications for C-section were mostly fetal with breech position as the main indication.
Introduction

During the last decades, the survival of the preterm neonate has increased. This has been ascribed to the use of antenatal administration of corticosteroids to improve neonatal lung function (1) and to the general improvement of neonatal intensive care treatment. Accordingly, the gestational age limit of neonatal survival is lowered. This has caused ethical considerations concerning the lower gestational age limit to initiate treatment following preterm delivery. There are several reports on survival rate for neonates born at or below 24 gestational weeks. These reports show improved survival of extreme preterm neonates, though with relatively high rates of moderate and severe disability compared to those born at a gestational age above 24 weeks (2). Recently, an American prospective multicenter study also showed that an active attitude to initiate lifesaving treatment in extreme preterm neonates (<24 gestational weeks) was related to an increase in survival and also in survival without impairment (3).

The method of delivery has been claimed to be important for the survival of the extreme preterm neonate. Some has shown an improved survival rate for those that were born following caesarean section compared to vaginal delivery (4).

The frequency of maternal complications is increased by caesarean section compared to vaginal delivery. The number of complications is related to gestational age with a higher rate following caesarean section early in pregnancy compared to caesarean section at term (5). Moreover, several studies have shown that the complication rate in future pregnancies is increased following caesarean section in a previous pregnancy (6; 7). Thus, the method of delivery early in pregnancy could be an ethical dilemma. The chance of neonatal survival has to balance the maternal complication rate in the present and future pregnancies. In countries with high rates of caesarean section precautions are examined to reduce the number of unnecessary caesarean sections (8).

In a prospective Norwegian study from 1998-1999 the main indications for caesarean section for those delivered before 28 weeks of gestation were preterm breech, preeclampsia and placental abruption (9). In the period 2005-2014 40 % of the neonates admitted to the Neonatal Intensive Care Unit (NICU) at Oslo University Hospital, Rikshospitalet, were born before gestational week 26, and 50 % of those born in week 24 and 25, were born following caesarean sections; where they performed due to maternal or fetal indication?

The present student thesis has three perspectives:

1. Give a literature review on complication rates following caesarean section with specific emphasis on the relation to gestational age at delivery.
2. Give a literature review on survival and future health prospective of preterm neonates with specific focus on extreme prematurity.
3. To examine the method of delivery for the neonates born before gestational week 26.0 admitted to the NICU at Oslo University Hospital, Rikshospitalet with specific focus on the indication for caesarean section.
Background

Caesarean delivery

Historical background

A Caesarean delivery (CD), also known as C-section is a surgical procedure in which incisions are made through a mother’s abdomen (laparotomy), and uterus (hysterotomy) to deliver one or more babies (10). CD has been a part of medical history since ancient times. There are many theories about the origin of the name. One of the myths is attributed to Julius Caesar that was said to be born in this manner, but because his mother Aurelia lived through childbirth it eliminates the possibility that the ruler himself was born by CD (11). An alternative theory suggests that the term caesarean derives from the Latin verb caedare, which means to cut (10).

Historically CD was only performed on dead women and fetuses to bury the child separately from the mother. First known CD saving the baby was in 300 years B.C in India. First known CD with surviving mother was in 1580 in Switzerland by a pig gelder, he performed CD on his wife after several days with labor pain and failed attempt by midwives to deliver the baby. The mother survived and gave birth vaginally to five children later on (12). The first CD in Norway was performed in 1843 where both the twins and mother died. The first CD in Norway where a child survived was in 1849, and the first CD in which the mother also survived was in 1890 (13).

