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# Caesarean Section: Reasons for and Actions to Prevent Unnecessary Caesareans

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Ylva Vladic Stjernholm

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## Abstract

According to data from 150 countries, the worldwide caesarean section rate increased from 7% in 1990 to 19% in 2014. Latin America and the Caribbean region reported the highest CS rate 42%, followed by North America 32%, Oceania 31%, Europe 25%, Asia 19%, and Africa 7%. This trend is accompanied by increasing reports of severe adverse outcomes, such as invasive placenta, peripartum hysterectomy, and massive obstetric bleeding. The World Health Organization stated in 2015 that caesareans are effective in saving maternal and infant lives only when they are required for medically indicated reasons and that caesarean rates higher than 10–15% at a population level are not associated with reduced maternal or newborn mortality rates. More than 90% of women claim that they want to give birth in a natural way. In contrast, recent studies suggest that the majority of planned caesareans are carried out for psychosocial or nonmedical reasons. Knowledge about the indications for caesareans is a prerequisite in order to define actions to prevent unnecessary caesareans. The aim of this chapter was to present a review of the history behind, and to evaluate the indications for, caesarean sections in order to suggest appropriate actions to prevent unnecessary caesareans.

**Keywords:** caesarean section, complication, delivery, fear, fetal distress, indication, labor, team

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## 1. Introduction

### 1.1. Caesarean section rates

Caesarean section (CS) rates continue to rise, particularly in middle- and high-income countries without evidence for maternal and perinatal benefits from the increase. According to

data from 150 countries, the worldwide CS rate increased from 7% in 1990 to 19% in 2014. Latin America and the Caribbean region reported the highest CS rate, 42%, followed by North America, 32%, Oceania, 31%, Europe, 25%, Asia, 19%, and Africa, 7% (**Figure 1**) [1] .

**1.2. Definition**

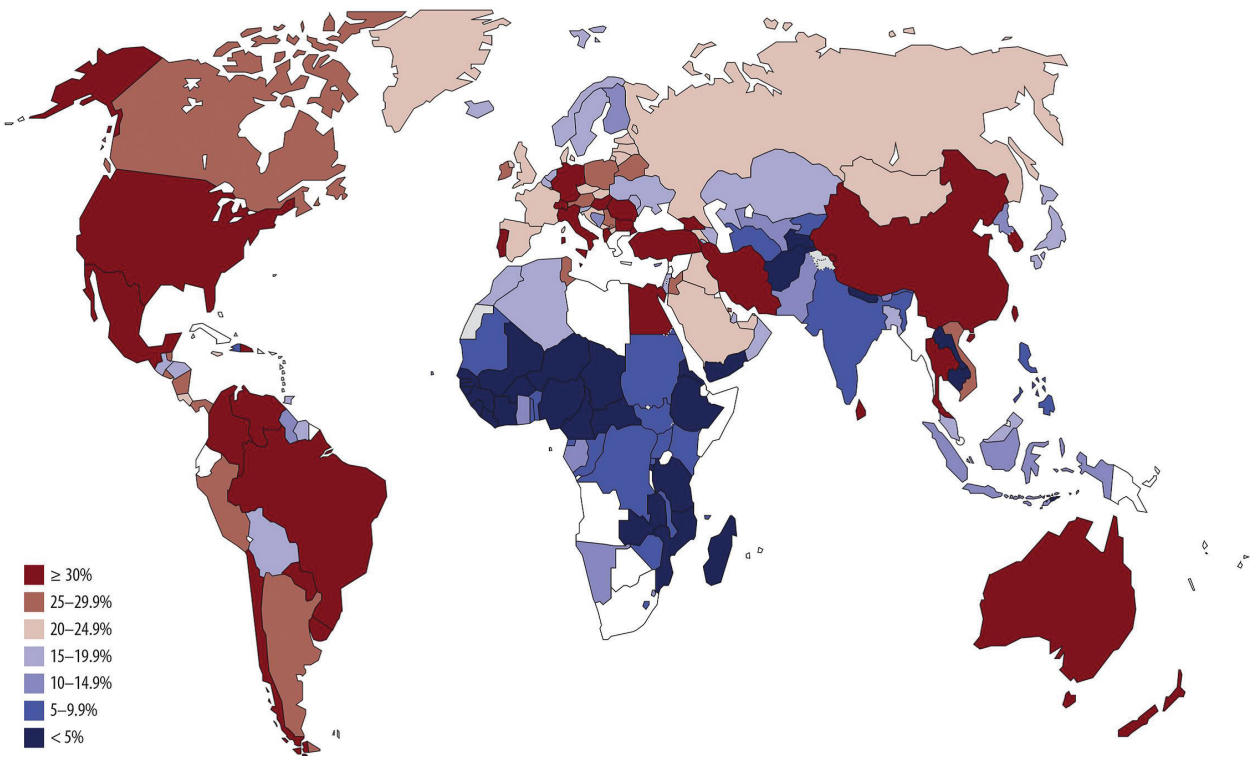
A CS is the delivery of a fetus through an abdominal incision (laparotomy) followed by a uterine incision (uterotomy), regardless of whether the fetus is alive or dead.

