

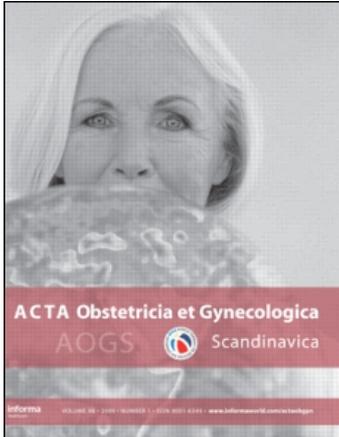
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### Severe maternal morbidity and the mode of delivery

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ORIGINAL ARTICLE

## Severe maternal morbidity and the mode of delivery

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### Abstract

**Objective.** To define the rate of severe maternal morbidity in different modes of delivery and to find out if the rate of severe morbidity has changed over a 5-year time span. **Design.** Retrospective register-based study. **Setting.** Finnish Medical Birth Registry and Hospital Discharge Registry. **Population.** All singleton deliveries in Finland in 1997 and 2002 ( $n=110,717$ ). **Methods.** Diagnoses and operative interventions recorded in the Hospital Discharge Registry indicating a severe maternal complication were linked with Birth Register data and compared by mode of delivery: spontaneous vaginal delivery (VD), instrumental VD, elective cesarean section and non-elective cesarean section. Main outcome measures were severe maternal morbidity: deep venous thromboembolism and amniotic fluid embolism, major puerperal infection, severe hemorrhage, events requiring operative intervention after delivery, uterine rupture and inversion, and intestinal obstruction. **Results.** Severe maternal morbidity was more frequent in cesarean than vaginal deliveries ( $p<0.001$ ), and more frequent in non-elective than in elective operations ( $p<0.001$ ). The rate of severe maternal morbidity increased considerably from 1997 to 2002; from 5.9 to 7.6 per 1,000 in all deliveries ( $p<0.001$ ), from 4.0 per 1,000 to 5.2 per 1,000 in spontaneous vaginal deliveries ( $p=0.005$ ), from 9.9 per 1,000 to 12.1 per 1,000 in elective cesarean sections (CSs) ( $p=0.164$ ), and from 19.6 per 1,000 to 27.2 per 1,000 in non-elective CSs ( $p=0.090$ ), respectively. **Conclusions.** Severe maternal morbidity has increased both in cesarean and vaginal deliveries from 1997 to 2002. Cesarean delivery, even an elective one, carries a significantly higher risk of life-threatening maternal complications than VD.

**Key words:** Maternal morbidity, caesarean section, vaginal delivery

**Abbreviations:** CS: caesarean section, VD: vaginal delivery

### Introduction

The optimal rate of cesarean sections (CSs) with minimal risks to both the mother and the fetus is not known, but it has been estimated that a rate exceeding 10–15% does not benefit the neonate, but increases maternal morbidity (1–4). An elective CS before the onset of labor may even be unfavorable to the child (5–8). Although many studies show that the risk of overall maternal complications is higher in cesarean than in vaginal delivery (VD), the CS rate has increased in all industrialized countries during last decades (9–13). In Finland, the rate of CS has increased from 7.9% in 1975 to 16.6% in 2002.

There is a common belief that because of high quality of modern obstetric and anesthetic care, CS today is a relatively safe procedure and may be performed even without a strict medical indication (14). The counseling of families about the safety of different modes of delivery is a daily task for obstetricians. To add current data on this decision-making process we investigated severe maternal morbidity by the mode of delivery.

### Material and methods

To evaluate severe maternal morbidity in different modes of delivery, we analyzed all singleton deliveries in Finland in 1997 and 2002,  $n=110,717$

(57,149 and 53,568, respectively). The data for the study were combined from the nationwide Medical Birth Registry and Hospital Discharge Registry provided by the National Research and Development Centre for Welfare and Health (STAKES), Finland. These registers collect all data on birth, death and hospital inpatient discharges, including all diagnoses and surgical procedures. All births with pregnancy duration of  $\geq 22$  weeks or a fetus weighing  $\geq 500$  g are included. Multiple births (1.6 and 1.5% of all births, respectively) were excluded because of the high risk of complications typical to these deliveries.

