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Title: Cesarean section complications according to degree of emergency during labour

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Abstract

Objective—Evaluate the complications rate of cesarean section delivery based on degree of labour emergency.

Study design—Monocentric (Lille, France), retrospective study of all term, singleton, and cesarean deliveries during labour. Three groups were categorized based on the degree of emergency according to a color code: green (no time limit between surgical decision and birth), orange (birth within 30 min), and red (birth within 20 min). Scheduled cesareans were excluded. Complications were defined as minor/major and intra-/post-operative.

Results—A total of 881 patients were included. Among these, 303 (34.5%) were in the green group, 353 (40.1%) in the orange group, and 225 (25.4%) in the red group. Major intra-operative complications, mainly postpartum hemorrhage, were more frequent in the red group compared with the green group (16.9% vs. 9.9%, $p=0.05$; OR 1.9; 95% CI [1.1–3.1]). Among the minor complications, there was no difference on moderate postpartum hemorrhage and four times uterine artery wounds in the red group (1.7% vs. 7.1%, respectively; $p=0.007$; OR 4.6; 95% CI [1.6–12.6]). The overall major post-operative complication rate, mainly infectious morbidity, was 6.1% and this was more frequent in the red group compared with the green group (12.4% vs. 1.7%, respectively; $p<0.0001$; OR 8.5; 95% CI [3.2–22.3]).

Conclusion—Pre- and post-operative complications of cesarean section delivery during labour (i.e., emergency cesarean) increase with the degree of labour emergency. It would be ideal to identify women in labour who are at increased risk of emergency cesarean earlier, so that the situation does not escalate to a red code cesarean.

Keywords—Cesarean section, color-coding, complications, postpartum hemorrhage, infection

Declarations:

Not applicable

Abbreviations

CI: confidence interval

PPH: postpartum hemorrhage

OR: odds ratio

Key message—Per- and post-operative complications of cesarean section during labour increase according to the degree of emergency.

Introduction

Although cesarean sections are commonly carried out, they are neither minor surgery nor without potential complications. Maternal morbidity is far higher with cesarean compared with vaginal delivery (1,2). In addition, the relative risk of death from an emergency cesarean is three times higher compared with a scheduled cesarean, which also has a higher risk of complications (2). Indeed, Van Ham et al. found that major complications (e.g., postpartum hemorrhage [PPH] \geq 1,000 mL, iterative laparotomy, pelvic infection, deep vein thrombosis, sepsis, pneumonia, and coagulation disorder) occur more frequently when a cesarean is performed following labour emergency (5.2%) compared with that prior to labour (2.6%) (3). The same has been reported for minor complications (e.g., endometritis, urinary infection, fever, anaemia, asthenia, abdominal pain), the incidence of which is significantly higher in emergency cesarean deliveries (34%) compared with those prior to labour (23.7%) (1,3,4). Most previous studies have compared emergency cesarean delivery, non-emergency cesarean following labour, and cesarean without labour. However, the level of emergency can vary during labour and complications are related to the level (5). Lucas et al. classified cesarean deliveries into three groups: very urgent, urgent, and not urgent (6). In 2003, Dupuis et al. proposed a color-coded communication tool to optimize the handling of labour emergencies, reduce the duration between the decision to operate and the birth, and to improve both maternal and neonatal outcomes (5). This color-coding process has been in place in our center since 2012.

The primary objective of this study was to evaluate complication rates with emergency cesarean delivery based on the degree of emergency using the color-coding system.

Methods

This retrospective cohort study with manual review of medical records was conducted in one center (Lille, France) from 1 January 2015 to 30 April 2017. It was approved by the local

committee “Commission Nationale de l’Informatique et des Libertés” (avis no. DEC16-206, 13/07/2017).

All cesarean deliveries that followed labour (i.e., unscheduled) for singleton pregnancies after 37 weeks’ gestation (based on last menstrual period) were included. The exclusion criteria were: scheduled cesarean (i.e., scheduled prior to labour), multiple pregnancies, foetus with a malformation syndrome, or *in utero* death.