Throughout history there has been progress in saving both the mother and child while at the same time reducing the risk of complications. The high maternal mortality has dramatically been reduced with some key steps:

- Anaesthesia was developed in 1846
- Semmelweiss introduced aseptic handwash in 1847
- Kehrer and Sänger each developed methods for preventing uterine bleeding by using suture to close the wound in 1882
- Extraperitoneal caesarean section followed by low transverse incision in 1912
- Blood transfusions
- Penicillin was discovered by Fleming in 1928

By the end of the 19th century, a wide range of technological innovations enabled surgeons to revolutionize their practice. Through the 20th century, there has been a rise in the rates of CD because of improved procedures. In addition there are many factors that have contributed to this rise, including reduced risk of post-operative complications, twin deliveries, increased maternal age, maternal request without medical reason and increasing numbers of women with previous CD. Some women want a CD because they fear the pain of childbirth, others prefer the convenience of being able to decide when and how to deliver their baby. Still others fear the risks of vaginal delivery including tearing and sexual problems (14).
Epidemiology

The frequency of CDs have rapidly increased during the last 20 years, and ranges from below 20 % in the northwestern European countries to about 50 % in southeastern Europe and to more than 60% in some Latin-American countries (15). In Norway, there are about 10 000 CDs performed every year. Approximately every 6th child (17%) in Norway is born with CD. The numbers differ from area to area in Norway. Large hospitals receive more of those with increased risk of complications compared to smaller hospitals that leads to increased need of CD. The difference can also be related to difference in practice. In Hordaland and Rogaland, there is 12-13 % CDs, in some other areas it is about 20 % (16).

The graph below shows that after 1999 it has been a considerable increase in performing CDs in Norway, with an increase from 1200 births in 1967 to 10.000 births in 2008 (16).

**Figure 1.** C-sections in Norway since 1967, % of all deliveries. Diagram from www.Norgeshelsa.no. Data from The Norwegian Medical Birth Registry (Medisinsk fødselsregister) (19).

The graph below shows the number of deliveries by gestational week from the period 1999 to 2013. The frequency of CD is highest in gestational week 28 with 68 percent, falls to 10 percent in gestational week 40, and then increases from gestational week 41 (16).
Procedure

CD can be performed electively or as an emergency procedure. The definition of elective surgery is that the decision is made at a minimum of 8 hours before the intervention (17). Planned CD is often performed 7-10 days before the estimated date of delivery (EDD). Most CDs are performed under regional anesthesia; a common choice is a spinal block. In an emergency, general anesthesia is sometimes needed.

CD is usually performed by making a 15-20 cm long horizontal incision that helps to rupture the amniotic sac around the baby. Then the baby is removed from the uterus by pressing the abdomen downward, the umbilical cord is cut and the placenta is removed. Time from the start of the surgery to delivery of the baby is approximately 5-10 minutes.

Indications

The risk for both mother and the child is higher with CD compared to vaginal delivery, thus the principal is to save women from an unnecessary intervention. There is no law giving woman the right to choose CD, the decision is made in consultation with the doctor at the delivery ward. In some cases, a CD is safer for the mother and the baby than vaginal delivery. Common maternal and fetal indications can be absolute or relative (18).

<table>
<thead>
<tr>
<th>Indications</th>
<th>Absolute</th>
<th>Relative</th>
</tr>
</thead>
</table>
| Maternal    | • Cephalopelvic disproportion  
• Placenta previa  
• Pelvic mass obstructing the birth such as large fibroids, pelvic fracture  
• Previous CD depending on the type of incision(if two or more previous CDs) | • Failed induction  
• Cervical dystocia  
• Severe pre-eclampsia/eclampsia/HELLP syndrome  
• Medical diseases such as |
or if the uterine incision was made vertically)
- Abdominal cervical cerclage
- Advanced cervix carcinoma
- Previously prolapse surgeries