The year 1997 was chosen as the first study year because the ICD-10 coding system was introduced in 1996. ICD-10 was assumed to be familiar to health care staff by 1997 and the registers to be more reliable than during the first year of the new coding system. The year 2002 was chosen to reflect the situation five years later.

All maternal diagnoses (based on ICD-10 codes) and operative interventions (based on Nordic Classification of Surgical Procedures) indicating a severe maternal complication (according to Table I) that were registered at the time of delivery and within six weeks after the delivery were recorded. The diagnoses and operative interventions were linked with Birth Register data by using the individual national identification number of each woman. Severe maternal morbidity was defined as the presence of one or more of the following complications: thromboembolism (deep venous thrombosis, pulmonary embolism and amniotic fluid embolism), major puerperal infection (peritonitis and sepsis), severe hemorrhage, events requiring post-delivery operative intervention (Table I), uterine rupture, uterine inversion, and intestinal obstruction. Delivery-related hysterectomies, cases with obstetric coagulation disorder, and patients requiring reoperation because of hemorrhage, were recorded as cases of severe hemorrhage because in the Finnish Birth Register data on blood transfusions or the severity of hemorrhage are not collected. Nor can severe peripartum hemorrhage ( $>1,500$  ml) be separated from less severe hemorrhage ( $>500$  ml but  $<1,500$  ml) by the ICD code.

Severe maternal morbidity in elective CS (planned, before labor), non-elective CS, spontaneous VD (including vaginal breech delivery), and instrumental VD (vacuum/forceps) was evaluated and compared between the groups. The rate of maternal morbidity between elective CS and attempted VD (including spontaneous VD, instrumental VD, and non-elective CS) was also compared, because non-elective CS and instrumental VD can be considered as a consequence of an attempted VD. To define long-term risks of CS,

Table I. The diagnoses and operative interventions indicating a severe complication.

Diagnoses	
ICD-10:	Thromboembolic disease I26.9, I80.1, I80.29, I80.8, I80.9, O87.1, O88
	Hemorrhage O67.0
	Infections K65.0, K65.9, O85
	Intestinal obstruction K56
	Uterine rupture O71.0, O71.1, O71.2
	Uterine inversion O71.2
Operative interventions – Nordic Classification of Surgical Procedures	
Hysterectomy (total and subtotal)	
LCC10	Subtotal hysterectomy
LCD00	Total hysterectomy
MCW00	Hysterectomy related to a delivery
MCA30	Cesarean section and subtotal hysterectomy
MCA33	Cesarean section and total hysterectomy
Reoperations	
MWA00	Repair of wound dehiscence in obstetric surgery
MWC00	Reoperation for deep infection in obstetric surgery
LWA00	Repair of wound dehiscence in gynecological surgery
LWE00	Reoperation for deep hemorrhage in gynecological surgery
LWF00	Reoperation for insufficiency of anastomosis or suture in gynecological surgery
LWW96	Other reoperation in gynecological surgery
MWE00	Reoperation for deep hemorrhage in obstetric surgery
MWW96	Other reoperation in obstetric surgery
JAH00	Explorative laparotomy
JAH96	Other explorative abdominal operation
JAK00	Laparotomy and drainage of peritoneal cavity

we compared the risk of placenta previa, uterine rupture and peripartum hysterectomy between women with and without a previous CS.

The differences in the incidences of different complications by the mode of delivery and by year were analyzed with a *t*-test for relative proportions. Risk ratios with 95% confidence intervals were calculated for each outcome by the mode of delivery with spontaneous VD as the reference. Risk ratios for elective CS using attempted VD as the reference were also calculated. The difference in the incidence of complications by the mode of delivery and by year was considered significant at a level of  $p < 0.05$ .