**1.3. Categorization**

A CS is categorized as planned (elective) when performed 8 h or more after the decision, usually before labor onset, and urgent when carried out between 30 min and 8 h after decision. Immediate caesareans are performed within 15–30 min due to an immediate threat to maternal or fetal health.

**1.4. The Robson classification system**

The lack of a standardized classification system to monitor and compare CS rates between obstetric units, regions and countries has hindered a better understanding of the increasing trend. In 2011, a systematic review of classifications for CS concluded that the Robson



**Figure 1.** Worldwide caesarean section rates. From Betrán et al. [1].

classification would be the optimal system. Proposed in 2001, the Robson system classifies women into 10 groups based on their obstetric characteristics—parity, gestational age, onset of labor, fetal presentation, previous CS and the number of fetuses. The system can be applied prospectively and every woman who is admitted for delivery can be classified based on these characteristics [2, 3].

## 2. Historic background

### 2.1. Ancient cultures

Referrals to abdominal delivery appear in the Indian epos *Ayurveda* (Knowledge of Life), 3300 BC, as well as in scriptures and pictures from ancient Persia, Egypt and China. Evidence that CS was performed arises from legal texts, such as a tablet describing the adoption of a little boy during the 23rd year of the Babylonian king Hammurabi (1795–1750 BC).

The ancient Jewish scriptures Talmud and Mishna, the collection of ancient Jewish laws (200 BC–600 AD), describe caesareans on living women who survived the operation. Postmortem caesareans were also performed [4].

The Roman *Leges Regiae* (Royal Laws) from 600 BC forbids the burial of a pregnant woman before extraction of the child from the uterus. When Rome became the Roman Empire, the law was named “*Lex caesarea*.” According to Greek mythology, Asclepius, founder of the medicine cult, was removed from his mother Coronis’ abdomen by his father Apollo. [5]. The origin of *caesarean* is commonly believed to be derived from the surgical birth of Julius Caesar (100–44 BC), which has been considered unlikely since his mother was reported to have lived to hear of her son’s invasion of Britain. Other possible Latin origins include the verb *caedere*, to cut, and the term *caesones* for infants born by postmortem operations (Figure 2) [6].

### 2.2. The medieval period

In the early medieval period, a CS was often performed by midwives [7]. Postmortem caesarean section was encouraged in order to secure baptism of the child. The Catholic theologian and philosopher St. Thomas Aquinas (1225–1274) stated that the mother must not be killed in order to deliver the child [8]. Islamic authorities favored postmortem caesareans, according to Imam Abu Hanifah (699–767). However, there are no referrals to caesareans in “The book of enabling him to manage who cannot cope with the complications” by Albucasis (Abul Qasim Al-Zahrawi, 936–1013), a leading book of surgery in Europe during five centuries.

### 2.3. Renaissance and modern ages

In 1500, a successful caesarean on a living woman who survived the operation was reported performed by Jacob Nufer, Switzerland. The woman (his wife) was unable to deliver her baby





**Figure 2.** The extraction of Asclepius from his mother Coronis' abdomen by his father Apollo. Woodcut from *De Re Medica* (1549) Alessandro Beneditti.

after several days in obstructed labor and despite help from many midwives. Her desperate husband gained permission from the local authorities to attempt a caesarean. The mother survived and subsequently went through several deliveries. The caesarean child lived until an older age. Success factors were that the caesarean was performed at an early opening stage, that it was performed in the house and that Nufer must have had anatomical knowledge because of his work with animal care. The story was not recorded until 1582; its accuracy has been questioned [9]. In 1581, the French physician François Rousset published a book with the subtitle "The extraction of a child through a lateral incision of the abdomen and the uterus of a pregnant woman who cannot otherwise give birth. And that without endangering the life of the one or another and without preventing subsequent fertility," where he suggested caesareans on living women for indications such as large fetus, dead fetus, twins, malpresentation, extremely young or elderly mother or narrow pelvis. In support of this proposal were 10 observations, of which he personally took part in a few without operating, as he was not a surgeon [10].