complex heart disease
- Multiple pregnancies

<table>
<thead>
<tr>
<th>Indication</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fetal distress (signs of hypoxia)</td>
<td>608</td>
<td>21,9</td>
</tr>
<tr>
<td>Slow progress in labor</td>
<td>574</td>
<td>20,7</td>
</tr>
<tr>
<td>Previous CD</td>
<td>248</td>
<td>8,9</td>
</tr>
<tr>
<td>Breech position after gestational age of 34 weeks</td>
<td>234</td>
<td>8,4</td>
</tr>
<tr>
<td>Mothers wish</td>
<td>211</td>
<td>7,6</td>
</tr>
<tr>
<td>Preeclampsia</td>
<td>172</td>
<td>6,2</td>
</tr>
<tr>
<td>Failed start of labor</td>
<td>112</td>
<td>4,0</td>
</tr>
<tr>
<td>Other indications</td>
<td>602</td>
<td>21,7</td>
</tr>
<tr>
<td>Indications not documented</td>
<td>17</td>
<td>0,6</td>
</tr>
<tr>
<td>Total</td>
<td>2778</td>
<td>100</td>
</tr>
</tbody>
</table>

Complications

A study from 1999 shows indications for CD in Norway. The study included 70% of those who had CD. The two most common indications were child distress and slow progress in labor. In that study, 64% of the CDs were performed as an emergency procedure. In the elective CD group the two most common indications were previous CD and maternal request (16).

Table 1. Indications for CD in Norway in 1999. Ref. Kolås et.al. 2003.

According to Häger RM et.al. 2004 complications occur in 1 out of 5 women with CD (5). The proportion is higher in emergency than elective CD, and the risk is higher if the procedure is performed late compared to early in the delivery process. There is also a higher risk when the procedure is performed before gestational week 30 or if the child has a weight
above 4500 g or below 1500 g. According to NICE guidelines, CDs should be restricted to pregnancies with additional risk factors (17).

### Complications after delivery:

| Maternal | Hemorrhage. Blood transfusion can become necessary if large volume is lost  
| Infection in the surgery scar.  
| Urinary tract infection or pneumonia  
| Surgical injury to the urinary bladder, ureter and colon.  
| Increased risk of thrombosis  
| Increased risk for CDs in subsequent pregnancies  
| Increased risk of complications with vaginal delivery after a CD.  
| Increased maternal morbidity (17)  
| Increase risk of uterine rupture and placenta previa/accreta in a subsequent pregnancy (17) |

| Neonatal | Iatrogenic early delivery in the case of elective CD, resulting in an increase in perinatal morbidity (17)  
| Child can have breathing problems because of the water in the lungs. Transient tachypnea – increased breathing frequency during the first few days after the birth. CDs before gestational age 39 can give respiratory distress syndrome.  
| Altered colonization of the infants gastrointestinal tract, resulting in a 20-30% increase in autoimmune disorders and child obesity (17) |

Following a previous CD maternal morbidity increases in each subsequent pregnancy, and is greater in magnitude than that associated with the choice of a trial of labor (15).

The study by Häger RM et.al. 2004 showed that 21.4% of the women had one or more complications. There were 4 independent risk factors for maternal complications; increasing cervical dilatation, general anesthesia, low gestational age and fetal macrosomia. Operations performed at 9 to 10 cm cervical dilatation had a complication rate of 32.6% compared with 16.8% at 0 cm dilatation. Patients with planned operations had a complication rate of 16.3 % compared with 24.1 % of patients with unplanned operation (5). Low gestational age has previously been shown to be a risk factor for complications, and complication rates as high as 45% has been reported in CD performed before gestational age 28 (5).
Preterm birth

Definitions

A normal pregnancy lasts between 37 and 42 weeks, 282 days in average. Preterm birth is defined as birth occurring before 37 weeks of gestation. The previous definition of a premature neonate was a neonate with a birth weight below 2500 g. WHO's current definition is a neonate born before 37 weeks of gestation, calculated from the first day of the last menstrual period (LMP). The actual word ‘‘premature’’ means before mature or immature and implies that the neonate does not have had enough time to fully develop and mature before it is born.

Premature neonates are divided into groups like the moderate to late premature that are born between 32-37 weeks of gestation, very premature that are born between 28-32 weeks of gestation and extremely premature (also called extremely low gestational age newborn, ELGAN) that are born before 28 weeks of gestation.