The study was approved by the Ethics Committee of the Hospital District of Southwest Finland. The National Research and Development Centre for Welfare and Health (STAKES) of Finland granted permission to use national register data.

## Results

The rate of CS in singleton deliveries was 15.3 and 16.1% in 1997 and 2002, and of instrumental VD 5.4 and 6.3%, respectively. The rate of severe maternal morbidity in all singleton deliveries increased from

Table II. Number of mothers with a severe complication during singleton delivery and six weeks after, by the mode of delivery, in Finland in 1997 and 2002.

Type of complication	CS – elective		CS – non-elective		Instrumental VD		Spontaneous VD		All deliveries	
	1997 ( <i>n</i> = 4,533)	2002 ( <i>n</i> = 4,644)	1997 ( <i>n</i> = 4,231)	2002 ( <i>n</i> = 4,004)	1997 ( <i>n</i> = 3,117)	2002 ( <i>n</i> = 3,362)	1997 ( <i>n</i> = 45,269)	2002 ( <i>n</i> = 41,558)	1997 ( <i>n</i> = 57,149)	2002 ( <i>n</i> = 53,568)
Thromboembolism	2	7	5	4	1	2	17	17	25	30
Hemorrhage										
Obstetric coagulation disorder	0	0	1	5	0	0	3	2	4	7
Reoperation for hemorrhage	19	13	19	30	2	3	4	4	44	50
Peripartal hysterectomy*	3	8	6 (-2)*	11 (-3)*	4 (-1)*	0	8 (-1)*	9 (-2)*	21 (-4)*	28 (-5)*
Major infection										
sepsis	10	20	21	21	14	13	126	165	171	219
Peritonitis	0	0	3	1	0	0	0	1	3	2
reoperation for infection	2	1	8	11	1	0	3	6	14	18
Reoperation, other	3	4	5	10	1	1	6	7	15	22
Intestinal obstruction	0	0	2	0	0	0	1	0	3	0
Uterine rupture	6	3	15	19	4	7	12	6	37	35
Uterine inversion	0	0	0	0	0	1	2	3	2	4
All complications ( <i>n</i> )	45	56	83	109	26	27	181	218	335	410
All complications per 1,000 deliveries	9.9	12.1	19.6	27.2	8.3	8.0	4.0	5.2	5.9	7.6

\*The cases that are registered both with hysterectomy and uterine rupture (*n* = 6), DIC (*n* = 1) or uterine inversion (*n* = 2) are reduced from the hysterectomy number to avoid counting them twice.

CS, cesarean section; VD, vaginal delivery.

Table III. The rate of severe maternal morbidity per 1,000 singleton deliveries and the change in the rate in different modes of delivery from 1997 to 2002.\*

	Elective CS	Non-elective CS	Vaginal delivery†	Attempted vaginal delivery‡	All deliveries
Thromboembolism	0.4→1.5 $p=0.051^*$	1.2→1.0 $p=0.674^*$	0.4→0.4 $p=0.348^*$	0.4→0.5 $p=0.403^*$	0.4→0.6 $p=0.171^*$
Major infection	2.6→4.5 $p=0.067^*$	7.6→8.2 $p=0.575^*$	3.0→4.1 $p=0.002^*$	3.3→4.5 $p=0.002^*$	3.3→4.4 $p=0.001^*$
Hemorrhage	4.8→4.5 $p=0.592^*$	5.7→10.7 $p=0.022^*$	0.4→0.4 $p=0.387^*$	0.9→1.2 $p=0.025^*$	1.2→1.5 $p=0.054^*$
Other§	2.0→1.5 $p=0.709^*$	5.2→7.2 $p=0.241^*$	0.5→0.6 $p=0.450^*$	0.9→1.1 $p=0.168^*$	1.0→1.1 $p=0.220^*$
All severe complications	9.9→12.1 $p=0.164^*$	19.2→27.2 $p=0.090^*$	4.3→5.4 $p=0.005^*$	5.5→7.2 $p<0.001^*$	5.9→7.6 $p<0.001^*$

\*The difference in the rate of morbidity in 1997 and 2002 is compared with a *t*-test for relative proportions.