Maternal characteristics, obstetric follow-up, and labour data were collected, including: gestational age, labour entry mode, cervical dilation, time of decision to proceed with cesarean, and associated color code (i.e., degree of emergency). The color-coding protocol followed in our center is based on that described by Dupuis et al (5). Modifications to the duration objectives between the decision to perform a cesarean and the birth were made following staff discussions at our center and included in the protocol. Red was used to identify cesarean deliveries to be performed fewer than 20 min after the surgical decision (hemorrhage from placenta praevia, placental abruption, umbilical cord prolapse, suspected uterine rupture, failure of operative vaginal delivery performed for abnormal fetal heart rhythm, acute fetal bradycardia without recovery, dystocia during second phase of labour with abnormal fetal heart rate, fetal blood sample with pH less than 7.20, and maternal seizure related to eclampsia or cardiac arrest). Orange indicated a duration of less than 30 min (operative vaginal delivery failure, fetal blood sample with pH between 7.20 and 7.25, persistent abnormal fetal heart rhythm, moderate hemorrhage from placenta praevia). Green indicated no time-based objective (failure to progress or abnormal presentation). The time of the cesarean, which may have been performed by the on-call team (between 6:00 pm and 8:00 am during weekdays or weekends), was also collected. During our study period, vaginal prep was not recommended. Prophylactic antibiotic treatment was administered during cord clamping using third-generation cephalosporins. Placental removal was performed by

umbilical cord traction, and suture skin closure was done. During cesarean delivery, we systematically weigh compresses and a collection bag is placed under the patient with an aspiration system to quantify the blood loss, deducting amniotic fluid.

Data collected regarding the cesarean delivery included: non-reassuring fetal heart rate (assessed by cardiotocography), cervical dystocia, failed instrument extraction, fetal presentation other than cephalic, cord prolapse, and uterine rupture.

As described by Van Ham et al., which is the main study on the specific subject of cesarean section during labour, we classified complications according to their degree (3). Intra-operative complications were categorized as minor (e.g., PPH \leq 1 L, vesical integrity test, fetal wound, uterine pedicle wound, hysterotomy sheared, and supplemental general anesthesia) or major (e.g., PPH $>$ 1 L, arterial ligation, uterine compression suture, uterine balloon tamponade, hemostasis hysterectomy, transfusion, and vesical or digestive wounds). Post-operative complications were also considered and categorized as minor (e.g., post-operative rehabilitation, hyperthermia defined as 38° twice, wound infection) and major (e.g., iterative sepsis, phlebitis, abscess, occlusive digestive syndrome, revision surgery, transfer to intensive care, death). Sepsis was defined as life-threatening organ dysfunction caused by a dysregulated host response to infection (Third International Consensus Definitions). Patients were followed up until discharge from the maternity ward.

Statistics

The study aimed to estimate prevalence rates of major post-operative complications among patients undergoing emergency cesarean section. According to the previous literature,³ this rate is \sim 5%. To accurately generalize to our target population, data from 881 patients were determined to be needed in order to achieve 3% accuracy (95% confidence interval [CI] [3.5–6.5%]). The three emergency-level color-coded groups were compared. Categorical variables

are reported as frequency and percentage; continuous variables are reported as mean and standard deviation. Normality was graphically verified using the Shapiro–Wilk test.

The three color-coded groups were compared using Chi-squared and Fisher exact probability tests for categorical variables and the Kruskal–Wallis test for continuous variables. In addition, we computed the odds ratios (ORs) and 95% CI using logistic regression. Statistical significance was considered when $p < 0.05$. Statistical analyses were performed using SAS software, version 9.4 (SAS Institute, Cary, NC, USA).