A neonate with low birth weight (LBW) is set to be between 1500 and 2500 g, very low birth weight (VLBW) is between 1000 and 1499 g and extreme low birth weight (ELBW) is below 1000 g.

It is standard to correct the age of babies born preterm up to 2 years of age. The corrected age for a preterm baby is determined by the actual age in weeks minus the preterm weeks. As an example, if a baby is born at 28 weeks’ gestation, it was born 3 months (12 weeks) preterm. 6 months (24 weeks) after birth, his corrected age is 24 weeks minus 12 weeks, which is 12 weeks (3 months). This is done because a baby, who is born 3 months preterm, would not be expected to be at the developmental level of a 6-month-old term baby, but at the level of a 3-month-old baby. Most of the preterm babies will catch up developmentally by the age of 2 years.

Epidemiology

Numbers from the Norwegian Medical Birth Registry (Medisinsk fødselsregister) show that the incidence of premature neonates in Norway has been decreasing over the last years. This is shown in the table below. Of all live births in Norway in 2014, about 0.3 % were born with ELBW, 0.5 % with VLBW and 3.7 % with LBW. At present, about 300 neonates are born annually in Norway with gestational age of 24-27 weeks, or with a birth weight between 500-999 g. (19, 21).

Incidence of premature neonates in Norway;

<table>
<thead>
<tr>
<th>Year</th>
<th>% born preterm</th>
<th>Numbers born preterm</th>
<th>% born before gestational age of 28 weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>8</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>2007</td>
<td>7,5</td>
<td>4400</td>
<td>-</td>
</tr>
<tr>
<td>2010</td>
<td>5,9</td>
<td>3554</td>
<td>0,4</td>
</tr>
</tbody>
</table>
The statistics on the duration of the pregnancies in Norway in 2002 are shown below:

<table>
<thead>
<tr>
<th>Gestational week</th>
<th>% of the neonates</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-21</td>
<td>0.4</td>
</tr>
<tr>
<td>22-27</td>
<td>0.6</td>
</tr>
<tr>
<td>28-36</td>
<td>7.5</td>
</tr>
<tr>
<td>37-38</td>
<td>6.0</td>
</tr>
<tr>
<td>38-39</td>
<td>14.4</td>
</tr>
<tr>
<td>39-40</td>
<td>23.1</td>
</tr>
<tr>
<td>40-41</td>
<td>26.3</td>
</tr>
<tr>
<td>41-42</td>
<td>15.9</td>
</tr>
<tr>
<td>42-43</td>
<td>5.7</td>
</tr>
<tr>
<td>43-44</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Every year an estimated number of 15 million neonates in the world are born preterm and this number is increasing. In more than 184 countries, the prevalence varies between 5 and 15% of all neonates, averaging to about 1 of 10 neonates. Preterm births are a global issue and more than 60% of them occur in Africa and South Asia. About 12% of the neonates in low-income countries are born preterm, compared with 9% in high-income countries. The 10 countries with the highest number of preterm births are India (n=3,519,100), China (n=1,72,300), Nigeria (n=773,600), Pakistan (n=748,100), Indonesia (n=675,700), The United States of America (n=517,400), Bangladesh (n=424,100), The Philippines (n=348,900), The Democratic Republic of the Congo (n=341,400) and Brazil (n=279,300).

The 10 countries with the highest rates of preterm birth per 100 live births are Malawi (18.1 per 100), Comoros (16.7), Congo (16.7), Zimbabwe (16.6), Equatorial Guinea (16.5), Mozambique (16.4), Gabon (16.3), Pakistan (15.8), Indonesia (15.5) and Mauritania (15.4).