In the early 1500s, the British Chamberlen clan introduced instrumental forceps delivery to pull the fetus from the birth canal during obstructed labor. During the following 300 years, the male midwife and obstetrician gradually wrested influence over deliveries from female midwives [9, 11].

Until the 1600s, the procedure was known as a caesarean operation. In a book on midwifery, 1598, published by the French surgeon Jacques Guillimeau, the term "section" was introduced and thereafter replaced "operation" [12].

#### **2.4. Industrialization and malnutrition in Western countries increase the need for caesareans**

Increasing urbanization due to industrialization in Western countries in the 1800s led to an increased need for caesareans. City children suffered from malnutrition and lack of sunlight,

which caused vitamin D deficiency and rachitis. Still, at the early 1900s, women commonly died in childbirth due to rachitic pelvis. When pasteurized milk became available in the 1930s, insufficient bone growth became less common [13].

## 2.5. Africa

In Uganda, 1879, the catholic missionary Robert Felkin observed a caesarean [14]. He concluded that the operative technique was well developed and had been used for a long time. The surgeons used anesthesia and antiseptics (banana wine), a low abdominal mid-line incision and a blunt uterine incision with the assistant holding up the sides of the abdomen wall with two fingers into the uterus. The child was removed, the cord cut and the child handed to an assistant. The placenta was removed, the cervix manually dilated allowing for blood to escape, manual compression of the uterus was carried out without suturing it and red irons were used to coagulate bleeding points. The peritoneum, abdominal wall and skin were approximated and closed with seven iron needles, which were removed within 1 week. A root paste was applied over the wound and covered by a cloth bandage. Felkin observed the woman for 11 days, and when he left the mother and infant both were alive and well. Similar reports are known from other African regions, where botanical preparations were also used to anesthetize the woman and promote wound healing.

## 2.6. Centralization of obstetric care, mobilization, blood transfusion, antibiotics, uterotonics and anesthesia

Since the 1940s, the trend toward medically managed pregnancy and childbirth has proceeded. Centralization of obstetric and neonatal care has led to decreasing maternal and perinatal mortality. In Sweden, 1900, approximately 10% of births took place in hospitals, which increased to 75% in the 1940s [15]. Maternal mortality declined when early mobilization after childbirth was practiced and after the introduction of blood transfusions, uterotonics, antibiotics and anesthesia.

*Mobilization:* Maternal mortality due to pulmonary embolism declined when early mobilization instead of bed rest during 1–2 weeks after childbirth was advised.

*Blood transfusions:* The main blood groups A, B and O were distinguished by the biologist and immunologist Karl Landsteiner, 1900. Based on these findings, the first successful blood transfusion was performed in 1907 in the United States [16].

*Antibiotics:* Sulfonamide drugs were introduced as the first antibiotics in the 1930s. Penicillin was generally available in the 1940s after its discovery by Fleming in United Kingdom, 1928, and subsequent purification [17].

*Uterotonics:* Ergometrine has been the most important drug for treatment of postpartum hemorrhage, a major cause of maternal mortality. “Ergot of rye has been known to possess deleterious and poisonous qualities for more than 800 years, and it has been used on the continent by female midwives as a promoter of labor pains for nearly 150 years,” according to Francis Ramsbotham, founder of the Obstetrical Society of London 1841. In 1954, the uterotonic octapeptide amide oxytocin was described by Vincent du Vigneaud in the United States, and 1 year later oxytocin was synthesized [18].

*Anesthesia:* Nitrous oxide (laughing gas) was used as an anesthetic, 1799, and ether was demonstrated in 1846. Chloroform/ether was introduced in obstetrics, 1847, by Sir James Young Simpson, Professor in Midwifery in Edinburgh, Scotland, after self-experimentation and despite the criticism from many obstetricians in Europe and the United States. Anesthesia was often provided by nurses, of whom many were recruited among nuns from the convents [19]. In the 1900s, regional anesthesia and the general anesthetic halothane became available after being tumultuously developed with self-experiments. The initial enthusiasm was followed by skepticism and development of new drugs from the 1930s to 1950s [20].

### 3. Operative techniques

As anesthesia and aseptics developed, obstetricians were able to concentrate on improvement of the operative techniques for cesareans.

#### 3.1. Classical caesarean

Until the 1800s, caesareans were performed with midline laparotomy and vertical corporal uterotomy without closing the uterus, which resulted in mortality rates of 85–100% among women delivered by caesarean. The main reasons for caesareans were obstructed labor, often for days with a dead fetus. The main reasons for maternal mortality were hemorrhage, “exhaustion,” septicemia and eclampsia [21].