Results

A total of 881 patients were included. Among these, the distribution of emergency-level-based cesarean color codes were: 303 green (34.4%), 353 orange (40.1%), and 225 red (25.5%) (Figure 1). The primary indication for cesarean, non-reassuring fetal heart rate, was more frequent in the red group compared with the green group (63.6% vs. 0.7%, respectively; $p < 0.001$), as were failed instrumental extraction (18.7% vs. 0%, respectively; $p < 0.001$), cord prolapse (7.6% vs. 0%; $p < 0.001$), and uterine rupture (2.7% vs. 0%; $p < 0.001$). However, cervical dystocia (75.5% vs. 0.9%; $p < 0.001$) and non-cephalic presentation (11.3% vs. 1.3%; $p < 0.001$) were more frequent in the green group compared with the red group. The average decision-to-delivery interval was 37 ± 20 min for the green group, 20 ± 6 min for the orange group, and 12 ± 3 min for the red group, with a significant respect of the decision-to-delivery interval according to color code ($p < 0.001$). The decision-to-delivery interval was similar considering the operator level and the period.

Table 1 shows the population characteristics. Maternal age and body mass index were comparable between the three groups. There were more nulliparous women in the green group (74%) compared with the other groups ($p = 0.01$). More small-for-gestational-age infants were

observed in the orange group (7.1%) compared with the other groups (2.9% and 4.9% for the green and red groups, respectively; $p=0.05$).

Intra-operative complications are shown in Table 2. Among the minor complications, there was no difference between the three groups on PPH between 500 mL and 1000 mL. There were twice as many vesicle integrity tests performed for the red group compared with the green group (18.7% vs. 9.6%, respectively; $p=0.009$; OR 2.2; 95% CI [1.3–3.6]) and four times as many uterine artery wounds (7.1% vs. 1.7%, respectively; $p=0.007$; OR 4.6; 95% CI [1.6–12.6]). For patients with epidural anesthesia prior to cesarean section, supplemental general anesthesia was performed in 3.3% of the green group (10/303), 5.4% of the orange group (19/353), and 10.2% of the red group (23/225) ($p=0.003$). For patients without anesthesia before cesarean section, the rate of general anesthesia was 67% (42/62 patients). Among the major intra-operative complications, severe PPH >1 L occurred twice as often in the red group than the other groups (16% vs. 8.9%, respectively; $p=0.046$; OR 1.9; 95% CI [1.1–3.3]).

Post-operative complications are detailed in Table 3. For minor complications in the green, orange, and red groups, hyperthermia (3.6% vs. 5.9% vs. 12.9%, respectively; $p<0.001$) and wall infection (3.6% vs. 4.5% vs. 9.8%, respectively; $p=0.005$) were higher in the red group. For major post-operative complications, sepsis (1.3% vs. 2.8% vs. 5.8%, respectively; $p=0.013$), phlebitis (0% vs. 0.9% vs. 3.1%, respectively; $p=0.002$), and abscess (0% vs. 0.9% vs. 4.0%, respectively; $p<0.001$) were more common in the red group.

Discussion

In this study, evaluating the rate of complications according to the degree of emergency, through the use of the color-coding scheme, we found that per- and post-operative complications were higher, consistent with the degree of emergency. This information is

important for practice in labour wards and it would be clearly ideal to identify women in labour who are at increased risk of emergency cesarean earlier, so that the situation does not escalate to a “red” cesarean section.

In previous studies, the cesarean complications rate was compared with that of scheduled cesarean or vaginal birth, but not specifically compared according to the indication or to the degree of emergency (3,7-10). Van Ham et al.’s study is one of the main studies evaluating complications. They included a total of 2,647 women delivered by cesarean section and formed three cesarean section groups: (1) primary elective, (2) primary acute, without any effort to deliver vaginally, and (3) secondary acute, due to a failed vaginal delivery. They found that the overall maternal intra-operative complication rate was 14.8%. The most common complications were lacerations of the uterine corpus (10.1%) and blood loss $\geq 1,000$ mL (7.3%). The complication rate of the secondary acute group (23.4%) was significantly higher ($p < 0.001$) compared with both primary groups (7.4%). The overall maternal post-operative morbidity rate was 35.7%. They concluded that emergency cesarean section (without analysis according to the degree) was associated with a higher rate of complications compared with scheduled cesarean section. In our study, we observed a similar rate of intra-operative complications. PPH > 1 L was higher in our series than that reported by Van Ham et al., but was consistent with the French study by Misme et al (11). In their series of cesarean sections ($n=1,774$), Misme et al. observed a mean volume of bleeding equal to 557.9 mL (± 496.2 mL), a median volume of 400 mL (IQR [300–700]) and the 95th percentile was 1,300 mL [CI 95% 1200–1500]. In our series, optimal quantification of peripartum blood loss (weighed compresses, collection bag placed under the patient, and aspiration system with deduction of amniotic fluid) may be one reason for this increased rate.