**Etiology**

Preterm birth occurs for a variety of reasons. Most preterm births happen spontaneously, but some are due to early induction of labor or cesarean birth, whether for medical or non-medical reasons. In Norway 80% of the cases are due to spontaneous preterm births, and 20% because of maternal or fetal diseases. Common causes of preterm birth include multiple pregnancies, infections and chronic maternal diseases, such as diabetes and high blood pressure. High maternal age is regarded as a risk factor, as well as smoking. However, in about 50% of the cases no cause is identified. There is also a genetic influence. The most common causes in Norway are cervical insufficiency and infections. Better understanding of the causes and mechanisms will improve the development of solutions to prevent preterm birth. There are several reasons that cause a preterm birth. These can be arranged into maternal, fetal, placental and uterine causes;
### Maternal causes and risk factors
- High or low age
- Lifestyle; smoking, alcohol consumption, poor nutrition, use of narcotics and heavy work
- Previous preterm birth(s)
- Late abortion(s)
- Hypertension
- Infections (especially in the birth canal)
- Heart disease
- Renal disease
- Hyperthyroidism
- Premature rupture of membranes
- Too much or too little amniotic fluid

### Fetal causes
- Malformations
- Genetic disorders
- Infections
- Intrauterine growth restriction
- Multiple pregnancies
- Twin-to-twin transfusion syndrome

### Placental causes
- Preeclampsia
- Placenta praevia
- Early abruption of the placenta

### Uterine causes
- Cervical insufficiency
- Cervix anomaly
- Fibromyomas
- Uterine bleedings
- Previous surgery on the uterus or cervix

### Treatment to prevent preterm birth or prolong pregnancy
More than 3/4 of premature neonates can be saved with feasible, cost-effective care, like essential care during child birth and in the postnatal period for every mother and baby, antenatal steroid injections, kangaroo mother care and antibiotics to treat newborn infections. To reduce preterm birth rates, women need better access to family planning and increased empowerment, as well as improved care before, between and during pregnancies. In 2012, WHO and partners published a report "Born too soon: the global action report on preterm birth" that included the first-ever estimates of preterm births by
country. WHO is committed to reduce the health problems and lives lost as a result of preterm birth (22).

Treatment with antenatal corticosteroids that is used to mature the lungs, are shown to reduce the incidence of early death, RDS and cerebral hemorrhage. A study by Smith et al (2014) shows that the use of antenatal corticosteroids in neonates born at gestational weeks 22-24 was associated with decreased risk of death, retinopathy of prematurity and necrotizing enterocolitis among 25-27 week neonates. It also shows that the use of corticosteroids together with caesarean deliveries and resuscitation is associated with lower mortality (24).

Another study shows that antenatal corticosteroids given to neonates born at 23-25 weeks gestation was associated with a lower rate of death or neurodevelopmental impairment (cerebral palsy and psycomotoric development) at 18-22 months of age, compared to those with non-exposure. The study invites to treat neonates from 22 weeks +1 day gestation with antenatal corticosteroids (1).

Newer studies have shown that high doses of corticosteroids before or after birth can lead to lung and brain damage. It is recommended to give antenatal corticosteroids if the birth occurs before gestational week 34. It is most efficient if it is given at least 24 hours before the birth, but it has also been shown a positive effect if it is given later than 24 hours before birth (25).

When the birth first starts, it is impossible to stop. However, it is possible to delay the birth to mature the baby’s lung after giving corticosteroids to the mother. Drugs given to inhibit the contractions are given if premature contractions are suspected or in case of premature rupture of membranes. Sympathomimetic drugs are the most common medication used worldwide. In Norway, Atosiban, which is an oxytocin antagonist, is the most common medication used. Other drugs like magnesium sulphate and nifedipine, a calcium-channel blocker, may also be used.

Progesterone pessaries can be given to prevent an early birth. Progesterone is a steroid hormone initially produced by the corpus luteum. In early pregnancy, progesterone is critical for pregnancy maintenance until the placenta takes over this function at 7 to 9 weeks of gestation. In addition, progesterone prevents apoptosis in fetal membrane explants, under both basal and pro-inflammatory conditions. This may help prevent preterm premature rupture of membranes, which is a common cause of preterm birth. Removal of the source of progesterone or administration of a progesterone receptor antagonist induces abortion before 7 weeks (49 days) of gestation. Functional withdrawal of progesterone activity at the level of the uterus appears to occur in proximity to the onset of labor both at term and preterm, without a significant change in serum progesterone levels in the weeks preceding labor (26).