†Spontaneous VD and instrumental VD.

‡Including spontaneous VD, instrumental VD, and non-elective CS.

§Reoperations, uterine rupture, intestinal obstruction, and uterine inversion.

5.9 per 1,000 deliveries in 1997 to 7.6 per 1,000 deliveries in 2002 ( $p<0.001$ ; Tables II and III).

The rate of severe maternal morbidity was significantly higher both in elective and non-elective CS than in VD ( $p<0.001$ ), and higher in non-elective CS than in elective CS ( $p<0.001$ ; Table IV). Instrumental VD was associated with a higher risk of severe complications than spontaneous delivery ( $p<0.001$ ), but a lower risk than either mode of CS (Table IV). Elective CS carried a higher risk of complications than attempted VD ( $p<0.001$ ; Table V).

The relative risk of thromboembolism was two to three times higher related to CS than to VD. Because of small numbers of these patients the difference reached significance only in year 2002 (RR 3.0, CI 1.4–6.3,  $p<0.002$ ). The incidence of thromboembolism related to elective CS increased from 0.4 per 1,000 to 1.5 per 1,000 from 1997 to 2002 ( $p=0.051$ ; Table III). In non-elective CS and VD groups the incidence of thromboembolism did not change

(Table III). Amniotic fluid embolism accounted for two and air embolism for three out of the total 55 cases of thromboembolism in the study.

The rate of major puerperal infections increased significantly from 1997 to 2002 ( $p<0.001$ ; Table III). In the group of non-elective CS infections were most frequent, but constant between 1997 and 2002 ( $p=0.575$ ). In elective CS group the rate of infections increased from 2.6 per 1,000 to 4.5 per 1,000 ( $p=0.067$ ) and in VD group from 3.0 per 1,000 to 4.1 per 1,000 ( $p=0.02$ ). The rate of major puerperal infections did not differ significantly between elective CS, VD and attempted VD.

Cesarean section was associated with a significantly higher risk of hemorrhage compared to VD, with non-elective CS even higher ( $p<0.001$ ) than elective CS ( $p<0.001$ ). Elective CS was also associated with a higher risk of hemorrhage than attempted VD ( $p<0.001$ ; Table V). The incidence of massive hemorrhage increased in non-elective CS from 1997 to 2002 ( $p=0.022$ ), but not in elective CS and VD ( $p=0.592$  and  $p=0.387$ ; Table III).

Operative intervention after the delivery was significantly more frequent after CS than after VD in both years ( $p<0.001$ ), more frequent after non-elective CS than after elective CS ( $p=0.084$  in 1997,  $p<0.001$  in 2002), and more frequent after instrumental VD than after spontaneous VD ( $p=0.04$ ). The risk of a reoperation increased from 1997 to 2002 in non-elective CS ( $p<0.009$ ), but not in elective CS ( $p=0.157$ ). Surgical interventions were also more frequent in elective CS than in attempted VD ( $p<0.001$ ).

To evaluate long-term risks of a previously performed CS, the risk of placenta previa, uterine rupture and peripartur hysterectomy was compared between women with a history of CS(s) and women with no previous CS. Of all parturients, 8.0% in 1997 and 8.3% in 2002 had a history of one or several CSs. Placenta previa, uterine rupture and peripartur

Table IV. The risk of severe maternal morbidity in different modes of delivery in 1997 and 2002, risk ratios compared to spontaneous vaginal delivery.\*

Mode of delivery	Incidence per 1,000 deliveries	Risk ratio (95% CI)
1997		
Elective CS	9.9	2.5 (1.9–3.2); $p<0.001$
Non-elective CS	19.2	4.9 (4.2–5.8); $p<0.001$
Instrumental VD	8.3	2.1 (1.5–3.0); $p<0.001$
Spontaneous VD	4.0	1.0
All deliveries	5.9	NA
2002		
Elective CS	12.1	2.7 (2.2–3.4); $p<0.001$
Non-elective CS	27.2	6.1 (5.3–7.0); $p<0.001$
Instrumental VD	8.0	1.8 (1.3–2.6); $p<0.002$
Spontaneous VD	5.2	1.0
All deliveries	7.6	NA

\*Singleton deliveries.

