Vaginal birth after caesarean section in Zimbabwe and the Netherlands
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Chapter 1

General Introduction
1.1 The history of the caesarean section

Caesarean sections have been carried out since pre-Christian times. Very often the operation would only be performed when a woman died during pregnancy: for example, the ancient Hindus carried out the operation when the mother had died and there were detectable movements of the foetus. There is some evidence that the operation may have been known to the ancient Egyptians. The operation was probably performed also by the Jews. The Mischnagoth, published in 140 BC, and the Talmud, written between 200 and 600 AD, contained instructions for twins and surviving women after caesarean section (1-4).

In Greek mythology, several non-vaginal births have been described. Asklepios, the son of Apollo and the king's daughter Coronis, was born through an abdominal delivery after his mother had been killed by one of the arrows of goddess Artemis. Dionysos, god of wine and agriculture, was the son of Zeus and Semele. He was born preterm through an abdominal delivery. Pallas Athena, goddess of wisdom, daughter of Zeus and Metis, was born out of the head of her father (2).

There is some debate over the origin of the word 'caesarean'. It is incorrect to associate the term caesarean with the birth of Julius Caesar (100-44 BC) through an abdominal incision. At that time, caesarean sections on living women were almost always fatal. It is known that during his life Caesar wrote letters to his mother, who, presumably, was alive at the time. The legendary king Numa Pompilius (715-673 BC) of Rome introduced a law by which it was forbidden to bury a pregnant woman until her child had been removed from her abdomen, even if there was little or no chance of its survival (2;3). Under the rule of Caesar, this Lex Regia became the Lex Caesarea and thus, the practice became known as the caesarean operation. The historian Plinius (23-79 AD), however, supports a different explanation. The word caesarean section might come from the Latin 'caedere' and 'secare', both meaning 'to cut' (5).

There are no recorded attempts of performing a caesarean on a living woman in Europe before 1500. In 1581, François Rousset (1535-1590) wrote a paper, which opened the debate on the relative benefits of the operation and argued the case for the possibility of performing a caesarean on a living woman (6). Not a medical practitioner, however, but Jacob Nufer, a hog gilder of Sigerhausen, Switzerland, performed the first caesarean section with a surviving woman and child. He carried it out on his wife, Elisabeth Aespachin, during a prolonged and obstructed labour in 1500. Mrs Nufer is said to have gone on to deliver six more children vaginally. She is, therefore, also the first woman with a recorded vaginal birth
after caesarean (7). However, the report was written a hundred years later and only from hearsay. The first authentic case of caesarean section intentionally performed upon a living woman was on 22 April 1610 in Wittenberg, Germany, by Jeremias Trautmann and published by professor Sennert. A living child was born, but the mother died on the 25th postoperative day (6;8). In the Netherlands, Amsterdam, the first successful caesarean section was performed on Femmetje Janszoon-Jans, by Steven Vennekool on 16 June 1637, and described by Hendrick van Roonhuijse in 1663 (9;10). A very famous legend is the caesarean section on the wife of Jacob Egge by the horn of a tempestuous bull on 29 August 1647 (Figure 1.1). Husband and wife both died. The child died at the age of nine months. Mother and child were buried at the Westzijderechurch at Zaandam. Since then, this church was popularly called "bull's church" or "bullekerk". Not only in the Netherlands, but also in Japan and China, the attack of the bull was a desired theme on painted chinaware (2;11;12).

### 1.2 Development of the operative technique of caesarean section

Because of the dangers for mother and child, caesarean section remained controversial far into the nineteenth century. A monograph on caesarean section, the first on the subject, was published in Paris in 1581 by François Rousset (1535-1590), although he himself had never performed the operation, but described it based on conversation and correspondence with others (6). Jacques Guillimeau (1550-1613) opposed the ideas of Rousset, because the

![Figure 1.1 Caesarean section by a tempestuous bull at Zaandam](image)
caesareans he had witnessed were always fatal (8). Francois Mauriceau (1637-1709) was a determined opponent of caesarean section, but his accurate description of a post-mortem caesarean on a woman was used as an “instruction guide” by other surgeons. As a result, he influenced the progress and development of the caesarean operation. In Paris, in 1797, opponents of caesarean section, with Jean Saccombe as leader, formed an 'Ecole Anti-Caesarienne'. They strongly opposed a report from Baudelocque (1748-1810), addressed to the Society of Medicine in Paris, in which he said that the operation could lead to saving the lives of both mother and baby (13).

Throughout Europe, up to the second half of the nineteenth century, maternal mortality remained extremely high. In 1844, in his dissertation entitled "De eventu Sectionis Caesarea", C. Kayser of Copenhagen described maternal mortality related to caesarean section. From 1750 to 1839, he recorded 338 caesareans on women of whom 38% survived. Infection was the commonest cause of death, followed by haemorrhage (14). Gerben Ynzonides described the first 95 known caesarean sections in the Netherlands up to 1873; maternal mortality was 68%; perinatal mortality was 32% (9). Most women died of sepsis or haemorrhage.

At Kayser's time, it was universally accepted that the uterus should not be closed, and there had been little discussion about this dogma in the previous hundred years. By the early operators, the abdominal incision was made at the left or right side, sometimes obliquely, or longitudinally above the umbilicus. The sub-umbilical lower midline incision, through the linea alba, only gradually became the preferred approach. The uterine incision has varied in position as well. The majority of the earlier surgeons made the incision in a longitudinal direction in the corpus of the uterus. But also oblique or lateral incisions have been practised. The principal aim of the inventors of the various incisions was preventing the gaping of the uterine wound, because suturing of the wound was hardly ever done (15).

The caesarean operation was revolutionised by suturing the uterus. Early efforts were made by M. Lebas in France (1769), but he was not followed by others. In 1817, James Barlow, a surgeon who had performed the first successful caesarean section in England in 1793, reported the suturing of a severe bleeding uterine wound (16). In 1856 in the USA, Warren Brickel, a professor in obstetrics and gynaecology, advocated the use of uterine sutures; many, however, opposed the idea (15). In 1869, the Dutch obstetrician A.E. Simon Thomas was called to attend a woman in Zoetermeer. The woman was forty years old, it was her first pregnancy, and she had been in labour for two days. A forceps delivery failed and by way of a classical (median uterine incision) caesarean section a daughter was born. The
uterine muscle was closed with eight silver wires. Both mother and daughter did well after the operation (17;18).

In 1886, the German Max Sänger (1853 –1903) published his experience with a suturing technique, used for closing a vertical corporal incision. After this publication, there was an international breakthrough and suturing became widely accepted (15;19). Previous to the practice of suturing the uterine wound, about 50% of those who survived caesarean section sustained uterine scar rupture in a subsequent pregnancy. After suturing had become the norm, uterine scar rupture rates were reduced to 4 - 5.5% (7;20). At the same time, in 1882 Kehr from Heidelberg described a low transverse uterine incision instead of the classical caesarean with the vertical scar in the corpus of the uterus, which used to be the common approach (15;21). In 1876, Porro of Pavia (Italy) developed his technique of amputating the body of the uterus, in order to lessen the dangers of haemorrhage and infection. There was opposition against this operation, because, due to the loss of her uterus, the woman was sterilised (22).

Another breakthrough came with the introduction of aseptic obstetrics by Semmelweiss (1846) and antiseptic surgery by Lister (1867) (15;23). In the Netherlands, by Van der Meij (Amsterdam) and Treub (Leiden), the aseptic techniques were fully supported by the end of the nineteenth century (23;24). For a short period, extra-peritoneal caesarean section was promoted in order to reduce the chance of infection. This technique was described by Fritz Frank in 1907, but never became popular because of complications of bladder and urethra (5;25). In 1908, Pfannenstiel advocated the horizontal abdominal incision through the skin and fascia. This incision was named after him. However, he adhered to a longitudinal incision of the peritoneum and the lower uterine segment (26).

Classical caesarean section with a vertical corporal incision in the uterus remained the standard technique in the Netherlands, United Kingdom and America until 1930. After previous classical caesarean section, repeat caesarean section was the treatment of choice, instead of the trial of labour. In 1921, Eardly Holland and Munro Kerr introduced the lower segment operation in the United Kingdom (27). Kerr recommended the semilunar incision with the curve directed upwards. It was not until after the publication of a paper by Wilson in 1931 that this operation came into common use (28). Also in the USA, the transverse incision in the lower segment became the favoured procedure. In the Netherlands, the transverse lower segment incision was supported by van der Hoeven in Leiden (1930) and Van Rooy (1921) in Amsterdam (29;30).
1.3 Caesarean section today

1.3.1 Surgical technique

The most common transverse abdominal incision is the Pfannenstiel, which is made 2 to 5 cm above the symphysis pubis, slightly curved extending through skin and subcutaneous fat to the level of the rectus sheath (Figure 1.2). Then, the rectus sheath is transversely incised on either side of the linea alba, which is cut separately, joining the two lateral incisions. Subsequently, it is separated from the underlying rectus muscles, which are again separated in the midline. Finally, the peritoneal cavity is entered longitudinally (26). Next, the transverse lower uterine segment incision is most commonly used (Figure 1.3, i.e. Kerr incision (27)). The advantages include less blood loss, and a low incidence of rupture during subsequent pregnancies. The major disadvantage of this incision is that significant lateral exposure is not possible without risking laceration of major blood vessels.

There are two types of vertical incisions: the low vertical and the classical vertical. The low vertical is performed in the lower uterine segment, but can be extended upwards into the fundus of the uterus, if necessary. The classical vertical incision is cut through the fundus of the uterus. This incision is associated with a higher risk of uterine scar rupture in subsequent pregnancies (4% - 9%), compared to low vertical (1% - 7%) and low transverse (0.2% - 1.5%) incisions (32;33).

When, with a scalpel in the centre of the lower segment, a small transverse incision is made, and entry into the uterine cavity is achieved, the incision can be laterally extended by either blunt expansion with the surgeon's fingers, or by employing a pair of scissors. In a study that evaluated these two techniques, it was found that sharp expansion of the uterine incision significantly increased intra-operative blood loss and the need for transfusion (34). A previous study, smaller in size, found no difference in intra-operative blood loss between blunt or sharp dissection of the uterine incision (35). Subsequently, the surgeon's hand is inserted into the uterine cavity to lift the presenting part and deliver the baby. The placenta is removed, either by spontaneous delivery (traction on the cord and the use of oxytocin to enhance uterine contractile expulsive efforts) or by manual removal. Controlled cord traction is preferable, since manual removal is reported to be associated with increased maternal blood loss (weighted mean difference 436 ml, CI95% 348 - 524 ml) and with increased postpartum endometritis (OR 5.4; CI95% 1.3-23.8) (36). Uterine exteriorisation, carried out by many surgeons, facilitates exposure and is associated with fewer postoperative febrile days (fever more than three days, OR 0.40; CI95% 0.17 - 0.94) and a non-significant trend towards fewer
Figure 1.2  Abdominal incisions for caesarean section (31)

Figure 1.3  Uterine incisions for caesarean section (31)
infections. There is, however, also a non-significant trend towards more nausea and vomiting when exteriorisation was done under regional analgesia (37).