Meis et al (27) included 459 women with previous preterm births in a randomized study, to examine whether or not treatment with progesterone would affect the risk of having another preterm birth. They received weekly intramuscular injections of hydroxyprogesterone caproate (250 mg) or placebo beginning at 16 to 20 weeks of gestation and continuing until 36 weeks. This significantly reduced the risk of delivery at all gestational ages studied:
  •<37 weeks; 36 versus 55 % in the placebo group.
• <35 weeks; 21 versus 31 % in the placebo group.

Progesterone has also been shown to prevent preterm birth among women with short cervix. Neonates from progesterone supplemented pregnancies had less perinatal morbidity, with significantly reduced rates of necrotizing enterocolitis, intraventricular hemorrhage, and need for supplemental oxygen. There was no evidence of virilization of female offspring, which is a theoretic concern of this therapy (26).

Cervical insufficiency increases the risk of preterm birth. This can be treated with a surgical tape, (cerclage), which is removed about a month before term. Studies show that this treatment gives mixed results, but most of the studies say that it is less likely for women to give birth before gestational age of 37 weeks after this treatment. Cerclage is shown to give best results if the treatment is given early in the pregnancy (28).

If the water breaks before gestational week 37, the woman can be treated with antibiotics, which are shown to prolong pregnancy up to one week by reducing the frequency of maternal and fetal infections. The regimen of prophylactic antibiotics is given for seven days to pregnancies <34 weeks of gestation at the time of membrane rupture (29).

**Caesarean delivery and preterm birth**

Some obstetricians recommend that preterm births should be performed as cesarean section. It is, however, not enough studies to recommend such a policy. Some studies show that cesarean section does not give any health benefit to the children, some does. A review article from UptoDate encourages avoiding elective cesarean delivery for a premature fetus with LBW in a cephalic position. A policy of elective cesarean delivery is associated with known risks to the mother, but the benefits to the LBW neonate in cephalic presentation are uncertain. They also state that head compression by maternal soft tissues in the LBW fetus is not a major determinant of intraventricular hemorrhage. There is no strong evidence supporting the hypothesis that avoidance of active labor and vaginal delivery might improve survival by reducing hypoxic stress, asphyxia, and intraventricular hemorrhage, and available evidence suggests that the route of delivery is not a significant independent factor affecting perinatal mortality or neurodevelopment (30).

In a 2013 Cochrane review of 4 randomized trials (n = 116 women) comparing cesarean versus attempted vaginal delivery for preterm singletons, there were no statistically significant differences in perinatal morbidity or mortality between the groups (31).

In a 2013 systematic review of case-control and cohort studies that analyzed the association between cesarean delivery and cerebral palsy, elective or emergency cesarean delivery was not associated with a significant reduction in risk of cerebral palsy in preterm infants (n = 2416 deliveries) (32).

In addition, most evidence from retrospective studies performed worldwide has not demonstrated significant improvement in perinatal morbidity or mortality for the fetus delivered by cesarean, particularly when the primary indication for operative delivery was LBW (33, 34). However, a few studies have observed an increased risk of IVH or death among LBW newborns delivered vaginally (35, 36).
Neonatal treatment and complications

Handling and treatment of the extremely prematurely born infant needs knowledge, skills and professionalism. Highly trained health professionals take care of this treatment in dedicated neonatal intensive care units. Including the neonatal care unit at Oslo University Hospital, Rikshospitalet, as the unit taking care of the most premature infants born in Norway. However, it’s not the scope of this study to report the process of treatment of these premature infants. Some highlights may however be important. Observation of respiration, circulation, spontaneous movements, oxygen saturation and blood gasses needs careful attention.