#### 3.2. The Porro technique

In 1876, the Italian obstetrician Eduardo Porro suggested a caesarean technique performing a subtotal hysterectomy with extirpation of the ovaries after delivery of the infant, in order to reduce hemorrhage and infection. This method claimed to result in more than 50% maternal survival [22].

#### 3.3. Vaginal cesarean

Between the 1880s and 1925, surgeons suggested transverse incisions in the lower uterine segment. Also, vaginal caesareans were carried out, in order to reduce peritonitis and septicemia. The need for vaginal caesareans ceased after World War II by the development of antibiotics [9].

#### 3.4. The Pfannenstiel-Kerr method

In 1897, Johannes Pfannenstiel in Germany documented a transverse abdominal incision just above the symphysis pubis [23]. In 1926, the British obstetrician John Munro Kerr reported a low transverse uterine incision, double-layer uterine sutures and peritoneal closure. This technique reduced maternal mortality and lowered the risk for uterine rupture in a subsequent



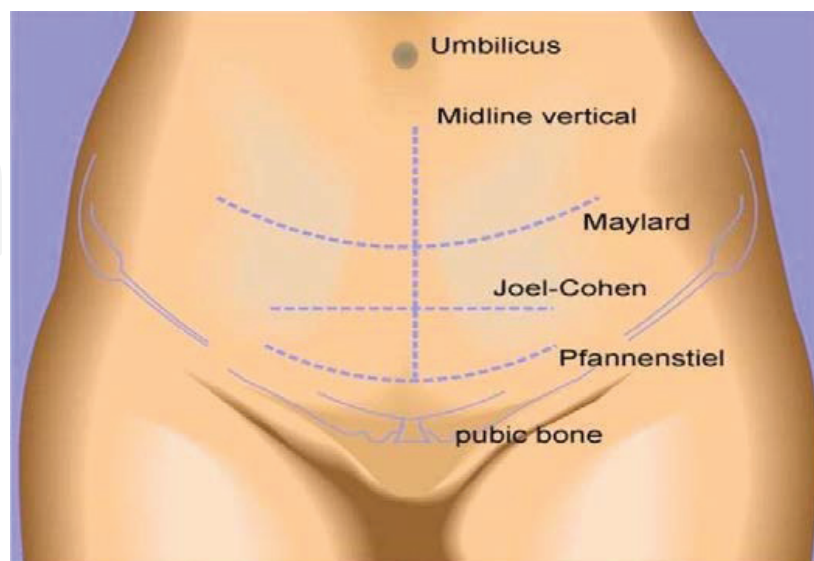
pregnancy. It was combined either with a low midline or a transverse abdominal incision, known as the Pfannenstiel-Kerr procedure, and gained acceptance in the 1940s [24].

### 3.5. The Misgav Ladach method

In 1972, Joel-Cohen and colleagues reported a new method for CS, which had first been used for hysterectomy, with a transverse laparotomy 5 cm above the symphysis pubis and blunt dissection of the abdominal wall. In the 1990s, one layer suture of the uterus and nonclosure of the peritoneum were recommended [25, 26]. This technique was first evaluated by Stark and colleagues in 1995 and was named after the Misgav Ladach Hospital in Jerusalem, Israel, where it was developed [27]. Today, many clinicians practice a modified Misgav Ladach method, with a skin incision 3–4 cm above the symphysis pubis. This technique reduces the risk of bladder injury, bleeding and pain compared with the Pfannenstiel method (**Figure 3**) [28].

*Uterine closure:* The idea to close the uterus was introduced by Lebas in France in the 1700s, suggested in certain situations by Harris in the United States in the 1800s, and first reported in 1882 by Max Sanger (Saumlinger) in Germany. Uterine closure with silver and silk sutures reduced maternal mortality significantly [29]. Silver threads had been launched into the gynecological field by the American surgeon James Marion Sims, who performed experimental surgery on postdelivery vesico-vaginal fistulas on enslaved, unanesthetized women in Alabama, United States.

The role of a single- or double-layer uterine closure for reducing subsequent uterine rupture has long been debated. According to randomized trials, the short-term complications are similar with either technique, but long-term follow-up is missing [30–32]. Locked sutures shall not be used, since they increase the risk of uterine ischemia and dehiscence [30, 33]. A single-layer suture of the uterotomy has been recommended by several authors [32]. However, a



**Figure 3.** The Joel-Cohen, Midline and Pfannenstiel abdominal wall incisions.



double-layer closure is related to a 4-fold reduction of subsequent uterine rupture compared with a single-layer closure [34]. Also, ultrasound investigations show a higher myometrial thickness after a double-layer closure [35, 36]. It is noted that besides the uterine closure technique several factors influence the risk of subsequent uterine rupture, such as labor progress [37], increasing maternal age and body mass index (BMI) [38, 39], short interpregnancy interval [40]; induced labor and method for labor induction [40–43] as well as fetal weight [38, 44].