NA, not analyzed.

Table V. Risk ratio of severe maternal morbidity in elective CS compared to attempted VD in 1997 and 2002, incidence per 1,000 deliveries.\*

Type of complication	Thromboembolism	Major infection	Hemorrhage	Other†	All severe complications	Risk ratio‡ (95% CI)
Attempted VD 1997	0.4	3.3	0.9	0.9	5.5	1.0
Elective CS 1997	0.4	2.6	4.8	2.0	9.9	1.8 (1.4–2.4) $p < 0.001$
Attempted VD 2002	0.5	4.5	1.2	1.1	7.2	1.0
Elective CS 2002	1.5	4.5	4.5	1.5	12.1	1.9 (1.5–2.4) $p < 0.001$

\*Attempted VD: including spontaneous VD, instrumental VD, and non-elective CS.

†Reoperations, uterine rupture, intestinal obstruction, and uterine inversion.

‡All severe maternal complications, elective CS compared to attempted VD.

1997: elective CS 4,532, non-elective CS 4,231, spontaneous VD 45,269, instrumental VD 3,117, and attempted VD 52,617.  
2002: elective CS 4,644, non-elective CS 4,004, spontaneous VD 41,558, instrumental VD 3,362, and attempted VD 48,924.

hysterectomy were significantly more frequent in women with previous CS ( $p < 0.001$ ; Table VI).

The risk of severe complications was compared between women  $< 35$  years and women  $\geq 35$  years. There were more severe complications in the group of women  $\geq 35$  years than in the younger group: 6.6 and 8.8 severe complications per 1,000 deliveries in 1997 and 2002, respectively, compared to 5.6 and 7.1 in the younger group. The difference between the age groups was significant in 2002 ( $p = 0.036$ ). The increase in severe complications was significant in both age groups ( $p = 0.002$  for the younger and  $p = 0.043$  for the older group).

## Discussion

This study indicates that despite advances in obstetric care, the rate of severe maternal morbidity related to the delivery has increased from 1997 to 2002.

Factors like advancing maternal age and obesity may account for the increased rates of severe complications (9,15,16). In Finland, the proportion of women giving birth at age  $> 35$  years has increased from 16.7% in 1997 to 19.2% in 2002. The Finnish Birth Registry did not register maternal height and pre-pregnancy weight in 1997 and 2002, but a Finnish study shows that the proportion of obese pregnant women (body mass index  $\geq 30$  kg/m<sup>2</sup>) has

increased from 7.5% in 1990 to 11% in 2000 and the trend continues (16).

Like several other studies, our study shows that CS, even an elective one, carries a higher risk for maternal complications than VD (8–12). The rate of severe maternal morbidity was three to four times higher in CS than in VD, as was presented also by Waterstone et al. by data collected during 1997–1998 in England (9) and Liu et al. by data collected during 1991–2005 in Canada (12). The morbidity in Finland was similar to that reported from England, but lower than in Canada. The frequency of severe maternal complications in different countries may vary due to differences in the definition of severe complication and data collection system.

All studies, including ours, have shown that CS carries a two- to fourfold risk for thromboembolism compared to VD (11,12,17). During the last decade, the incidence of thromboembolic events seems to have increased especially in CS. Also a Swedish group reported recently an increase in thromboembolic events during last decades (18). This may partly be explained by the increased number of obese parturients and women over the age of 35 years, but partly by the development of better diagnostic methods to detect thrombosis. Furthermore, it is possible that antithrombotic prophylaxis was not used in CS as widely as recommended.