In the late 1980s, single layer closure of the uterus became routine clinical practice. Operation time was reported to be reduced (with 5.6 minutes), without significant differences in the use of extra haemostatic sutures, incidence of endometritis or use of blood transfusion (38;39). In particular, single layer closure did not increase the risk of wound dehiscence during the next pregnancy, compared to two layer repair (38;40;41). These findings were questioned, however, by a cohort study of 489 women with a single continuous interlocking suture, containing the entire thickness of the uterine wall from decidua to visceral peritoneum, and 1,491 women with a double layer closure of the uterine incision. The double layer consisted of a continuous interlocking suture through the myometrium and the decidua, followed by a continuous second layer, and by closure of the visceral peritoneum. In this cohort study, women with previous single layer closure experienced a higher rate of uterine rupture than women with previous double layer closure (OR 3.95; CI95% 1.35-11.49) (42). But the only thorough way to determine the relative effects of single versus double layer uterine closure will be a randomised controlled trial of sufficient size. With a classical incision, the myometrium is thick and a double or even triple layer closure might be necessary, but there are no publications of studies comparing suturing techniques during classical caesarean section.

In a systematic review of four trials, it was found that non-closure of the visceral and parietal peritoneum saved operating time (mean difference 6.1 minutes, CI95% 4.3 - 8.0) (43). In a study by Grundsell et al., postoperative wound infection and febrile morbidity occurred significantly less after non-closure of visceral and parietal peritoneum (44). There is no evidence that closing the peritoneum is of benefit to the patient and non-closure should therefore be the treatment of choice. The fascia must be closed with a delayed-absorbable suture, using a continuous stitch. Especially, with a vertical incision in high risk patients for fascial dehiscence, a delayed-absorbable monofilament (e.g. polydioxanone, PDS) is recommended.

Closure of the subcutaneous layer was reported to be helpful in preventing postoperative wound disruption in women with at least 2cm of subcutaneous adipose tissue (45). Prevention of accumulation of serum and blood in the "dead space" is supposed to prevent wound seroma and subsequent wound breakdown and infection. This would support the idea of suturing subcutaneous tissue. However, a recent randomised trial, comparing subcutaneous closure with placement of a subcutaneous drain, or with no intervention,
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showed no difference in the risk of wound complications (46). In a multiple logistic regression analysis, thickness of subcutaneous tissue depth of more than 3 cm appeared to be the only significant risk factor associated with abdominal wound infection after caesarean delivery (OR 2.8; CI95% 1.3-5.9) (47). Subcutaneous suturing or the use of subcutaneous drains does not lower the risk of infection (48). At the end of the operation, reapproximation of the skin can be performed with staples or sutures.

1.3.2 Alternative surgical techniques

In 1954, S. Joel-Cohen developed a method for opening the abdomen in hysterectomy. At the Misgav-Ladach Hospital in Jerusalem, this technique was implemented and evaluated for caesarean section. The opening is performed by a superficial transverse straight cut in the cutis, about one and a half centimetres higher than the Pfannenstiel incision (Figure 1.2). The subcutaneous tissues are incised for three centimetres, only in the midline, to expose the fascia. The fascia is dissected laterally below the fat tissue, with the slightly opened tip of a scissors; the tendon plate is not freed upwards; after manual bilateral traction of the rectus muscles and the subcutis, the peritoneum is exposed and opened transversely. Then, the bladder peritoneum is opened and pushed down ("a bladder flap is made") and the uterus is opened in the lower segment. The fingers are used to extend the lower segment incision laterally. After delivering the child and the placenta, the uterus is closed with interrupted sutures in the original description of the operation. Continuous (non)-locking suture, however, has become common practice. The fascia is closed with continuous non-locking absorbable sutures and the skin with staples or sutures. Compared to the traditional Pfannenstiel incision, the Joel-Cohen technique was reported to have reduced blood loss and shorter mean operating time (250 versus 400 ml, and 20 versus 28 minutes) (49-54).

M.A. Pelosi developed a technique, combining a Pfannenstiel incision through the skin and fascia with blunt separation of the rectus muscles (Figure 1.2) (55). The subcutaneous tissue and the fascia are opened by electrocautery. After the peritoneum is perforated with a finger, the full thickness of the abdominal wall (skin, subcutaneous tissue, fascia, muscles, peritoneum) is stretched by both hands to the size of the skin incision. The traditional separation of the bladder peritoneum ("bladder flap") is not performed (56). The lower segment is sharply incised in the midline to the amniotic sac, and extended laterally by the index fingers or a pair of scissors. After delivering the child, the placenta is removed by controlled cord traction and the uterus is then closed in one layer with a continuous locking suture. Parietal and visceral peritoneum are not closed; the fascia is reapproximated with a
continuous nonlocking absorbable suture, and the skin with staples. In a study comparing the
Pelosi technique with a Pfannenstiel, postoperative fever was 2.0 % and 9.8% respectively
( RR 4.9; CI95% 1.2-20.9) The mean operating time was 27 minutes in the Pelosi group versus
45 minutes in the traditional group (P = 0.01) (57). Another transverse approach has been
described: the Maylard incision. A wide transverse suprapubic interilac incision, which
involves cutting the rectus muscles and ligating the inferior epigastric artery, provides good
access in short obese women (Figure 1.2) (31).

1.3.3 Antibiotic prophylaxis
A Cochrane review of 81 trials examined the effect of prophylactic antibiotics with elective
and non-elective caesarean delivery. Use of antibiotic prophylaxis substantially reduces the
incidence of postoperative endometritis across elective and non-elective caesarean patients
((RR 0.38; CI95% 0.22-0.64) and (RR 0.39; CI95% 0.34-0.46) respectively). Wound infections
are also reduced for elective and non-elective caesarean section ((RR 0.73; CI95% 0.53-0.99)
and (RR 0.36; CI95% 0.26-0.51) respectively) (58). Ampicillin (2 grams i.v.) and first
generation cephalosporins (1 gram i.v.) were similarly effective in reducing postoperative
endometritis and there was no added benefit in utilising a multiple dose regimen. The optimal
timing of administration (immediately after the cord is clamped versus pre-operative) could
not be determined. A single dose of ampicillin or cefazolin is recommended for infection
prophylaxis at caesarean section (59).

1.4 Maternal and neonatal risks due to caesarean section

1.4.1 Maternal mortality
Until the 20th century, the prohibitively high rates of maternal mortality after caesarean
section limited its use as a surgical procedure. However, as technical advances in the
procedure became available, along with techniques of antisepsis, maternal mortality rates fell
rapidly. Continuing advances in anaesthesia, the introduction of intravenous fluid and blood
replacement, and the use of antibiotics have further contributed to a safer caesarean birth. In
1928, German statistics showed a caesarean section mortality rate of 71% (60). In 1938, a
caesarean section mortality rate of 52% was registered in the Netherlands, but by 1960 this
rate was as low as 3.3% (61;62). Between 1966-71, 1972-78 and 1979-85 the caesarean
section mortality rates further declined to 2.3%, 0.7% and 0.4% respectively (63). In the
USA, the following rates were registered: in Rhode Island, using data from 1965-73, the
caesarean delivery mortality rate was 0.3%; in Georgia, using data from 1975-76, the caesarean delivery mortality rate was 0.6% (64;65); in Massachusetts, between 1976-84, the frequency of deaths, being directly related to caesarean section, was 0.06%, with an overall mortality rate of caesarean section of 0.22% (66). In a confidential enquiry in the Netherlands into maternal deaths between 1983-92, a direct risk of dying from caesarean section of 0.13% was reported. After adding the associated risk of, for example pre-eclampsia and thrombosis, the estimated case fatality rate was 0.28% (67). In Washington state, between 1987-96, the pregnancy-related mortality for primiparas who delivered by caesarean section was 0.01% (68).

The risk of maternal mortality from caesarean section is, however, still higher than from vaginal birth. From Cape Town, between 1975-86, a sevenfold relative risk of maternal mortality associated with caesarean section was reported, compared to that of vaginal birth (RR 6.7; CI95% 4.4-9.9). This risk decreased to five when women with medical or life-threatening complications were excluded (RR 4.7; CI95% 2.0-9.9) (69). In the United Kingdom, between 1994-96, the case fatality rate of elective caesarean section was almost three times that of vaginal birth (OR 2.85; CI95% 1.72-4.70) and for emergency caesarean section this was almost nine times (OR 8.84; CI95% 5.60-13.94) (70). Calculated from the confidential enquiry in the Netherlands (1983-92), mortality related to caesarean section was three (direct risk) to sevenfold higher than vaginal delivery. The causes of death were mostly postoperative sepsis, haemorrhage or pulmonary embolism. The case fatality rate, directly associated with anaesthesia was about one per 25,000 caesarean sections (67). A study by Hawkins et al. reported data on the method of anaesthesia and its relation to maternal mortality. The case fatality rate with general anaesthesia was higher than with regional techniques, and was estimated at 3.2 and 0.19 per 100,000 live births respectively (71).

Mortality related to caesarean section is higher in low-income countries, but actual data are scarce. In a review, combining data on 8,446 caesarean sections from Tanzania, Malawi and Nigeria between 1971-84, the case fatality rate was 18% (range 6%-50%) (72-74). In a maternal mortality audit in the Midlands province of Zimbabwe, the case fatality rate for caesarean section was 17 times higher than the case fatality rate for vaginal delivery (75). In this audit, the maternal mortality rates after caesarean section and vaginal birth were 5.1% and 0.3% respectively. In Malawi, in a prospective observational study of 8,070 caesarean sections, Fenton et al. reported a maternal mortality rate of 10.5% (n=85). Obstructed labour was the major indication for caesarean section (63%). Ruptured uterus, maternal haemorrhage, sepsis, anaemia and general anaesthesia were associated with
increased maternal mortality. Without uterine rupture (n=7,737), the maternal mortality rate was 6.5%; with a ruptured uterus (n=333) this was 110% (76).