*Removal of the placenta:* External compression of the uterus at caesarean, rather than manual removal of the placenta is recommended to reduce bleeding. The risk of postoperative endometritis was comparable with the two techniques and independent of whether the uterus was externalized or not during surgery. Manual or instrumental dilatation of the cervix did not reduce the risk of postoperative endometritis. Hematometra was not evaluated in the studies [31, 32].

*Closure of the abdominal wall:* Historically, both the urterovisceral and parietal peritoneum were closed during caesarean. This strategy was abandoned when it was shown that non-closure of the peritoneum results in short-term advantages, such as shorter operative time, reduced risk of intra-abdominal hematomas and adhesions, postoperative analgetic requirement and shorter hospital stay [45, 46]. However, adaptation of the rectus muscle reduces the risk of rectus diastasis and may also reduce the risk of adhesions between the uterus and abdominal wall [46]. Closure of the external fascia of the abdominal wall with resorbable PDS suture is recommended to minimize the risk of abdominal wall hernias [47]. Closure of the subcutaneous fat regardless of thickness reduces the risk of hematomas [48]. Skin closure of a transversal skin incision with sutures reduces the risk of wound complications as compared to staples. However, a midline laparotomy requires a robust closing technique [49].

*Uterotonics:* Low-dose oxytocin 2.5 U reduces preoperative bleeding during caesarean as efficiently as a high dose of 15 U. Oxytocin must be administered with care, because of the risk for cardiac arrhythmias, heart incompensation and pulmonary edema, particularly after doses of 30 U or more [50].

*Prophylactic antibiotics:* The effectiveness of prophylactic antibiotics depends on their presence in adequate concentrations during the operative period. Prophylactic antibiotic administration is recommended during emergency and immediate caesareans and by some authors also at elective caesareans. A single dose of cephalosporin is as effective as repeated doses of broad-spectrum antibiotics [51]. Preoperative administration within 15 min – 2 h before surgery is associated with a lower incidence of endometritis and wound infection as compared to intraoperative administration. It is noted that *in utero* exposure of a fetus to antibiotics is related to the development of allergy during infancy [52].

#### 4. Indications for caesarean section

More than 90% of pregnant women claim that they want to give birth in a natural way [53]. In contrast, recent studies suggest that the majority of planned caesareans are carried out for psychosocial or nonmedical reasons [54, 55]. Interestingly, 80% of women who experience obstetric complications neither consider the birth a negative overall experience nor develop fear of vaginal delivery [56].

#### 4.1. Planned caesareans

Historically, the primary indications for planned caesareans have been malpresentation, previous uterine scar, narrow pelvis and twin pregnancies with the first twin in a breech presentation [54, 57]. According to recent studies, the most common indications today appear to be psychosocial/nonmedical reasons, defined as fear of vaginal birth or maternal request without any co-existing medical indication in women with simplex cephalic pregnancy at a normal gestational age [54, 55]. Secondary fear of vaginal delivery after a negative birth experience was reported by 60% of these women (2.7% of all deliveries), primary fear of vaginal delivery by 34% (1.5%), whereas 5% (0.2%) was related to a pre-existing psychiatric health disorder such as severe depression, bipolar disease or an attention deficit disorder, and 1% (0.04%) was carried out on maternal request without further explanation. Fear of vaginal delivery is related to psychosocial burdens such as anxiety, depression, abuse, violence and a negative birth experience [53, 56, 58, 59]. The dominant Robson Classification Groups in Sweden 2015 were Group 2 (primiparous women with single cephalic pregnancy 37 weeks or more, who either had labor induced or were delivered by CS before labor) and Group 5 (multiparous women with single cephalic pregnancy 37 weeks or more and at least one previous uterine scar) [60].

#### 4.2. Urgent caesareans

Most urgent caesareans are carried out because of prolonged labor (labor dystocia) [54, 55, 61–64]. Prolonged labor is related to fetal malpresentations such as occipital posterior presentation or asynclitism in approximately 15% [55, 62]. Lack of support during delivery, high maternal age, high BMI and induced labor are risk factors for prolonged labor [39, 65, 66]. The second most common reported indication for urgent caesareans is imminent fetal distress [37, 54, 55, 62, 67].