Table VI. The incidence and risk ratio of periparturient hysterectomy, placenta praevia and uterine rupture in parturients with previous caesarean section (one or more) and in parturients with no previous caesarean section in Finland, years 1997 and 2002 combined.

	Incidence per 1,000 deliveries		Risk ratio*
	One or more previous CS	No previous CS	
Hysterectomy	1.8 (1.1/2.5)†	0.3 (0.3/0.3)†	5.3, CI (2.9–9.6); $p < 0.001$
Placenta praevia	6.0 (4.0/8.0)†	2.0 (2.2/1.7)†	3.0, CI (2.2–4.1); $p < 0.001$
Uterine rupture	3.4 (3.5/3.4)†	0.4 (0.4/0.4)†	8.5, CI (5.3–13.6); $p < 0.001$

\*Parturients with previous CS(s) compared to parturients with no previous CS.

†The incidence of complications per 1,000 singleton deliveries in 1997/2002. CI, 95% confidence interval.

In contrast to the results of most previous studies we found a similar risk of sepsis in elective CS and VD (8,11,19,20). In non-elective CS sepsis was two to three times more frequent than in VD. Perioperative prophylactic antimicrobial therapy is a routine in most Finnish hospitals in non-elective CS, but not in elective CS, but the use of antibiotics is not recorded in the registers. It is possible that the use of antimicrobial prophylaxis in non-elective CS has increased from 1997 to 2002, which could explain why the rate of major puerperal infection has not increased in non-elective CS while this happened in elective CS and VD.

The incidence of severe hemorrhage was lower in our study than in other studies (9,12). We included only the most severe cases with hysterectomy, coagulation disorder or reoperations in the study, while in other studies severe hemorrhage has been defined as blood loss over 1,500 ml, a drop in hemoglobin concentration  $\geq 40$  g/l or transfusion of four or more units of blood.

The most important long-term consequences of CS are the risk of placenta accreta, placenta previa and rupture of the uterine scar in subsequent deliveries, which often lead to massive hemorrhage and hysterectomy (13,21,22). Also in our study placenta previa, uterine rupture and peripartur hysterectomy were more common in women with a history of CS than without a history of CS. ICD-coding does not separate placenta accreta from other cases of placental retention, and therefore only the cases that lead to hysterectomy were included.

Our data are based on national registers, which allow analysis of a large number of deliveries, but have also its limitations. In general, data in the Medical Birth Registry and Hospital Discharge Registry are complete and their quality is high (23). A weakness in a register-based study is that it is not possible to analyze the individual pregnancies in detail. The indications for cesarean delivery are not known and may add an additional risk to the procedure. In several studies comparing elective CS to VD, women with pre-existing medical disorder or a risk factor such as pre-eclampsia, hemorrhage before the onset of labor, and delivery before 37 gestational weeks have been excluded from analysis, but the results are still in line with our findings (11–13,20). Women with severe pre-eclampsia, placental abruption or severe antepartum hemorrhage, all conditions which include a high risk of severe complications, are often delivered by non-elective CS, and a VD is not attempted. This distorts the

comparison of risks in favor of elective CS when compared to attempted VD in our study.

Some obstetricians accept the liberal use of elective CS instead of attempting VD which may turn into an emergency CS with high risk of complications. However, in our study, elective CS carried a significantly higher risk of severe complications than attempted VD (Table V).

In conclusion, severe acute and long-term maternal morbidity is significantly more frequent in CS, even an elective one, than in VD. Consequently, operative delivery without a medical indication should be avoided. Despite advances in obstetric and anesthetic care, life-threatening maternal complications appear to have increased during the last years both in CS and in VD, probably partly due to advancing maternal age and increasing obesity, both of which are factors that are not easily influenced by obstetricians.

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