1.4.2 Short-term maternal morbidity

The major morbidity related to caesarean section is due to infection, haemorrhage, injury to pelvic organs and thrombo-embolic disorders. Infectious complications following caesarean section include fever, wound infection, endometritis and urinary tract infection. Without antibiotic prophylaxis, the incidence of endometritis ranges from 25 to 85% and wound infection is reported to be 25%. Prophylactic antibiotics reduce the overall rate of infection by approximately 60% (58). In a retrospective study by van Ham et al., wound haematoma, wound infection and cystitis occurred after respectively 3.5%, 3% and 3% of caesarean deliveries; major infection of the pelvis and sepsis were reported after 1.5% and 0.3% of caesarean sections; bloodloss of more than 1,500 ml occurred in 2.4% of women; re-laparotomy was indicated in 1.6% of women; and postoperative ileus was managed conservatively in 1.5% of caesarean sections (77). In a study by Petitti et al., 1-2% of all patients delivering by caesarean section required blood transfusion (78). Urinary tract injuries are uncommon; bladder lesions were reported between 1.4 to 8 per 1,000 caesarean sections, and ureteric injuries between 0.27 to 0.9 per 1,000 caesarean sections (77;79;80). In these studies, scar tissue from a previous caesarean section increased the risk of bladder injury.

In low income countries, caesarean sections are performed by general practitioners (not by obstetricians), anaesthesia is given by specially trained nurses, and the expectant mothers are in a less favourable condition in terms of nutrition, anaemia and infection. Especially the HIV/AIDS epidemic increases pregnancy-related mortality and morbidity (81). De Muylder, in 1985-86, investigated caesarean morbidity in Zimbabwe in 643 women. His data were collected before the awareness and full outbreak of the HIV epidemic. Sepsis, postoperative endometritis, urinary tract infection and wound infection occurred in 5%, 11%, 4.5% and 6.1% of women respectively. Febrile morbidity was present in nearly one third of patients. Re-laparotomy was necessary in 1.6% of women for various reasons like sepsis, haemorrhage or burst abdomen. Haemorrhage was a major problem due to anaemia; 30% of women were transfused! Bladder injuries occurred in 1.7% of caesarean sections (82). When elective or early labour caesarean section was compared to emergency caesarean section, the complication rates were lower for elective procedures, both in high income and low income countries (77;82;83). There is no doubt, however, that in low income countries caesarean
section, elective or emergency, remains a major operation and is associated with a much higher morbidity than in Western countries.

Deep venous thrombosis of the lower leg (DVT) is a rare event and only large study populations have enough power to show a significant difference in DVT incidence between caesarean section and vaginal birth. Because DVT can be complicated by pulmonary embolism, which is still a major contributor to maternal mortality in association with caesarean section, DVT in the lower leg should be considered as major morbidity (84). In one study, involving 395,335 women with live births, the incidence of DVT after caesarean section was 178 per 100,000 births compared to 65 per 100,000 after vaginal birth (85). In another series of 268,525 births over an 11 year period, pulmonary embolism was strongly associated with caesarean section (19 of 36,479 caesarean sections compared to 4 of 232,032 vaginal deliveries) (86). In a meta-analysis DiMatteo et al. described a psychological side effect of caesarean section, which could be classified as caesarean morbidity. Caesarean mothers, compared to women who delivered vaginally, expressed less satisfaction with their delivery, short-term as well as long-term. Maybe as a result, breast-feeding failed more often in women who underwent caesarean section (87).

1.4.3 Long-term maternal morbidity

1.4.3.1 Fertility

There is a complex relationship between caesarean section and subfertility. Murphy et al. investigated 14,541 pregnant women and found that a history of previous caesarean section was associated with an increased risk of taking more than one year to conceive from the time of planning a pregnancy (OR 1.5; CI95% 1.1-2.1). On the other hand, nulliparous women with a history of subfertility were at increased risk of delivery by caesarean section. After three years of subfertility, the odds ratio was 2.3 (CI95%1.6 - 3.3). Subfertility may both precede and be a consequence of caesarean section (88). It was not possible to draw a more specific conclusion from this study, due to the fact that the indications for caesarean section were not examined.

1.4.3.2 Placenta praevia and placenta accreta

Caesarean section increases the risk of abnormal placentation in future pregnancies. In a large meta-analysis by Ananth et al. (3.7 million women), the reported baseline frequency of placenta praevia was 1 in 200 deliveries (range 0.28-2%). Women with at least one previous
caesarean delivery were at 2.6 times greater risk of development of placenta praevia in subsequent pregnancy and this risk increased with the number of caesarean births (CI95%: 2.3 - 3.0) (89). Lydon-Rochelle et al. selected primiparous women with one previous caesarean section, and adjusted for maternal age, leading to a frequency of placenta praevia at second birth of 0.52%; a 1.4 times greater risk compared to women with one previous vaginal birth (CI95%: 1.1 - 1.6) (90). Studies by McMahon et al. and Gilliam et al. showed that the likelihood of placenta praevia was related to both parity and the number of previous caesarean sections. The odds ratio for the likelihood of placenta praevia for a primiparous woman with one caesarean section was 1.28 (CI95%: 0.82 - 1.99); for a woman with four or more deliveries and one previous caesarean section the OR was 1.72 (CI95%: 1.12 - 2.64); and for a para 3 with three previous caesarean sections the OR was 4.09 (CI95%: 1.53 - 10.96) (91;92). In two studies (Clark et al. and Chattopadhyay et al.), patients presenting with placenta praevia and an unscarred uterus had a 4.5-5% risk of placenta accreta. With a placenta praevia and one previous caesarean section, the risk of placenta accreta was 24-38%; this risk continued to increase to 59-67% with a placenta praevia after two or more previous caesarean sections (93;94). The increased rate of placenta praevia and accreta is of concern, due to the inherent risks of these disorders. For example, serious haemorrhage can lead to severe morbidity and even mortality, illustrated by Kastner et al. in a retrospective study, describing 47 peripartum hysterectomies; almost 50% was indicated because of placenta accreta (95).

1.4.3.3 Uterine rupture

It is essential to distinguish between a dehiscence of the uterine wall (visceral peritoneum intact) and a complete rupture of all layers with or without partial fetal extrusion in the abdominal cavity. Unfortunately, in many studies, dehiscence and uterine rupture are often commingled, and indistinguishable. Unless indicated differently, in this thesis uterine rupture is defined as: separation of the entire thickness of the uterine wall in conjunction with caesarean section for suspected fetal distress, extrusion of any portion of the fetal-placental unit, intraperitoneal or vaginal haemorrhage, need for a hysterectomy, or bladder injury (96;97). The risk of uterine rupture depends on the type and location of the previous incision in the uterus. During labour, the rates described by scar type are: 4 - 9% for a classical uterine incision; 4 - 9% for a T-shaped incision; 1 - 7% for a low vertical incision; and 0.2 - 1.5% for a low transverse incision (32;97-100). Rupture usually occurs during labour, but may occur antepartum. After previous lower segment caesarean section, the risk of antepartum rupture
was estimated 1.6 per 1,000 (101); after classical previous caesarean section, the antepartum dehiscence was reported to be as high as 6 - 9% (33;102).

Fetal bradycardia is the most common clinical manifestation of uterine rupture, but variable or late decelerations can also occur. More than 90% of uterine ruptures in Western countries are associated with previous caesarean delivery. Dehiscence of a previous caesarean scar is much less traumatic and, in a study by Kieser et al., maternal and perinatal outcome was almost without long-term sequelae (103). Complete extrusion of the foetus represents the worst spectrum of uterine rupture. In this subgroup of patients, Leung et al. reported 14% perinatal death, and 68% of neonates had an umbilical artery pH < 7.00 (104). Chauhan et al. reviewed the literature for morbidity and mortality rates that are related to uterine rupture during trial of vaginal labour. Per 1,000 TOLs, the following complication rates were identified: uterine rupture 6.2%, hysterectomy 0.9%, genitourinary injury 0.8%, blood transfusion 1.8%, umbilical artery pH < 7.00 1.5%, and perinatal death 0.4% (97). Even maternal mortality can occur due to postoperative complications, initiated by severe bleeding. In the above review, one death was identified to be related to uterine rupture during TOL and described by Farmer et al (105).

1.4.4 Fetal risks

There are also fetal risks from caesarean section, even though the procedure is usually performed for the benefit of the foetus. Nowadays, the dangers to the neonate from general as well as from spinal anaesthesia are nowadays very limited. Datta et al. demonstrated that during general anaesthesia, induction-to-delivery intervals of more than 8 minutes and uterine incision-to-delivery intervals of more than 3 minutes were associated with only a minor change in umbilical artery pH (pH 7.22 versus pH 7.31). Also after receiving spinal anaesthesia, the prolongation of uterine incision-to-delivery interval by more than 3 minutes had only a slight influence on the umbilical artery pH (pH 7.18 versus 7.30). The time between the actual spinal injection and delivery of the baby was of no influence on the umbilical artery pH (106). The surgeon, however, seems to be more harmful to the neonate than is often thought, which is shown in a study by Smith et al.; fetal laceration injuries were recorded in 6% of caesarean sections when the presentation was breech or transverse; after vertex presentation and caesarean section, 1.4% of neonates were recorded to have laceration injuries. Only 6% of the injuries were documented by the surgeon in the operative report of the caesarean section; the other lacerations were noted by paediatric nurses or paediatricians (107). In a study by Hook et al., transient tachypnoea of the new-born, often only a "wet
lungs", occurred in 6% of neonates after an elective caesarean section (108). Graziosi et al. claim a relative risk of 0.14 (CI 95% 0.03 - 0.64 for respiratory morbidity after delivery by elective caesarean section with a gestational age of 39-42 weeks, compared to 37-38 weeks (109). A retrospective study from 1988-1992 of 179,701 babies in the North of England showed that those born at 37-38 weeks were 120 times more likely to receive ventilatory support for surfactant deficiency, than those born at 39-41 weeks, especially if subjected to pre-labour caesarean delivery (110). Moreover, in a study comparing elective caesarean section (n=1,889) with vaginal delivery (n=21,017), neonates which were delivered by elective caesarean section were almost 5 times more likely to develop pulmonary hypertension than those which were delivered vaginally (0.37% vs 0.08%, OR 4.6; CI 95% 1.9 - 11) (111). Therefore, routine elective caesarean section should be performed from 39 weeks onwards. It is not clear whether this policy will also reduce the increased risk of pulmonary hypertension.