#### 4.3. Immediate caesareans

Immediate caesareans are performed because of immediate threats to maternal or fetal health, which include signs of immediate fetal distress according to cardiotocography (CTG) or fetal scalp blood lactate sampling, placental abruption, umbilical cord prolapse and severe pre-eclampsia [55, 62, 67].

#### 4.4. Preterm caesareans

The rate of preterm caesareans has increased during the 2000s as a result of altered clinical guidelines recommending referral of women with threatening preterm birth to a tertiary hospital and active management including urgent caesareans at an earlier gestational age [68]. This development motivates long-term follow-up of maternal and child health, since preterm caesareans between 24 and 33 weeks reduce neonatal mortality and morbidity only when performed because of urgent fetal distress or a breech presentation [69]. Preterm caesareans more often require a high uterine corporal myometrial incision than term caesareans, due to an inadequately developed lower uterine segment in preterm gestation. This technique increases the risk of subsequent pathological placentation and uterine rupture compared with a low-transverse uterine incision [70].

## 5. Vaginal birth after caesarean

By the quote “once a caesarean, always a caesarean,” 1916, the American physician Edwin Craigin urged his colleagues to avoid unnecessary caesareans and emphasized that one of the risks of a primary caesarean is that repeat operations might be required [71]. This piece of advice is more actual than ever in today’s obstetric care, when the rate of vaginal birth after caesarean (VBAC) is less than 10% in some countries [55, 63, 64, 72]. Trial of VBAC after one CS results in successful vaginal delivery in 80% with a 0.5–1% risk of uterine rupture as compared to a 0.05% risk of uterine rupture among women without a previous caesarean. The success rate is as high as 90% if the woman has a previous vaginal birth [43, 73, 74]. The risk of uterine rupture is increased by an interdelivery interval of less than 16 months [40]. Trial of VBAC is possible in most situations except after two situations, a high corporal uterine incision or three previous caesareans. The success rate of VBAC after two caesareans is approximately 70%, and the risk of uterine rupture may be higher, 1.5–2%, after 2 previous caesareans than after 1 previous caesarean [73, 75, 76].

## 6. Complications after caesarean

### 6.1. Short-term complications

#### 6.1.1. Maternal

*Mortality:* A WHO global survey on maternal and perinatal health found that all caesareans including antepartum CS without medical indications are associated with severe maternal outcomes, such as an increased risk of death, admission to intensive care unit, blood transfusion and hysterectomy, as compared to vaginal delivery. In addition, this association is stronger in Africa, as compared to Asia and Latin America [77].

*Amniotic fluid embolism:* The risk for amnion fluid embolus is 2–5 times higher after CS compared with vaginal delivery [78].

*Venous thromboembolism:* The risk of venous thromboembolism increases by 10–15 times from early pregnancy, and further 2–8 times during caesarean, more during urgent CS in general anesthesia than planned CS in regional anesthesia [79].

*Infections:* Infections such as endometritis, urinary tract infection and wound infection are more common after caesarean than vaginal delivery [52].

*Traumatic injury of bladder or intestine:* Intraoperative traumatic bladder or intestine injury occurs in less than 1%, and the risk increases with increasing number of caesareans [80].

*Postoperative pain:* Postoperative pain after caesarean is shown to be more intense and persistent than was previously presumed [81].

### 6.1.2. Neonatal

*Breast feeding:* The onset of breast feeding is slower, and breast complications are more common after CS compared to vaginal delivery [82].

*Neonatal breathing disturbances:* Neonatal breathing disturbances are five times more common after caesarean (3.7 per 1000) compared with vaginal birth (0.7 per 1000). The risk diminishes if a planned CS is performed by 39 completed gestational weeks rather than earlier [83, 84].

## 6.2. Long-term complications

### 6.2.1. Woman

*Abdominal adhesions:* The risk of intra-abdominal adhesions increases with the number of caesareans [85, 86].