One other main complication of cesarean section is infection. Indeed, it is associated with a 5-to-10-fold increased rate of infection at the operative site compared with vaginal delivery,

despite cephalosporin antibiotic prophylaxis (12-15). This rate is even higher when cesarean section follows labour (15-18). Studies have identified clinical features that are major risk factors for infection. Patients undergoing cesarean section who have had prolonged labour and rupture of membranes incur a 40–85% risk of endometritis. Infection occurs generally in less than 10% of women undergoing vaginal delivery (14). To decrease this risk, many actions can be proposed: prophylactic antibiotics (both cefazolin and azithromycin) at least 30 min before incision, chlorhexidine alcohol skin preparation, use of clippers instead of a razor, vaginal cleansing with povidone iodine, placental removal by umbilical cord traction, subcutaneous tissue closure if wound thickness >2 cm, and suture skin closure. In a quasi-experimental study, Kawakita et al. evaluated the impact of a protocol of prevention of infection for women undergoing cesarean delivery (19). A total of 1,624 women underwent cesarean delivery in the pre-implementation and 1,523 in the post-implementation periods, respectively; 1,100 women in the post-implementation period were also matched to 1,100 women in the pre-implementation period. The rate of surgical site infections in the unmatched cohort was significantly lower in the post-implementation period compared with those in the pre-implementation period (2.2% [33/1,523] vs. 4.5% [73/1,624]; OR 0.47 [95% CI 0.31–0.71]; p=0.001). This decrease in the rate of surgical site infections remained statistically significant after matching (1.9% [21/1,100] vs. 4.1% [45/1,100]; OR 0.46 [0.27–0.77]; p=0.001). In our center, during the study period, the only changes to the protocol proposed by Kawakita et al. was the absence of vaginal cleansing and use of chlorhexidine alcohol for skin preparation. Interestingly, our data show a higher rate of hyperthermia, wound infection, and sepsis in the red group. In the cases of acute emergency cesarean section, we can also hypothesize that skin preparation and also the delay in administering antibiotics before incision were not performed strictly according to the protocol, and this reflects the importance of the delay before decision and birth for neonatal outcome. In that situation, we also

observed other more frequent complications such as uterine pedicle wounds and bladder integrity tests.

Regarding post-operative complications, the rates reported in the literature vary from 10% to 85%, depending on whether the investigators included complications and the monitoring time. These usually affect 20–50% of deliveries (31% for Van Ham et al.), but this percentage can reach 85% when patients are interviewed at home (1-3). In thromboembolic complications, the need for a second surgery or transfer to intensive care is considered major; our findings agree with the literature on this major complications rate (20).

In conclusion, per- and post-complication rates increased according to the degree of emergency of the cesarean section. This may be related to the necessity of a rapid surgical procedure, but also to the context. Indeed, we can assume that this higher rate is also linked to the indication of the cesarean section in the red group (hemorrhage from placenta praevia, uterine rupture). Therefore, it seems important to respect color-code indications and prevent the situation from changing during labour and requiring a hyper-acute cesarean section. In the study by Bloc et al., all red code cesarean sections (n=38) were independently reviewed by four experimental obstetricians, including two external to the department (21). For each cesarean section, they had to confirm or reject the indication for “red code” cesarean section. Thirty-eight “red code” cesareans were performed during their study period. The indications were confirmed in 12 cases and rejected in 13 cases. Opinions were discordant in the 13 other cases. They concluded that a trivialization of this high-risk procedure and that indications should be restricted to avoid unjustified maternal and fetal complications. In our center, we observed in the same population of that study a significant consistency between the initial color code and the reassessed one, with a kappa agreement test of 95%CI 0.95 (0.93–0.97) (22). We can also note that the rate of “red code” cesareans was high in our center (25.5%) using the list of indications in our protocol. It would be interesting to re-evaluate it to

decrease the rate of hyper-acute cesarean sections.