Complications following preterm birth are the leading cause of death among children under 5 years of age, responsible for nearly 1 million deaths worldwide in 2013 (22).

Some complications occur more frequently at some gestational ages. The more premature the neonate is, the more serious complications it can have. Frequent complications following preterm birth include respiratory distress syndrome (RDS), intra cranial hemorrhage (ICH), bronchopulmonary dysplasia (BPD) and retinopathy of prematurity (ROP). The more immature the infant is at birth, the more frequent these complications occurs and the more serious they are. Lifelong sequelae may in some cases be the result from these complications.

Complications following preterm birth

| Respiratory complications | - Apnea periods |
| - Respiratory distress syndrome |
| - Bronchopulmonary dysplasia |
| Circulatory complications | - Variating blood pressure |
| - Cerebral hemorrhage |
| - Persistent ductus arteriosus |
| - Circulatory failure |
| Poor thermoregulation | - Hypothermia |
| Nutritional complications | - Difficulties with breast feeding |
| - Immature bowel function |
| - Necrotizing enterocolitis |
| Hematological complications | - Hyperbilirubinemia |
| Infections | - Septicemia |
| - Meningitis |
| - Infections with Gram negative rods, MRSA and Listeria |
| - Coagulase negative staphylococci |
| - Fungal infections |
| Cerebral complications | - Periventricular leukomalacia |
| - Learning disabilities |
| - Hyperactivity disorders |
Survival of the preterm born child

The prognosis for premature neonates has improved over the recent 20 years (23). The limit for intensive treatment of the premature is reduced to a gestational age of 23 weeks. It is shown that up to 85% of all neonates born after a gestational age of 28 weeks can survive.

Numbers on survival of premature neonates from Norsk Nyfødtmedisinsk Kvalitetsregister (NNK) show a survival rate of neonates born in the period 1999-2000 at gestational age of 23, 24 and 25 weeks of 39, 60 and 80 %, respectively. Recent numbers show a survival rate of neonates born in the period 2011-2014 at a gestational age of 22, 23, 24 and 25 weeks of 37, 35, 61 and 84 %, respectively.

The diagram below shows the chance of survival if birth occurs at a given gestational age.

<table>
<thead>
<tr>
<th>Gestational age</th>
<th>Rate of survival*</th>
<th>Rate of survival in NICU**</th>
<th>Rate of survival from NNK***</th>
<th>Rate of survival abroad ****</th>
</tr>
</thead>
<tbody>
<tr>
<td>23 weeks</td>
<td>16 %</td>
<td>39 %</td>
<td>35 %</td>
<td>17 %</td>
</tr>
<tr>
<td>24 weeks</td>
<td>44 %</td>
<td>60 %</td>
<td>61 %</td>
<td>39 %</td>
</tr>
<tr>
<td>25 weeks</td>
<td>66 %</td>
<td>80 %</td>
<td>84 %</td>
<td>50 %</td>
</tr>
<tr>
<td>26 weeks</td>
<td>72 %</td>
<td>84 %</td>
<td>83 %</td>
<td>80 %</td>
</tr>
<tr>
<td>27 weeks</td>
<td>82 %</td>
<td>93 %</td>
<td>89 %</td>
<td>90 %</td>
</tr>
<tr>
<td>28 – 31 weeks</td>
<td></td>
<td></td>
<td>91 - 97 %</td>
<td>90 – 95 %</td>
</tr>
</tbody>
</table>

- Behavioral disorders
- Lower motoric and mental function

Visual disabilities
- Retinopathy of prematurity
- Blindness
- Strabismus
- Myopia
- Cerebral visual impairment