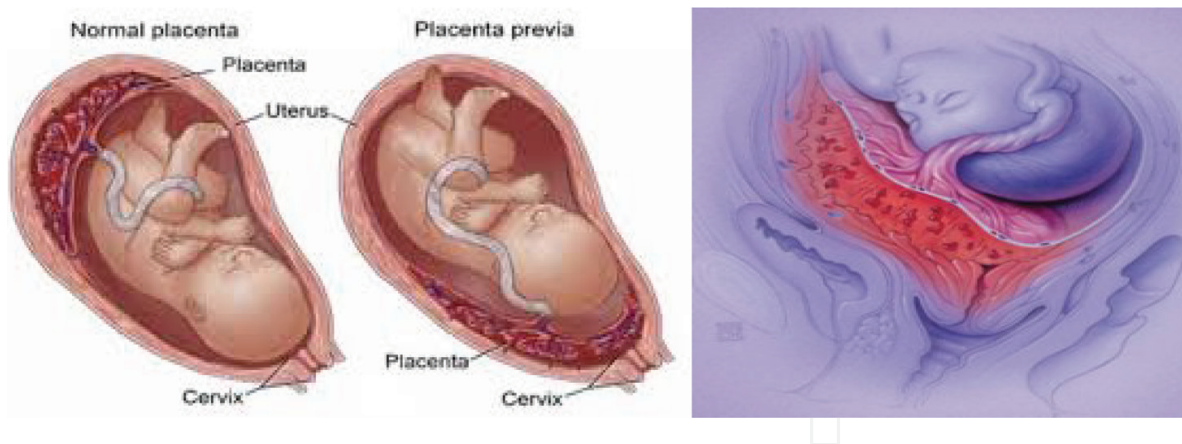
*Placenta praevia:* The risk of *placenta praevia*, where the placenta implants in the low uterine segment, covers the internal orifice of the uterine cervix (or internal os), through which the uterine cervix communicates with the uterine cavity and hinders vaginal delivery, increases with the number of scars in the lower uterine segment, mostly after caesarean section, vacuum aspiration or in vitro fertilization. The rate of *placenta praevia* increases from 0.5–1% after 1 caesarean and 2% after 2 caesareans [80].

*Placenta accrete:* Placental implantation in the lower uterine segment, which is composed mainly of connective tissue in contrast to the dominating smooth muscle in the uterine corpus, is the primary risk factor for abnormally invasive placenta (*placenta accreta*). This severe obstetric complication comprises a high risk of massive obstetric bleeding, complicated surgery and peripartum hysterectomy. Abnormally invasive placenta includes several types of trophoblast invasions into the uterine wall, in 70% invasion into less than 50% of the wall (*placenta accreta*), in 30% invasion in more than 50% of the wall (*incretta*) or through the uterine wall (*percretta*) perhaps into adjacent organs such as the urinary bladder, abdominal wall or intestine [80, 87]. The rate of *placenta accreta* has increased during the past 30 years and is reported in 2–90 per 10,000 births [87]. The prevalence of *placenta accreta* among women with *placenta praevia* is 3% after 1 caesarean, 11% after 2 caesareans and 40% after 3 caesareans [80].

*Peripartum hysterectomy:* The reported prevalence of emergency peripartum hysterectomy, primarily because of abnormally invasive placenta, secondly because of atonic bleeding and thirdly uterine rupture, in the Nordic countries is 3–4 per 10,000 births, as compared to 7 per 10,000 births in Germany and 23 per 10,000 births in the United States [88]. The risk of peripartum hysterectomy due to *placenta accreta* increases with the number of caesareans, rising markedly after three caesareans to 2–3% [80].

*Uterine rupture:* The risk of uterine rupture during delivery is estimated to 0.05% among women without a previous caesarean, 0.5% after 1 caesarean and 1.5% after 2 caesareans [73]. Prolonged opening stage after 6–7 cm cervical dilatation was related to an increased risk of uterine rupture (**Figure 4**) [37].





**Figure 4.** Placenta previa and abnormally invasive placenta, here *placenta percreta*. Source: Wikipedia.

*Urinary and bowel incontinence:* The prevalence of postpartum stress urinary incontinence is similar following spontaneous vaginal delivery and caesarean section performed for obstructed labor. It is quite possible that pelvic floor injury in such cases is already too extensive to be prevented by surgical intervention. Antepartal caesarean section was found to be associated with a lower rate of stress urinary incontinence. There is no difference between the groups after 2 years, and there is no difference at menopause between women with a previous vaginal delivery and women who never gave birth. It has been concluded that the pregnancy in itself leads to distension of pelvic ligaments and tissues. Caesareans do not protect against bowel incontinence [89, 90].

#### 6.2.2. Child

*Intestinal microbiota and obesity:* Mode of delivery influences gut microbiota. Infants born by CS are exposed mainly to their mother's skin bacteria, in contrast to infants born vaginally, who become exposed to their mother's vaginal and intestinal microbiota. Thus, infants born by caesarean harbor more staphylococci and less bacterial diversity in the intestinal microbiota colonization. Such a pattern is linked with increased capacity for energy harvest and risk of overweight and obesity that persists throughout early adult life [91].

*Allergy, diabetes mellitus and other autoimmune diseases:* Delivery by CS has been associated with increased prevalence of asthma, allergies, diabetes mellitus, gluten intolerance and leukemia [92, 93]. Epigenetic changes of the genome have been suggested as possible molecular mechanisms for perinatal contributions to the later disease. It has been shown that infants born by CS exhibit higher DNA methylation in leucocytes compared with infants born with vaginal delivery [94].