Strengths and limitations

Our study focused specifically on cesarean complications during labour, based on the degree of emergency. Many studies have focused on cesarean section complications compared with those of vaginal birth, and scheduled versus emergency cesarean sections. However, to our knowledge, this is the first study to assess these complications based on the standard cesarean-section color-coding scheme. Although it was a retrospective study, we established a priori the number of patients required, with an expected 5% rate of major post-operative complications (6.1% observed). However, our analyses were limited to complications arising during the immediate post-operative period and thus excluded complications that may have arisen more than six weeks later, particularly infectious and thromboembolic complications (23-25). The choice of a composite variable that includes PPH with a threshold of 1 L for major complications, can also be discussed. To be able to compare our results and to calculate the number of subjects needed, we used the method proposed by Van Ham et al (3).

Conclusion

Pre- and post-operative complications of cesarean section delivery during labour (i.e., emergency cesarean) increase with the degree of labour emergency. It would be ideal to identify women in labour who are at increased risk of emergency cesarean earlier, so that the situation does not escalate to a “red” cesarean.

Author contribution:

C. Garabedian: Project development, manuscript writing

A. Grabarz: Manuscript writing, Data collection

V. Delporte, S.Bodart: Data collection

N. Ramdane: Data analysis

L. Ghesquière, V. Debarge, P. Deruelle, D. Subtil: Manuscript reading and correcting

Compliance with Ethical Standards:

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Conflict of Interest:

All authors report no conflict of interest.

Ethical approval:

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional. Study was approved by the local committee “Commission Nationale de l’Informatique et des Libertés” (avis no. DEC16-206, 13/07/2017).

Informed consent:

Informed consent was obtained from all individual participants included in the study.

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Tables

Table 1—Characteristics of the population and cesarean section groups

	Global N=881	Green N=303	Orange N=353	Red N=225	p
Age (years)	31±7	30±5	31±6	32±10	0.19
BMI (kg/m²)	26±6	27±7	26±6	25±6	0.09
Nulliparous	596(66)	223(74)	234(66)	139(62)	0.01
Previous C-section	153(17.4)	53(17.5)	70(19.8)	29(12.9)	0.09
Gestational diabetes	203(23.0)	79(26.1)	81(22.9)	42(18.7)	0.25
Hypertension	83(9.4)	29(9.6)	34(9.6)	19(8.4)	0.87
Pre-eclampsia	57(6.5)	20(6.6)	23(6.5)	13(5.8)	0.92
SGA	45(5.1)	9(2.9)	25(7.1)	11(4.9)	0.05
Induction of labour	464 (52.7)	184 (60.9)	180 (50.9)	99 (44.2)	<0.001
Cervical dilation at C-section (cm)	5±3	4±2	5±2	6±3	<0.001