1.5 Caesarean section world wide

1.5.1 Caesarean section rates

Before 1965, caesarean birth rates in most Western countries remained stable between 1.5% and 5% of all births (112). In the 1970s, rates began to rise; gradually in the Netherlands and Ireland, more steeply in other Western countries (Figure 1.4). In the Netherlands, the caesarean section rate rose from 0.52% in 1938 to 6% in 1985 and 13.5% in 2001 (61;63;113-116). Figure 1.4 also shows that between 1970 and 2000, the rates of caesarean delivery in the USA of America and Canada rose from 5% to more than 15%, with a peak in 1988, followed by a short period of decrease. Recent data, however, show again an increasing trend, resulting in a caesarean section rate in the USA of 22.9% in 2000 (113;117;118). In England, the rate of caesarean delivery has climbed steadily since the second world war. During the 1990s, the rate has increased more rapidly, reaching 18% by 1997 and 22% in 2001 (119-121). The rise of caesarean section rates has not been limited to Europe and North-America. In the 1990s, Latin American countries were reported to have high national caesarean section rates, e.g. Cuba 23%, Mexico 31%, Argentina 25%, Brazil 32% and Chile 40% (122). Also from Asia, reports mention a rise in caesarean sections; from Mumbai, India, institutional caesarean section rates between 1957-98 increased from 1.9 to 16% (123); an urban population survey between 1997-99 in Madras City, India, identified a caesarean section rate of 32.6% and in the Indian private sector 47% of births were by caesarean section (124).
Figure 1.4  International caesarean section rates (61;3;113-116;132;133)
However, in 1997 in neighbouring Nepal, with very poor access to health care, the estimated population based rate of caesarean section was 2.3% in urban areas and 0.2% in rural areas (125). In Hong Kong from 1987-99, the overall annual caesarean section rate rose steadily from 16.6 to 27.4%. The private sector contributed most to this increase; 43.4% of births was by caesarean section (126). In Shantou, China, hospital based caesarean section rates increased from 11 to 30% between 1990-97 (127). In a district survey in the Minhang District of Shanghai, China, the caesarean section rates from 1960 to 1993 were calculated; the proportion of infants born by caesarean section increased from 4.7% to 22.5% (128).

Caesarean section rates from sub-Saharan Africa are in shirll contrast with data from the Western world. Reviewing studies between 1970 and 2000, Dumont et al. observed a caesarean section rate of 1.3% in West-Africa (129). At two different time intervals 1991-93 and 1996-99, demographic data from eight countries were analysed by Buekens et al.; Burkina Faso, Madagascar, Niger and Zambia had caesarean section rates lower than 2%; Cameroon, Ghana and Tanzania had caesarean section rates between 2% and 5%; Kenya had a caesarean section rate of around 6%. Between the different time intervals, the number of caesarean sections even decreased in Ghana, Madagascar, Niger, Tanzania and Zambia (130). In 1999, the population caesarean section rate in Zimbabwe was 3.1% (131).

On the one hand, there has been public concern for over 30 years about the increasing caesarean section rates world wide; but on the other hand in low income countries the caesarean section rate is often still too low to guarantee safe obstetric care. The UNICEF, WHO, and UNFPA guidelines (1992) recommend that a minimum of 5% of deliveries are by caesarean section (134;135). Several studies confirmed that there is a lower bench-mark of a minimal number of needed caesarean sections in order to save lives of pregnant women; a minimal need was reported to be 5.4% (range 3.6 - 6.5%) by Dumont et al., 2.3% (range 1.3 - 4.7%) by Ronsmans et al. and 1 to 2% by De Brouwere et al. (129;136;137). However, it seems far more difficult to identify the cut-off point for the right upper number of caesarean sections (114;135;136). The WHO/UNFPA/UNICEF guidelines were agreed upon in a compromise between countries with probably too high caesarean section rates, and low income countries with far too low caesarean section rates, The upper bench-mark of needed caesarean sections has arbitrarily been set at 10-15%. This recommendation on maximum caesarean section rates originate from a conference in 1985 on appropriate technology for birth, held at Fortaleza, Brazil. This conference, organised by regional offices of the WHO from Europe and the Americas and the Pan American Health Organisation, was attended by over 50 participating groups representing midwifery, obstetrics, paediatrics, epidemiology,
sociology, psychology, economics, health administration, and mothers (138). According to the evidence at that moment, there were no additional perinatal or maternal health benefits to be expected from a caesarean section rate of more than 10 - 15%. It was stated that higher rates indicate over-utilisation of the procedure.

1.5.2 Determinants of increasing caesarean section rates

Perinatal mortality rates have continued to decline since the 1950s and it has been argued by Bottoms et al. that this was due to an increased caesarean section rate, improving the prognosis for the foetus (112). In Dublin's National Maternity Hospital, however, the caesarean section rate remained stable below 5% between 1965 and 1980, but the perinatal mortality made the same dramatic fall as in the Unites States from 42 to 16.8 per 1,000 infants born. The improvement of neonatal care has contributed to this reduced perinatal mortality, not the expansion of caesarean section rates (139).

The relative safety of caesarean section as discussed in section 1.4.1 makes physicians less hesitant to perform the procedure. The common belief, that most cases of cerebral palsy were the result of intrapartum asphyxia or vaginal delivery trauma, led to an increase in caesarean sections, out of fear for malpractice litigation (140). Nevertheless, critical assessment of long-term neonatal outcomes have shown that only a small minority of cases of cerebral palsy can be attributed to intrapartum events (141;142). Because of the perceived safety of the caesarean operation by doctors and the public, even factors like convenience of delivery time, socio-economic status and type of medical insurance influenced caesarean section rates (143-145). In addition, deliveries predominantly supervised by doctors have higher caesarean section rates (146). Deliveries with the same lay support person available during the entire labour reported lower intervention and caesarean section rates and higher satisfaction. Due to more and more supervision of birth by doctors, caesarean section rates are rising (147).

Have changes in population characteristics contributed to the observed increases in caesarean section rates? For example, women are delaying childbirth and have fewer children. In the Netherlands, the average age for a woman to have her first child has been postponed from 25 years in 1975 to 29 years in 2001. Nowadays, one in eight women is 35 years of age or older at the time of her first born (148). The same trend is seen in Northern-America and other European countries (112;114;140). Older women are more likely to have chronic medical conditions and pregnancy complications, tend to have longer labour and are more often diagnosed with "failure to progress". Practitioners' attitudes toward pregnancy in older
women may also contribute to the increase of caesarean sections (140). Shifts in the age of the population, however, have shown to account for only a small part of the increase in caesarean section rate. Age explained 1% and 17% of the caesarean increase in studies from Canada and the USA respectively (149;150).

An early and consistent observation has been that over 70% of caesarean sections can be attributed to the following four indications: dystocia (failure to progress during labour), fetal distress, breech presentation and repeat caesarean section (112;114;140;149;151;152).

**Dystocia** is the most frequent indication for caesarean section. It accounts for 33% of the increase in caesarean section rates (112). It includes cephalopelvic disproportion (CPD) and inefficient uterine contractions. Absolute cephalopelvic disproportion is these days quite rare. Dystocia has become a subjective diagnosis and depends more on the characteristics of the individual clinician than on the characteristics of the woman (153). Central to the management of presumed dystocia is augmentation of labour, when uterine contractions do not result in dilatation of the cervix. The guidelines of the partograph and the principles of the active management of labour have been brought up as tools to improve the diagnosis (154).

**Fetal distress:** electronic fetal monitoring was widely accepted in the USA in the late 1960s, well before evidence from randomised controlled trials (RCT) had demonstrated either efficacy or safety. A Cochrane review, including 9 RCTs, compared continuous electronic fetal heart rate monitoring (EFM) to intermittent auscultation. It identified no better neonatal outcome after EFM, but the rate of caesarean section (RR 1.41; CI<sub>95%</sub> 1.23-1.61) and operative vaginal delivery increased (RR 1.20; CI<sub>95%</sub> 1.11-1.30) (155). The introduction of continuous EFM during labour has resulted in a more frequent diagnosis of fetal distress, leading to more caesarean sections. Fetal scalp blood sampling reduces the false-positive rate of fetal distress associated with continuous EFM (156).

**Breech presentation:** approximately 3.5% of pregnancies present at term with a foetus in breech presentation. Changes in management of breech presentation have contributed to the increasing rates of caesarean section. Especially, after the publication of the term breech trial by Hannah et al. in 2000 the majority of women in high income countries with a breech presentation at term are delivered by caesarean section (157).

**Repeat caesarean section** is responsible for 23% of the increase in caesarean sections (112). The influence of previous caesarean sections on the overall caesarean section rate is most clearly illustrated by comparing women with a previous caesarean section with nulliparous women. The risk of caesarean section after a trial of labour is higher in women who have had a previous caesarean section compared to nulliparous women. Women who had had a
previous caesarean section for failure to progress were four times more likely to have a caesarean section as nulliparous women (OR 4.5; CI$_{95\%}$ 3.6-5.5). Women who had had a previous caesarean section for fetal distress were twice as likely to have a repeat caesarean section compared to nulliparous women (OR 2.2; CI$_{95\%}$ 1.6-2.9), but women with a previous caesarean section for breech presentation had a risk of caesarean section similar to that of nulliparous women (OR 0.95; CI$_{95\%}$ 0.7-1.3) (158). In a population, an increase in the number of women who have had a previous caesarean section will always result in a disproportionate increase in the overall caesarean section rate. The influence of previous caesarean section on the total caesarean section rate will be reinforced by a high elective repeat caesarean section rate. Especially, in the USA a policy adhering to Cragin's dictum of "once a cesarean, always a cesarean" resulted in low trial of labour rates and low vaginal birth after caesarean rates (159). Nowadays, in the USA and England about one third of caesarean sections are repeat procedures (114;140).

1.6 Vaginal birth after caesarean

1.6.1 Introduction

When Cragin addressed the medical community of New York in 1916, in an attempt to convince them that primary caesarean section should be avoided unless absolutely essential, he could not have predicted that his recommendation of "once a cesarean, always a cesarean" would be so universally accepted by American obstetricians in the decades thereafter. Cragin's plea to minimise primary caesarean section rates has been largely forgotten (159). Certainly, during Cragin's time his recommendation on repeat caesarean section was not unreasonable. The vast majority of caesarean sections were for major cephalopelvic disproportion, using a corporal uterine incision instead of the lower uterine segment, which is the standard today.

In the United Kingdom and continental Europe, Kehrer's transverse lower segment incision became popular and was modified by Munro Kerr (section 1.2) (21;27). Uterine rupture gradually became far less common with this incision than with the classic approach. In 1957, Dewhurst, reviewing the literature at that time, concluded that "an attempt at vaginal delivery after previous lower segment caesarean section can be made with a considerable degree of safety". During trial of labour, he reported uterine rupture rates after classical caesarean section between 4.7 - 8.9%, and after lower segment caesarean section between 0.8 - 1.2% (160). Among American obstetricians, the risk of uterine rupture received far greater
attention than the risk of repeat caesarean section. In addition, lower segment caesarean section was frequently performed by a vertical incision, which often entered the upper segment. In 1950, elective repeat caesarean section had become established practice in North America (161).