## 7. Prevention of unnecessary cesareans

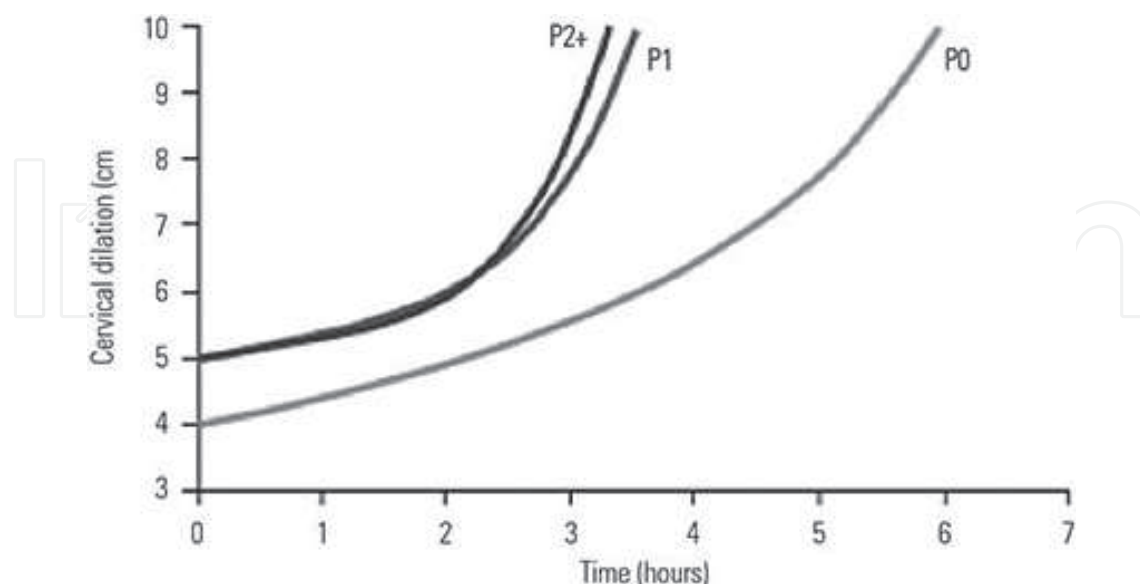
Actions to prevent unnecessary caesareans should focus on the main indications for caesarean sections' prolonged labor, imminent fetal distress, psychosocial/nonmedical



reasons and previous uterine scar [54, 55, 62, 72]. Recent studies have shown that normal labor progress during the opening stage is slower than 1 cm/h in all women, which was suggested by Emmanuel Friedman in the United States in the 1950s. Therefore, a slower progress than 1 cm/h is during the first stage of labor, which is not an indication for emergency caesarean in the absence of signs of fetal or maternal distress (**Figure 5**) [63, 64, 95].

Evidence-based management of labor, structured support during delivery, reduced labor induction and developed ability to perform instrumental deliveries instead of caesareans could be achieved through systematic theoretical education and team training programs on labor progress, fetal monitoring and delivery skills [55, 67, 96]. Such actions, taken together with structured counseling and support during pregnancy, would reduce planned caesareans due to psychosocial/nonmedical reasons or previous uterine scar. An increasing amount of evidence show that pregnancy-related anxiety is common and increasing with advancing pregnancy. A standardized definition of fear of vaginal delivery including an evidence-based scale for assessment of fear has been suggested [97]. Recommended systematic counseling and support for women fearing vaginal delivery include repeated meetings with a psychosocial team during pregnancy, objective information about benefits and risks related to different delivery modes including the influence on future reproductive health as well as support during delivery and planned follow-up after a negative birth experience [65, 98, 99].

Importantly, the attitudes among midwives and obstetricians influence a patient's choice [100]. A "coping attitude" rather than an "autonomy attitude" is strongly associated with a change in desire for a caesarean in women fearing vaginal delivery [59, 101].



**Figure 5.** Average labor curves. From Zhang et al. [63].

## 8. World Health Organization recommendations

The World Health Organization (WHO) stated in 2015 that caesareans are effective in saving maternal and infant lives only when they are required for medically indicated reasons and that CS rates higher than 10–15% at a population level not associated with reduced maternal and newborn mortality rates [102].

### Author details

Ylva Vladic Stjernholm

Address all correspondence to: ylva.vladic-stjernholm@sll.se

Department of Women's and Children's Health, Karolinska University Hospital and Karolinska Institutet, Stockholm, Sweden

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