BMI: Body Mass Index

SGA: Small for the gestational age

Results are presented as numbers (percentages) or mean ± standard derivation

Table 2—Intraoperative complications

	Global N=881	Green Code N=303	Orange Code N=353	OR	Red Code N=225	OR	p
Minor intra-operative complications							
PPH (500 mL – 1 L)	374(42.5)	128(42.2)	143(40.5)	0.9 (0.7–1.3)	103(45.78)	1.2 (0.8–1.6)	0.46
Bladder integrity test	124(14.1)	29(9.6)	53(15.0)	1.7 (1.0–2.7)	42(18.7)	2.2 (1.3–3.6)	0.009
Fetal wound	5(0.6)	1(0.3)	2(0.6)	–	2(0.9)	–	NA
Uterine artery wound	40(4.5)	5(1.6)	19(5.4)	3.4 (1.3–9.2)	16(7.1)	4.6 (1.6–12.6)	0.007
Unintended extension of the hysterotomy	60(6.8)	9(2.9)	32(9.1)	3.2 (1.5–6.9)	19(8.4)	3.0 (1.3–6.8)	0.004
General Anesthesia + Epidural	52(5.9)	10(3.3)	19(5.4)	1.7 (0.8–3.6)	23(10.2)	3.3 (1.6–7.2)	0.003
Major intra-operative complications							
PPH >1 L	106(12.0)	27(8.9)	43(12.2)	1.4 (0.9–2.4)	36(16)	1.9 (1.1–3.3)	0.046
Arteria ligature	6(0.7)	4(1.3)	2(0.6)	–	0(0)	–	NA
Compression suture	2(0.2)	1(0.3)	0(0)	–	1(0.4)	–	NA
Uterine balloon tamponade	3(0.3)	1(0.3)	2(0.6)	–	0(0)	–	NA
Hemostasis hysterectomy	1(0.1)	1(0.3)	0(0)	–	0(0)	–	NA
Transfusion	20(2.3)	3(0.9)	11(3.1)	3.3 (0.9–11.6)	6(2.7)	2.7 (0.7–11.1)	0.17
Vesical wound	13(1.5)	2(0.7)	8(2.3)	3.5 (0.7–16.6)	3(1.3)	2.0 (0.3–12.3)	0.23
Digestive wound	–	0(0)	0(0)	–	0(0)	–	NA

PPH: Postpartum hemorrhage

Results are presented as numbers (percentages). The OR derives from comparisons between the orange and the green groups and between the red and the green groups, respectively.

Table 3—Post-operative complications

	Global N=881	Green Code N=303	Orange Code N=353	OR	Red Code N=225	OR	<i>p</i>
Minor post-operative complications							
Hyperthermia	61(6.9)	11(3.6)	21(5.9)	1.7 (0.8–3.5)	29(12.9)	3.9 (1.9–8.0)	0.0001
Wall infection	49(5.6)	11(3.6)	16(4.5)	1.3 (0.6–2.8)	22(9.8)	2.9 (1.4–6.1)	0.005
Composite variable	797(90.5)	275(90.8)	316(89.5)	1.2 (0.7–2.3)	206(91.6)	2.7 (1.5–4.8)	0.70
Major post-operative complications							
Sepsis	27(3.1)	4(1.3)	10(2.8)	2.2 (0.7–7.0)	13(5.8)	4.6 (1.5–14.3)	0.013
Phlebitis	10(1.1)	0(0)	3(0.9)	–	7(3.1)	–	0.002
Abscess	12(1.4)	0(0)	3(0.9)	–	9(4)	–	0.0002
Scar disunion	37(4.2)	12(3.9)	12(3.4)	0.9 (0.4–1.9)	13(5.8)	1.5 (0.7–3.2)	0.37
Occlusive digestive syndrome	2(0.2)	0(0)	0(0)	–	2(0.9)	–	NA
Need for second surgery	14(1.6)	1(0.3)	6(1.7)	5.2 (0.6–43.6)	7(3.1)	9.7 (1.2–79.3)	0.03
Transfer to intensive care	3(0.3)	0(0)	2(0.6)	–	1(0.4)	–	NA
Death	0(0)	0(0)	0(0)	–	0(0)	–	NA
Composite variable	54(6.1)	5(1.7)	21(5.9)	3.8 (1.4–10.1)	28(12.4)	8.5 (3.2–22.3)	<0.001

Results are presented as numbers (percentages). The OR derives from comparisons between the orange and the green groups and between the red and the green groups, respectively.

Figure caption

Figure 1—Flow chart of the population during the study period

Figure

Figure 1 – Flow chart of the population during study period