Because of the increasing caesarean section rate world wide and the parallel increase of repeat caesarean sections, the issue of vaginal birth after caesarean became more and more relevant (see Figure 1.4). Countries with high caesarean section rates also have a high proportion of repeat caesarean sections; e.g. in 1978, 98.9% of women with a previous caesarean section in the USA were delivered by repeat caesarean section (162). Traditionally, Europe had a more liberal policy on vaginal birth after caesarean section. In the 1980s, VBAC rates were 56% in Norway, 39% in Scotland, and 40% in Sweden (163). No national data for the Netherlands on VBAC were (and are still not) available on a routine basis. Several hospital based studies by Roumen, Jansen and van Vugt reported VBAC rates ranging from 57 to 62%, which suggests that also among Dutch obstetricians trial of labour after previous caesarean section has been the policy for many years (7;164;165).

With caesarean section rates of 20% or even 25%, it is more obvious than ever that a liberal policy on vaginal birth after caesarean section can contribute to a lower overall caesarean section rate. Nowadays, in the USA 37% and in England 29% of caesarean sections are repeat procedures (114;140). It is not surprising that most studies on vaginal birth after caesarean section stem from the USA. Elective repeat caesarean was the standard, and pioneer work on VBAC by Riva et al. and others in the seventies and eighties was often heavily criticised by "elective repeat believers" (Table 1.1) (166-173).

In this thesis, the definitions on "vaginal birth after caesarean" (VBAC) and "success rate" of trial of labour are used as formulated by the American College of Obstetricians and Gynecologists (ACOG) in 1996; to compare results of different studies, VBAC rates should contain all previous caesarean sections in the denominator, including even repeat caesarean sections for placenta praevia (174).

\[
VBAC\ Rate = \left( \frac{\text{Number of VBACs}}{\text{Number of all women with previous caesarean sections}} \right) \times 100
\]

\[
Success\ Rate = \left( \frac{\text{Number of VBACs}}{\text{Number of women who had a trial of labour after caesarean section}} \right) \times 100
\]
Table 1.1  
Vaginal birth after caesarean section and its outcome in Western and African countries

<table>
<thead>
<tr>
<th>Reference</th>
<th>Country + Study design</th>
<th>n</th>
<th>VBAC Rate¹ (%)</th>
<th>Success Rate¹ (%)</th>
<th>Uterine rupture (%)</th>
<th>PNM/1,000</th>
<th>MMR</th>
<th>Other remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riva, 1961 (166)</td>
<td>USA, retrospective</td>
<td>214</td>
<td>74</td>
<td>78</td>
<td>0.9</td>
<td>0</td>
<td>0</td>
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<tr>
<td>van Vugt, 1966 (7)</td>
<td>the Netherlands, retrospective USA</td>
<td>214</td>
<td>57</td>
<td>87</td>
<td>1.4</td>
<td>32</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Merrill, 1978 (167)</td>
<td>USA, retrospective</td>
<td>634</td>
<td>41</td>
<td>49</td>
<td>0.6</td>
<td>0</td>
<td>0</td>
<td></td>
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<tr>
<td>Saldana, 1979 (168)</td>
<td>USA, retrospective</td>
<td>226</td>
<td>26</td>
<td>40</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Meier, 1982 (169)</td>
<td>USA, retrospective</td>
<td>226</td>
<td>?</td>
<td>85</td>
<td>0.4</td>
<td>0</td>
<td>0</td>
<td></td>
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<tr>
<td>Gellman, 1983 (170)</td>
<td>USA, retrospective USA</td>
<td>220</td>
<td>35</td>
<td>63</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
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<tr>
<td>Martin, 1983 (171)</td>
<td>USA, retrospective USA</td>
<td>717</td>
<td>14</td>
<td>62</td>
<td>0.4</td>
<td>0</td>
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<tr>
<td>Graham, 1984 (172)</td>
<td>USA, retrospective</td>
<td>1,551</td>
<td>11</td>
<td>69</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Boucher, 1984 (173)</td>
<td>USA, retrospective</td>
<td>852</td>
<td>32</td>
<td>80</td>
<td>2.6</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Lavin, 1982 (180)</td>
<td>Review</td>
<td>4,729</td>
<td>45</td>
<td>67</td>
<td>0.7</td>
<td>0.93, due to ruptured uterus in labour 4.7 one intra uterine death before labour</td>
<td>0</td>
<td>Success rate after CPD 33% 0</td>
</tr>
<tr>
<td>De Jong, 1987 (230)</td>
<td>South-Africa, prospective cohort, non randomised</td>
<td>212</td>
<td>26</td>
<td>39</td>
<td>0.5</td>
<td>0.93, due to ruptured uterus in labour 4.7 one intra uterine death before labour</td>
<td>0</td>
<td>Success rate after CPD 33% 0</td>
</tr>
<tr>
<td>Flamm, 1988 (222)</td>
<td>USA, prospective non-randomised</td>
<td>4,929</td>
<td>27</td>
<td>74</td>
<td>0.2</td>
<td>0</td>
<td>0</td>
<td>Success rate after: CPD 65%, Breach 85%, Fetal distress 71% 0</td>
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<tr>
<td>Jansen, 1989 (165)</td>
<td>the Netherlands, retrospective</td>
<td>462</td>
<td>62</td>
<td>83</td>
<td>0.2</td>
<td>6.5</td>
<td>0</td>
<td>Success rate after CPD 65% 0</td>
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<tr>
<td>Roumen, 1989 (164)</td>
<td>the Netherlands, retrospective</td>
<td>249</td>
<td>61</td>
<td>79</td>
<td>0.4</td>
<td>3.3</td>
<td>0</td>
<td>after 2 x CS (n=15); VBAC 27%, Success rate 67%; VBAC less: blood transfusion p=0.025, fever p=0.005</td>
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To be continued
<table>
<thead>
<tr>
<th>Reference</th>
<th>Country, Study design</th>
<th>n</th>
<th>VBAC Rate(^1) (%)</th>
<th>Success Rate(^2) (%)</th>
<th>Uterine rupture (%)</th>
<th>PNM/1,000</th>
<th>MMR</th>
<th>Other remarks</th>
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<tr>
<td>Flamm, 1990 (175). Flamm 1988 included</td>
<td>USA, prospective non-randomised</td>
<td>15,098</td>
<td>28</td>
<td>75</td>
<td>0.17 after TOL overall, 0.36 with oxytocin, 0.1 without oxytocin</td>
<td>0.17 due to ruptured uterus in labour</td>
<td>21/100,000</td>
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<tr>
<td>Rosen, 1991 (98)</td>
<td>USA, meta-analysis</td>
<td>17,564</td>
<td>17 - 40</td>
<td>40 - 74</td>
<td>5.7 after failed TOL OR 2.8; CI95, 1.4 - 5.4 0.7 after VBAC OR 0.7; CI95, 0.4-1.2 0.5 after ERCS (OR 1.0)</td>
<td>1.2 after TOL OR 0.8; CI95, 0.3-2.1 1.4 after ERCS excluding antenatal deaths, &lt; 750 g, congenital anomalies</td>
<td>28/100,000 after TOL 24/100,000 after ERCS</td>
<td></td>
</tr>
<tr>
<td>Mock, 1991 (223)</td>
<td>Ghana, retrospective</td>
<td>220</td>
<td>50</td>
<td>66</td>
<td>0.5</td>
<td>64</td>
<td>454/100,000</td>
<td></td>
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<tr>
<td>Van Roosmalen, 1991 (224)</td>
<td>Tanzania, retrospective</td>
<td>134</td>
<td>65</td>
<td>65</td>
<td>6.7</td>
<td>97</td>
<td>0</td>
<td></td>
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<tr>
<td>Van der Wijden, 1993 (225)</td>
<td>Lesotho, retrospective</td>
<td>74</td>
<td>56</td>
<td>56</td>
<td>0</td>
<td>27</td>
<td>0</td>
<td></td>
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<tr>
<td>Flamm, 1994 (226)</td>
<td>USA, prospective non-randomised</td>
<td>7,229</td>
<td>52</td>
<td>75</td>
<td>0.8</td>
<td>0</td>
<td>0</td>
<td>TOL compared to ERCS (p=0.0001): hospital stay, 57 vs 87 hours postpartum transfusion, 0.72 vs 1.72% fever, 12.7 vs 16.4% success rate after: 1 x CS success rate 83% 2 x CS 75%</td>
</tr>
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<td>Miller, 1994 (177)</td>
<td>USA, Retrospective</td>
<td>17,322</td>
<td>60</td>
<td>82</td>
<td>0.6 after 1 x CS 1.7 after 2 or more CS OR 3.06; CI95, 2.0-4.8</td>
<td>0.18 after 1 x CS 0.63 after 2 x CS due to ruptured uterus in labour</td>
<td>7.9/100,000</td>
<td></td>
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<tr>
<td>van der Walt, 1994 (231)</td>
<td>South-Africa, retrospective, 1 x CS</td>
<td>189</td>
<td>45</td>
<td>57</td>
<td>2.1</td>
<td>10.6</td>
<td>529/100,000</td>
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To be continued
<table>
<thead>
<tr>
<th>Reference</th>
<th>Country + Study design</th>
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<th>VBAC Rate$^1$ (%)</th>
<th>Success Rate$^1$ (%)</th>
<th>Uterine rupture (%)</th>
<th>PNM/1,000</th>
<th>MMR</th>
<th>Other remarks</th>
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<td>McMahon, 1996 (189)</td>
<td>Canada, retrospective, 1 x CS</td>
<td>6,138</td>
<td>32</td>
<td>60</td>
<td>major compl. (uterine rupture + hysterectomy + operative injury) 1.6 after TOL 0.8 after ERCs OR 1.8; CI$_{95}$ 1.1-3.0</td>
<td>9.0 after TOL 5.0 after ERCs p=0.09</td>
<td>Failed TOL compared to VBAC: Major complication 3.8 vs 0.2% (OR 5.1; CI$<em>{95}$ 2.8-9.4) Minor complications (fever, transfusion, wound infection) 9.3 vs 4.3% (OR 1.5; CI$</em>{95}$ 1.3-1.7) PNM and MMR based on 17 studies, 4,254 women</td>
<td></td>
</tr>
<tr>
<td>Boulvain, 1997 (232)</td>
<td>meta-analysis, sub-Saharan Africa</td>
<td>3,288</td>
<td>47</td>
<td>71</td>
<td>2.1</td>
<td>58</td>
<td>188/100,000</td>
<td></td>
</tr>
<tr>
<td>Spaans, 1997 (227)</td>
<td>Zimbabwe, retrospective</td>
<td>281</td>
<td>44</td>
<td>44</td>
<td>0.4</td>
<td>42.7</td>
<td>357/100,000</td>
<td></td>
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<tr>
<td>Rageth, 1999 (176)</td>
<td>Switzerland, retrospective cohort</td>
<td>29,046</td>
<td>45</td>
<td>74</td>
<td>0.4 after TOL 0.19 after ERCs RR 2.07; CI$_{95}$ 1.3-3.3</td>
<td>1.9 after TOL 0.9 after ERCs RR 2.14; CI$_{95}$ 1.07 - 4.27 &amp; &gt; 28 weeks excluding lethal anomalies</td>
<td>3/100,000</td>
<td>TOL compared to ERCs hysterectomy (RR 0.36; CI$<em>{95}$ 0.23-0.56) thrombo-embolic compl. (RR 0.52 CI$</em>{95}$ 0.34-0.78) Induction increased uterine rupture (RR 1.74; CI$_{95}$ 1.13-2.70)</td>
</tr>
<tr>
<td>Zelopp, 1999 (199)</td>
<td>USA, case-control, 1 x CS</td>
<td>2,774</td>
<td>na</td>
<td>na</td>
<td>0.7 after spontaneous labour 2.3 after induction p=0.001 number of ruptures: 29</td>
<td>0 only calculated for uterine rupture</td>
<td>6 hysterecomies after uterine rupture</td>
<td>2,214 women spontaneous labour 550 women induced with oxytocin/PGE$<em>2$ Induction with oxytocin increased uterine rupture (OR 4.6; CI$</em>{95}$ 1.5-14.1) TOL compared to ERCs: febrile morbidity (OR 0.70; CI$<em>{95}$ 0.64-0.77) blood transfusion (OR 0.57; CI$</em>{95}$ 0.42-0.76) hysterectomy (OR 0.39; CI$_{95}$ 0.27-0.57)</td>
</tr>
<tr>
<td>Mozurkewich, 2000 (99)</td>
<td>meta-analysis, review</td>
<td>47,682</td>
<td>44</td>
<td>72</td>
<td>0.4 after TOL 0.2 after ERCs OR 2.10; CI$_{95}$ 1.45-3.05</td>
<td>2.0 after TOL OR 2.05; CI$_{95}$ 1.17 - 3.57 &amp; excluding lethal anomalies and death before labour</td>
<td>10/100,000</td>
<td>3 in TOL group</td>
</tr>
</tbody>
</table>