Hearing disabilities
- Sensorineural hearing loss
- Auditory processing difficulties
The mortality among extreme premature neonates has decreased dramatically during the last 20-25 years. The decline has been most pronounced for the smallest, especially the neonates with a birth weight below 800 g and a gestational age below 26 weeks. A survival rate of 20-30% was reported for these neonates in the 1980s. Today this number has increased to 60% (38, 39). The perinatal mortality is higher the smaller the neonate is. Premature neonates accounts for about 50-60% of the perinatal deaths. Most of the deaths occur during the first week because of immaturity, often because of failing respiration. Other causes are malformations and birth traumas. After the first week the most important cause of death is infections such as pneumonia and septicemia (22). Several studies show that the mortality and morbidity is significantly higher among neonates that are transported from the hospital where the birth took place to another hospital for treatment, compared to neonates who are born and treated at the same hospital.
Aim of the study

With the second part of this student thesis, our aim is to examine the method of delivery of the neonates born before gestational week 26.0 admitted to the NICU at Oslo University Hospital, Rikshospitalet, with specific focus on the indication for caesarean section.

Materials and methods

We collected our material for the selected 99 patients in the time period 2005-2010. The study was approved by the Privacy and Data Protection Officer at Oslo University Hospital.

Patients included in the present study was identified through the clinical database Neonatalprogrammet at the NICU, Rikshospitalet. All included infants had a gestational age from 23 to 26 weeks. The database is part of Norsk Nyfødtmedisinsk Kvalitetsregister, (Norwegian Neonatal Network) which is a registry established in 2003 as a joint venture between Oslo University Hospital, Rikshospitalet, Norwegian Institute of Public Health and the Norwegian Pediatric Association and is located at the neonatal department at Rikshospitalet in Oslo Norway. NNK received status as a national medical quality registry in year 2004. NNK is a registry of collected detailed clinical data from all the 21 neonatal departments in Norway. The data is collected by observation of treatment, interventions, diagnosis, illness and death at the departments and entered into locally placed databases. The main purpose of establishing NNK is to use this data to help with quality improvement, research and development of the neonatal field.

Items that among others which are registered in NNK:

- Demographic and anthropometric data
- Survival
- Number of days on mechanical ventilation
- Duration of admission at the department
- Occurrence of chronic lung disease, like BPD, among premature babies
- Occurrence of brain injuries, like intracranial hemorrhage, among premature babies
- Occurrence of NEC
- Use of systemic antibiotics
- Occurrence of suspected and confirmed infection

The basis for NNK, is Neonatalprogrammet, a PC-based application which was specifically developed to register treatment activity and outcomes in the Norwegian neonatal units with the purpose of quality surveillance and improvement and research in neonatal medicine (40).

The information from NNK was used to look at the mother’s medical record in DIPS; an electronic health system used in Norwegian hospitals. We looked at delivery method, if C-section was performed electively or in emergency and the indications for why C-section was performed. We also found it interesting to look at complications during pregnancy, complications after delivery, previous pregnancies and deliveries, gestational age at delivery and which methods used to calculate it, neonates weight, height and head circumference.
Results

Among the 99 mothers, 61 had previous pregnancies, most of them were gravida 1 or 2 but there were also women with up to 6 pregnancies.

Forty-five women had delivered previously, mostly para 1 or 2 but there were also women with up to 5 children.

The most common delivery method for neonates born before week 26 was vaginal, but there were 37 deliveries with C-section where (94.5 % of these were unplanned). Five of these 37 women had previously been delivered by C-section.
This graph shows that the main indication for C-section was breech presentation followed by HELLP, twins, preeclampsia and cord prolapse. We categorized the indications in fetal, maternal and combined. As we can see, 22 out of 37 indications (59.5%), were fetal.
Most of the neonates were born in gestational week 25. Different methods were used to estimate the gestational age. Ultrasound alone was the method used in most of the pregnancies.

<table>
<thead>
<tr>
<th>Gestational age</th>
<th>Minimum value</th>
<th>Maximum value</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>22+4</td>
<td>25+6</td>
<td>24+5</td>
</tr>
</tbody>
</table>

**Conclusion**

According to our examination of neonates born before week 26, there were performed C-section in 37 of 99 pregnancies, 94,5 % were unplanned. Indications for C-section were mostly fetal with breech position as the main indication.
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