*To be continued*
<table>
<thead>
<tr>
<th>Reference</th>
<th>Country + Study design</th>
<th>n</th>
<th>VBAC Rate¹ (%)</th>
<th>Success Rate² (%)</th>
<th>Uterine rupture (%)</th>
<th>PNM/1,000</th>
<th>MMR</th>
<th>Other remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appleton, 2000 (228)</td>
<td>Australia, retrospective, all prev. CS included</td>
<td>21,452</td>
<td>25</td>
<td>?</td>
<td>0.34 (estimated for TOL group) number of ruptures: 26</td>
<td>0.5</td>
<td>0</td>
<td>risk of hysterectomy due to uterine rupture 0.05%</td>
</tr>
<tr>
<td>Bais, 2001 (229)</td>
<td>the Netherlands, retrospective cohort</td>
<td>252</td>
<td>56</td>
<td>77</td>
<td>0.5 after TOL</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Hibbard, 2001 (190)</td>
<td>USA, retrospective, 2 x CS allowed</td>
<td>2,450</td>
<td>37</td>
<td>69</td>
<td>0 after ERCS 0.2 after VBAC 1.8 after failed TOL OR 8.9; Chns 1.9-42</td>
<td>0.8</td>
<td>0</td>
<td>hysterectomy 0.5% Failed TOL compared to VBAC: endometritis, 18.5 vs 3.4% (OR 6.4; Chns 4.1-9.8) RR 3.3; Chns 1.8-6.0 RR 4.9; Chns 2.4-9.7 RR 15.6; Chns 8.1-30.0</td>
</tr>
<tr>
<td>Lydon-Rochelle, 2001 (101)</td>
<td>USA retrospective cohort Para I, 1 x CS</td>
<td>20,095</td>
<td>?</td>
<td>?</td>
<td>0.16 after ERCS 0.52 spontaneous TOL 0.77 ind. without PGE; 2.45 induc. with PGE²</td>
<td>?</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>Thistle, 2001 (233)</td>
<td>Zimbabwe, retrospective</td>
<td>177</td>
<td>66</td>
<td>75</td>
<td>2 perinatal deaths: 1 puerperal syndrome 1 at 23 wks, no labour</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Yap, 2001(193)</td>
<td>USA, retrospective chart review of 21 ruptures</td>
<td>38,027</td>
<td>40</td>
<td>65</td>
<td>0.8 after prev. CS 0.01 without prev. CS</td>
<td></td>
<td>3.319 women with previous caesarean 19 uterine ruptures among previous caesarean 2 hysterectomies: after classical and unknown scar</td>
<td></td>
</tr>
<tr>
<td>Smith, 2002 (192)</td>
<td>Scotland, retrospective cohort, singleton births 37 - 43 wks</td>
<td>313,238</td>
<td>47</td>
<td>75</td>
<td>? 1.29 after TOL 0.11 after ERCS OR 11.6; Chns 1.6-86.7 TOL, 1 in 775 Nullipara, 1 in 1016</td>
<td>0</td>
<td>1x CS with TOL 15,515 women 1x CS with ERCS 9,014 women Nulliparas 137,160 women Multiparas with no prev. CS 151,549 women</td>
<td></td>
</tr>
</tbody>
</table>

¹VBAC Rate = (No. of VBACs/No. of women with previous caesarean sections) x 100
²Success Rate = (No. of VBACs/No. of women who had a trial of labour after caesarean section) x 100
1 x CS= one previous caesarean section
2 x CS= two previous caesarean sections
na= not applicable
1.6.2 VBAC, success rates and indicators for success

Many studies resulted in "evidence" or better named "obstetric consensus", that VBAC compared to elective repeat caesarean section has lower rates of postpartum fever, wound infection, blood transfusion, length of hospital stay and thrombo-embolic complications. The success rate after trial of labour (TOL) is high and varies between 45 and 80%. (Table 1.1, Flamm (175), Rageth (176), Mozurkewich (99), Miller (177), Rosen (98)). After previous caesarean for breech presentation and after previous vaginal delivery the success rate of TOL was almost 90% (178-180). In a meta-analysis of studies between 1982-1989, Rosen et al. calculated indicators for success and failure of trial of labour. He found lower VBAC rates after previous cephalopelvic disproportion and more than one previous caesarean section, and higher VBAC rates after previous breech presentation and previous vaginal delivery. Any previous indication, however, had a success rate of more than 50% (181). As long ago as 1991, after investigating morbidity and mortality of VBAC, Rosen et al. suggested to change Cragin's dictum into "Once a cesarean, a trial of labor should precede a second cesarean except in the most unusual circumstances" (98). Also, many studies have reported on high success rates of trial of labour after two or more previous caesarean sections. Success rates are comparable to success rates after one previous caesarean section (Table 1.2), but the overall VBAC rate among women with more than one previous caesarean section is lower, which means that many of those women deliver by elective repeat caesarean section.

Pelvimetry was suggested to predict the success rate of trial of labour after previous caesarean section (182-184). In Glasgow, Krishnamurthy et al. reviewed the case records including postpartum pelvimetries of 331 women delivered by caesarean section in their first pregnancy. The pelvis was considered to be inadequate in 248 (75%) of them and adequate in 83 (25%). Seventy-six women with a radiologically inadequate pelvis were allowed trial of labour and 67% (n=51) had a VBAC; among women considered to have an adequate pelvis, 73% (n=61) had a VBAC. These rates were not significantly different. In addition, three cases of uterine rupture occurred in women with a radiologically adequate pelvis (185). In Durban, South-Africa, Thubisi et al. randomly allocated 288 women to either X-ray pelvimetry at 36 weeks (n=144) or a trial of labour without ante-partum pelvimetry (n=144). All women in the control group underwent postnatal pelvimetry, which did not differ from the ante-partum group. The success rate after TOL of 84 women with adequate ante-partum pelvimetry was 28% (n=23, VBAC rate 16%). Women without ante-partum pelvimetry had a VBAC rate of 42% (OR 3.8; CI95% 2.0-6.8) (186). In Singapore among women with one previous caesarean
<table>
<thead>
<tr>
<th>Reference</th>
<th>n</th>
<th>VBAC Rate1 (%)</th>
<th>Success Rate2 (%)</th>
<th>Uterine rupture (%)</th>
<th>PNM/1,000</th>
<th>MMR</th>
<th>Other remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rivar, 1961 (166)</td>
<td>78</td>
<td>?</td>
<td>66</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Saldana, 1979 (168)</td>
<td>38</td>
<td>?</td>
<td>58</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Martin, 1983 (171)</td>
<td>192</td>
<td>10</td>
<td>63</td>
<td>0 after TOL</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Porreco, 1983 (196)</td>
<td>21</td>
<td>?</td>
<td>81</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Wadhawan, 1983 (234)</td>
<td>96</td>
<td>23</td>
<td>71</td>
<td>6.5</td>
<td>70</td>
<td>0</td>
<td>Study from Zambia, PNM due to low birth weight and asphyxias.</td>
</tr>
<tr>
<td>Farmakisides, 1987 (195)</td>
<td>121</td>
<td>36</td>
<td>77</td>
<td>1 silent dehiscence</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Pruett, 1988 (235)</td>
<td>55</td>
<td>?</td>
<td>45</td>
<td>5.5</td>
<td>0</td>
<td>0</td>
<td>2 hysterectomies after uterine defect after VBAC.</td>
</tr>
<tr>
<td>Novas, 1989 (236)</td>
<td>69</td>
<td>42</td>
<td>81</td>
<td>1.4</td>
<td>43</td>
<td>0</td>
<td>PNM not related to TOL or CS.</td>
</tr>
<tr>
<td>Phelan, 1989 (237)</td>
<td>1,088</td>
<td>32</td>
<td>69</td>
<td>1 after 2 x classic CS</td>
<td>24 after TOL</td>
<td>12 after TOL</td>
<td>PNM not related to TOL.</td>
</tr>
<tr>
<td>Flamm, 1990 (175)</td>
<td>245</td>
<td>?</td>
<td>69</td>
<td>not specified after 2 x CS</td>
<td>4.1</td>
<td>(ruptured uterus)</td>
<td></td>
</tr>
<tr>
<td>Hansell, 1990 (238)</td>
<td>170</td>
<td>16</td>
<td>77</td>
<td>0.7 after ERCS</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Granovsky-Grissar, 1994 (239)</td>
<td>52</td>
<td>37</td>
<td>73</td>
<td>2.9 after TOL</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Chattopadhyay, 1994 (240)</td>
<td>1,136</td>
<td>9</td>
<td>90</td>
<td>0.8 after TOL</td>
<td>26 after TOL</td>
<td>10 after ERCS</td>
<td>one after ERCS because of atomic bleeding</td>
</tr>
<tr>
<td>Miller, 1994 (177)</td>
<td>3,728</td>
<td>37</td>
<td>75</td>
<td>1.7 after TOL</td>
<td>0.55 after 2 or more CS</td>
<td>(ruptured uterus)</td>
<td></td>
</tr>
<tr>
<td>Asakura, 1995 (197)</td>
<td>435</td>
<td>45</td>
<td>64</td>
<td>2.0 after TOL</td>
<td>18 after failed TOL</td>
<td>46 after TOL</td>
<td>PNM in TOL group occurred before labour.</td>
</tr>
<tr>
<td>Caughey, 1999 (198)</td>
<td>2 x CS=134</td>
<td>?</td>
<td>62</td>
<td>3.7 after 2 x CS</td>
<td>15 after ERCS</td>
<td>0 after 2 x CS</td>
<td>1 maternal death related to uterine ruptures, not specified after 1, 2 or more prev. CS.</td>
</tr>
<tr>
<td></td>
<td>1 x CS=3,757</td>
<td>?</td>
<td>75</td>
<td>0.8 after 1 x CS</td>
<td>0.27 after 1 x CS</td>
<td>OR 4.8; CI 1.8-13.2</td>
<td></td>
</tr>
<tr>
<td>Bretelle, 2000 (241)</td>
<td>180</td>
<td>35</td>
<td>66</td>
<td>3.1 after TOL (dehiscence)</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Spaans, 2003(242)</td>
<td>246</td>
<td>20</td>
<td>83</td>
<td>1.7 after TOL</td>
<td>4.1</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

1VBAC Rate = (No. of VBACs/No. of women with previous caesarean sections) x 100
2Success Rate = (No. of VBACs/No. of women who had a trial of labour after caesarean section) x 100
1 x CS= one previous caesarean section
2 x CS= two previous caesarean sections
section, Wong et al. performed CT-pelvimetry in combination with ultrasound measurement of the fetal head and abdominal circumference (n=170). The calculated fetal-pelvic index had a positive predictive value of only 49% (187). The outcomes of these studies show that pelvimetry rather increases the repeat caesarean section rate and should no longer be used to decide on the mode of delivery after previous caesarean section (188).

### 1.6.3 VBAC and maternal and neonatal risks

In the USA, the VBAC rate increased from 1% in 1978, to a maximum of 28.6% in 1996, after which it decreased again (Figure 1.5) (113). VBAC is not without risk; the most serious complications are perinatal death and uterine rupture, which can be related or independent events. The risk of uterine rupture has been illustrated in several large studies (section 1.4.3.3). McMahon et al. (Table 1.1) found that major maternal complications were twice as common in women attempting trial of labour compared to those choosing elective repeat caesarean section (189). Major complications were five times as common in women with a failed trial of labour, compared to those who were successful and had a VBAC. In a meta-analysis of 15 studies, Mozurkewich et al. (Table 1.1) showed that women undergoing trial of labour were at significantly higher risk of uterine rupture compared to ERCS (0.4 vs 0.2%)

![Image](image.png)

**Figure 1.5** Caesarean section rate and VBAC rate in the USA (113;194)
(OR 2.10; CI_{95\%} 1.5-3.1) (99). Also, perinatal mortality differed significantly between these two groups (2/1,000 vs 1/1,000) (OR 2.1; CI_{95\%} 1.2-3.6). Rageth et al. (Table 1.1) reported from Switzerland that the risk of uterine rupture was twice as high in women attempting trial of labour, compared to women who elected repeat caesarean section (0.4 vs 0.19%) (RR 2.1; CI_{95\%} 1.3-3.3) (176). In addition, perinatal mortality was twice as high in this study after trial of labour (1.9/1,000 vs 0.9/1,000) (RR 2.1; CI_{95\%} 1.1-4.3). Hibbard et al. (Table 1.1) reported that women having a failed TOL had a higher risk of uterine rupture compared to VBAC (1.9% vs 0.2%) (OR 8.9; CI_{95\%} 1.9-42) (190).

Perinatal mortality and morbidity are highest among foetuses who experience complete extrusion into the maternal abdomen. In this subgroup, Leung et al. reported 14% perinatal death and Bujold et al. reported a strong association with severe metabolic acidosis of the newborn (pH < 7.0). But also without this severe stage of uterine rupture, significant fetal morbidity can occur. In both studies, even emergency caesarean section, 15 to 17 minutes after the onset of fetal heart rate decelerations, which is a sign of early uterine rupture, could not prevent severe neonatal morbidity (104;191). The risk of perinatal death is higher in women who attempt VBAC than in women who undergo planned caesarean delivery. This was confirmed by Smith et al. (Table 1.1) in a Scottish retrospective cohort between 1992-97, linking morbidity register records to stillbirth and neonatal death enquiry records (192). Among women who had a trial of labour following previous caesarean section, delivery related perinatal death was approximately 11 times higher than the risk associated with planned repeat caesarean section (OR 11.6; CI_{95\%} 1.6-86.7). The absolute risks, however, were small and the risk of perinatal death with a trial of labour was not significantly different from that of nulliparous women. In contrast to the above studies, Yap et al. reported that uterine rupture did not result in major morbidity. In San Francisco, between 1976 and 1998, he reviewed 21 uterine ruptures; 17 occurred after previous caesarean section (Table 1.1); two women with a history of previous caesarean section needed a hysterectomy; no maternal death occurred; at the time of discharge, there were no neonatal neurological abnormalities among neonates whose birth was complicated due to uterine rupture (193).

### 1.6.4 VBAC and risk of uterine rupture

Uterine rupture is one of the major complications of trial of labour after previous caesarean section. The risk of uterine rupture during labour is about 0.2 - 1.5% after a low transverse uterine incision (section 1.4.3.3). Several risk factors have been identified.
1.6.4.1 More than one previous caesarean section

The risk of uterine rupture increases with the number of previous caesarean sections. The first reports on selected patient groups with two or more previous caesarean sections were published by Riva et al., Saldana et al., Martin et al., Porreco et al., and Farmakides et al. (Table 1.2). The patient groups were small, hardly any complications were reported and the success rate after TOL was between 58% and 81% (166;168;195;196). Asakura et al. studied 435 women with more than one previous caesarean section. Uterine rupture or dehiscence occurred in 2.0% of women undergoing a TOL. After one previous caesarean section the uterine rupture rate was 1.1%, but the difference was not significant (Table 1.2) (197). Leung et al. conducted a case-control study of 70 patients with a uterine rupture. The risk of uterine rupture after two or three previous caesarean sections was increased to 2%, compared to 0.6% after one previous caesarean section (OR 2.6; CI95% 1.1-6.4). Uterine rupture was also significantly increased by oxytocin use (OR 2.7; CI95% 1.2-6.0) and dysfunctional labour (OR 7.2; CI95% 2.7-20.0). Epidural anaesthesia, macrosomia, previous vaginal delivery or previous cephalopelvic disproportion were not associated with uterine rupture (96). Miller et al. (Table 1.1 and Table 1.2) reported 10 years of experience with VBAC (177). Among women undergoing a TOL, uterine rupture was significantly more common with two or more previous caesareans (1.7%) than with only one (0.6%) (OR 3.1; CI95% 2.0-4.8) (177). Caughey et al. reported on women undergoing a trial of labour after one or two previous caesarean sections, in a 12 year period of (Table 2). The rate of uterine rupture was 0.8% and 3.7% respectively (OR 4.8; CI95% 1.8-13.2) (198).

1.6.4.2 Oxytocin and prostaglandins

Large studies by Flamm et al. and Rosen et al. (Table 1.1) have found no significant increase in the rate of uterine rupture when oxytocin is utilised during a trial of labour (98;175). However, in a study by Zelop et al. (Table 1.1), induction of labour with oxytocin after one previous caesarean delivery and no other deliveries was associated with a 4.6-fold increased risk of uterine rupture (CI95% 1.5 - 14.1). Increased risk of uterine rupture after PGE2 use did not reach significance after controlling for oxytocin induction and augmentation (199). In an additional case control study by Goetzl et al. (n=24), an analysis was done to investigate doses or patterns of oxytocin which might influence the risk of uterine rupture during a trial of labour after caesarean. No induction protocols or oxytocin levels could be identified which were without increased risk of uterine rupture (200). A large study examining the association of PGE2 gel (n=453) with risk of uterine rupture was conducted by Flamm et al.; uterine
rupture occurred in 1.3% (n=6), which was not significantly different from the 0.7% (n=33) uterine rupture rate in women who were not treated with PGE₂ (n=4,569) (201). Lyon-Rochelle (Table 1.1) analysed data of a retrospective cohort of primiparous women who gave birth to live singleton infants by caesarean section. In their next pregnancy, the rates of uterine rupture in women with ERCS, spontaneous labour, labour induced without prostaglandins, and prostaglandin-induced labour were 0.16% (n=15), 0.52% (n=56), 0.77% (n=15) and 2.45% (n=9) respectively (101). The study was criticised because International Classification of Disease codes (ICD-9) from hospital discharge data were used to identify cases of uterine rupture, but these data were not validated by a review of the women's charts (202;203). In additional studies, however, the risk of prostaglandins was again identified by Ravasia et al., who evaluated 2,119 trials of labour. The relative risk of uterine rupture with PGE₂ use versus spontaneous trial of labour was 6.41 (CI₉⁵₉ ².₁ -2₀.₀). The absolute risks of uterine rupture were 0.45% (7/1544) after spontaneous onset of labour, 0.74% (3/403) after induction of labour without prostaglandins and 2.9% (5/172) after induction with prostaglandins (204). Taylor et al. reported on 790 trials of labour with an overall uterine rupture rate of 1.8%. With PGE₂ use the uterine rupture rate was 10.3% (6/58); without PGE₂ the uterine rupture rate was 1.1% (8/732) (p<0.05) (205).

1.6.4.3 Influence of induction on success rates of TOL

A recent study by Delaney et al. on spontaneous labour (n=2,943) versus induced labour (n=803) after previous caesarean delivery reached no statistically significant levels for higher uterine rupture rates after induction (0.7% vs 0.3%; p=0.128). After induction, however, caesarean delivery was more frequent than after spontaneous onset of labour (38% versus 24%; OR 1.8; CI₉⁵₉ ¹.₅ - ².₃) (206). Zelop et al. studied women before (n=1,504) and after (n=1,271) 40 weeks of gestation. Overall, rate of caesarean section was higher for women after 40 weeks (35.4% compared to 26.7%, p<0.001). Induction of labour after 40 weeks resulted in 43.0% caesarean sections (p=0.03). In this study, uterine rupture did not significantly change by induction (207). Sims et al. (n=236) found 51% repeat caesarean section after induction of labour, compared to 26% after spontaneous onset of labour, among women with no previous vaginal delivery, but also no increased rate of uterine rupture (208).

1.6.4.4 Interdelivery interval

In two studies, the risk of uterine rupture was related to the time-interval between caesarean section and subsequent trial of labour. Shipp et al. reported a three fold increase with an
interval of less than 18 months (OR 3.0; CI\textsubscript{95\%} 1.2-7.2) and Bujold et al. calculated a two to three fold increase after an interval of less than 24 months (OR 2.65; CI\textsubscript{95\%} 1.08-5.46) (209;210). Huang et al. found no influence of interdelivery intervals on the rate of symptomatic uterine rupture (211).

1.6.4.5 Previous postpartum fever
Shipp et al. conducted a case-control study to investigate whether fever after previous caesarean section was associated with the risk of uterine rupture. Fever was defined as a temperature above 38\(^\circ\)C. Postpartum fever was more frequent in patients with uterine rupture (8/21;38\%) than in the controls (13/84;15\%). Multiple logistic regression associated fever with a four-fold increase in the risk of uterine rupture during subsequent trial of labour (OR 4.0; CI\textsubscript{95\%} 1.0-15.5) (212).

1.6.4.6 Single-layer closure
Single or double-layer closure of the uterus and its influence on subsequent uterine rupture has already been discussed in section 1.3.1 “surgical technique”.

1.6.4.7 Maternal age
In a study by Shipp et al., among women with only one previous caesarean section (no vaginal deliveries), the risk of uterine rupture increased in women older than 30 years (1.4\%) After excluding confounding factors like birth weight, induction, augmentation and interval delivery, the odds ratio was 3.2 (CI\textsubscript{95\%} 1.2 - 8.4) compared to women younger than 30 years of age (0.5\%) (213).

1.6.4.8 Previous vaginal deliveries
In the earlier mentioned case-control study by Leung et al., somewhat fewer patients with a uterine rupture than those in the control group had previously delivered vaginally (16\% vs 23\%, not significant) (96). In a study by Zelop et al., among pregnant women at term with one previous caesarean section, previous vaginal delivery was associated with one fifth the risk of uterine rupture, in comparison to pregnant women with no previous vaginal delivery (0.2\% vs 1.1\%, OR 0.2; CI\textsubscript{95\%} 0.04-08) (214).

1.6.4.9 Thickness of the lower uterine segment
Antenatal measurement by abdominal ultrasound of the lower uterine segment has been proposed to assess the risk of uterine rupture during trial of labour. Rozenberg et al.
conducted a study of 642 pregnant women with uterine scars to determine whether the thickness of the lower uterine segment late in pregnancy (36-38wks) was a predictor of uterine rupture and dehiscence during labour. The risk was 0% (0/278) with a lower uterine segment > 4.5 mm, 0.6% with a lower uterine segment 3.6-4.5 mm, 6.6% with a lower uterine segment 2.6-3.5 mm, and 9.8% with a lower uterine segment of 2.5 mm or less. In the population of Rozenberg et al., the uterine rupture rate was relatively high (2.3% and 1.7% dehiscence). His proposed cut-off thickness of 3.5 mm or less identified 29% of the population as being at high-risk for rupture, but only 7.4% of those identified actually had a rupture. At the moment, clinical value of this technique seems to be limited (215;216).

1.7 VBAC and guidelines

Studies published in the international literature have lead to several practice guidelines on vaginal birth after caesarean section. The guidelines of the Society of Obstetricians and Gynaecologists of Canada (SOGC), the American College of Obstetricians and Gynecologists (ACOG) and the Deutschen Gesellschaft für Gynäkologie und Geburtshilfe are summarised in Table 1.3. In the late 1980s and early 1990s, VBAC rates were rising steeply in the USA and obstetricians extended the trial of labour to women with more than one previous caesarean section, multiple pregnancy and suspected fetal macrosomia. Reports on the complications of trial of labour, however, raised concern about neonatal and maternal morbidity and liability claims (117). Until 1998, ACOG guidelines indicated that a physician capable of performing a caesarean section should be "readily" available when a VBAC patient is in labour (217). In July 1999, the ACOG changed the criteria to "immediately" available (32). Even though "immediately" was not defined, many obstetricians understood this as meaning a quicker response than "readily". Especially within the USA, the 1999 guideline on VBAC has been interpreted as requiring obstetricians and anaesthetists to be in-house for 24 hours a day. Hospitals without 24 hour coverage are afraid of facing liability claims if complications after trial of labour might arise. As a result, the optimism about VBAC in the USA was tempered and the VBAC rate is decreasing. In 2000 the VBAC rate was back at the 1989 level. The new ACOG guidelines have already been blamed for the observed decrease in VBACs (Figure 1.5) (218;219). In 2000, the ACOG Task Force on Evaluation of Cesarean Delivery restricted trial of labour to one previous low transverse caesarean delivery. Prostaglandins after a previous caesarean section are "out" since the report by Lydon-Rochelle (101). Based on this study, the ACOG published a committee opinion in 2002 on induction of labour for VBAC and discourages prostaglandins for cervical ripening or induction. Breech presentation after
previous caesarean section and trial of labour will most likely fade out, due to the publication of the term breech trial by Hannah et al. (157). Articles criticising this study will most likely not be able to stop the trend of repeat caesarean section for breech presentation in subsequent pregnancy (220;221).

After having reviewed the literature and international guidelines, it seems clear that there is world wide consensus on the success rates of trial of labour at least: in the majority of patients more than 50% of TOLs will be successful, irrespective of the indication for the previous caesarean section. However, research from the USA and the ACOG guidelines are trend setting. It might be high time for a European answer to the American way of risk perception of previous caesarean section.
| Table 1.3  Practice Guidelines for VBAC (32; 140; 243; 244) |
|-------------------------------|-----------------|---------------------------------|
|                               | SOGC\(^1\) 1997 | ACOG\(^2\) 1999/ Task force on Caesarean / Committee opinion 2002 | DGGG\(^3\) 2000 |
| Contra-indications to VBAC    | Previous: classical cs, inverted T or unknown scar, myomectomy, uterine rupture. Placenta praevia, transverse lie. Other contra-indications to labour (obstetric/medical). | Previous: classical cs, T-shaped or transfundal surgery, uterine rupture or contracted pelvis. Obstetric or medical complication precluding vaginal delivery. | Previous: classical cs, uterine rupture, or contracted pelvis. Obstetric or medical complication precluding vaginal delivery. |
| Candidates for trial of labour | Women with one or more than one previous CS, breech or twin pregnancies. | Women with one previous CS, singleton and vertex. Oxytocin allowed. Prostaglandins discouraged. | Women with one or more than one previous CS, breech or twin pregnancies. Oxytocin allowed. Prostaglandins, safety not established. |
| Medication                    | Oxytocin allowed. Prostaglandins, safety not established. |                                                |                                                |
| Fetal monitoring during trial of labour | In cases of induction or augmentation continuous electronic fetal heart rate monitoring necessary | Continuous fetal heart rate monitoring recommended. | Not mentioned. |
| Analgesia                     | Not mentioned. | Epidual allowed | Epidual allowed |
| External version of breech presentation after previous CS | Not mentioned. | Limited data suggest it can be successful | not contra-indicated. |
| Place of trial of labour after previous CS | Hospital equipped for obstetrical care | Institution equipped to emergencies, with physicians immediately available to provide emergency care. | In institution which can perform emergency caesarean section within a short span of time. |

\(^1\) SOGC = Society of Obstetricians and Gynaecologists of Canada  
\(^2\) ACOG = American College of Obstetricians and Gynecologists  
\(^3\) DGGG = Deutsche Gesellschaft für Gynäkologie und Geburtshilfe
1.8 Aim of the thesis

The aim of this thesis is to address the following questions:

1. Why have caesarean section rates increased?
2. What is the use and effectiveness of African maternity waiting homes, especially with respect to previous caesarean section?
3. Is a trial of labour after previous caesarean section safe for mother and child in rural Africa?
4. What are the risk factors at caesarean section which predict failure of a trial of labour in subsequent pregnancy?
5. Is a trial of labour after two or three previous caesarean sections safe for mother and child?
1.9 Outline of the thesis

Chapter 1 describes history, development, technique and safety of caesarean section. The caesarean section rates worldwide are outlined and discussed. Background information on VBAC with an overview of relevant literature is given and international guidelines on VBAC are compared.

Chapter 2 outlines the history, geography and demography of Zimbabwe and Mberengwa District. The concept of maternity waiting homes is introduced and reviewed. It describes two studies from Zimbabwe. One is on the use of maternity waiting homes in Mberengwa District in Zimbabwe; the number of home and hospital births, district caesarean section rate and district VBAC rate are assessed. The other study contains information on trial of labour after previous caesarean section in hospital births; maternal and neonatal outcome, indication for the primary caesarean section, success rate and VBAC rate are described; predicting factors for VBAC are investigated.

Chapter 3 gives background information on obstetric care in the Netherlands, together with an overview of Dutch dissertations which have caesarean section as their major subject. It describes two studies on trial of labour in the Netherlands. The first study investigates at the Academic Medical Centre of Amsterdam women with one previous caesarean section; the indications for the first caesarean section, the number of trial of labours, and the number of successful trial of labours are described; factors in the previous labour experience and factors in the next labour experience that may predict failure of a trial of labour are studied. The second study focuses on trial of labour after two or three previous caesarean sections at the Academic hospitals of Leiden and Amsterdam; the success rate, induction rate, neonatal outcome and maternal outcome are described.

Chapter 4 discusses the aims of this thesis in relation to the literature and the studies presented in chapter one, two and three.

Finally, a summary and guidelines for vaginal birth after caesarean section are given.
References chapter 1


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