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Red, orange and green Caesarean sections: A new communication tool for on-call obstetricians

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Abstract

Objective: To evaluate the effect of a novel communication tool, related to the degree of urgency for Caesarean sections (CSs), on the decision-to-delivery interval for emergency CS.
Study design: Red CS are very urgent cases corresponding to life-threatening maternal or foetal situations, orange CS are urgent cases and green CS are non-urgent intrapartum CS. We carried out this cohort study in a French maternity hospital. The study included all emergency Caesarean sections during two 6-month periods, before and after introduction of the code. We compared the decision-to-delivery interval of the two study periods.
Results: Our study included 174 emergency CS. The mean decision-to-delivery interval after introduction of the code was 31.7 min, significantly shorter ($p = 0.02$) than the 39.6 min interval before introduction of the colour code. Except for the preparation time, each time interval decreased. This included transporting the patient into the operating theatre, and the incision-to-delivery time interval.
Conclusion: This study suggests that the use of the three-colour code could significantly shorten the decision-to-delivery interval in emergency CS. Further prospective studies are needed to confirm this result.

Keywords: Emergency Caesarean section; Decision-to-delivery interval; Degree of emergency; Quality of communication

1. Introduction

In 1969, Faro and Windle [1] showed that periods of anoxia exceeding 10 min induced irreversible cerebral injury in monkeys. Bujold and Gauthier [2] described three infants born 15, 16, and 23 min after the beginning of foetal bradycardia, all of whom developed ischaemic encephalopathy. Recently, Bloom and Leveno [3] reported a neonatal death from ischaemic encephalopathy in an infant born 33 min after the decision was made to operate. These findings highlight the importance of the time interval from the decision to perform a Caesarean section to the birth of the infant. In its committee opinion number 256, the ACOG stated that ''the availability of anaesthesia and surgical personnel should be sought to permit the start of a Caesarean delivery within 30 min of the decision to perform the procedure'' [4–6]. Various studies have demonstrated that the 30-min rule is not achieved in 29–61% of cases [7–11]. The same studies also showed that the decision-to-delivery interval (DTDI) in very urgent CS is significantly shorter than in urgent CS and that mean DTDIs have a broad range (11.4–42.9 min) [7,11–15]. These findings, associated with the large number of professionals involved in such situations

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(senior obstetrician, anaesthesiologist, midwife, anaesthesia nurse), raised the question of the relationship between quality of communication and team performance.

In 2000, Lucas et al. [16] suggested that CS should be classified into three groups according to degree of urgency. Unfortunately, this classification system was not supported with a communication tool enabling prompt communication of the CS urgency within the delivery team.

In March 2003, the first author implemented a three-colour code to facilitate communication of the degree of urgency for CS within the perinatal team. Red, orange and green CS corresponded to degrees of urgency from highest to lowest and to ideal DTDIs of, respectively 15, 30, and 60 min.

The aim of this study was to evaluate the impact of this new communication tool on the mean DTDIs in emergency CS.

2. Materials and methods

This study took place in the public University maternity hospital (Lyon, France) over two 6-month periods in 2000 and 2003. The maternity unit in this hospital provided immediate access to an on-call obstetrician, an anaesthesiologist, an anaesthesia nurse and three midwives 24 h a day. The delivery ward contains an operating theatre dedicated to CS.

Two 6-month periods were chosen: stage I, before introduction of the colour code, was from 1 January to 30 June 2000; stage II, after introduction of the code, was from 15 April to 14 October 2003. During stage I, the on-call obstetrician did not use any code to communicate the degree of CS urgency, but informed the delivery team of the urgency in his/her own manner. In March 2003, all senior obstetricians were informed of this new procedure and meetings were held to inform each member of the delivery ward (midwives, anaesthesiologists and junior obstetricians). A three-step method was used to educate the hospital staff: the written step was a letter defining the red, orange and green code (i.e. ideal DTDI of, respectively 15, 30 and 60 min [17]) that was sent to every anaesthesiologist and on-call obstetrician, the letter also suggested when to use a red, orange or green code. The visual step was a procedure posted in the medical office of the delivery room. Finally the ''oral'' step was a meeting held by the authors explaining the findings of the Faro and Bujold studies, defining the red, orange and green code and suggesting when to use a red, or orange code.

During stage II, the on-call obstetrician informed the team of the Caesarean code as soon as a CS was deemed necessary.

The decision time, time of arrival at the operating theatre, time of incision, time of delivery and indication of CS were ascertained from the ''Caesarean section file''. In our department, between 7 a.m. and 7 p.m. the midwife in charge of the surgical theatre systematically fills in a form (the so-called Caesarean section file) that includes more than 24 items, including those 5 data. Between 7 p.m. and 7 a.m., this operating file is filled in by the midwife in charge of the patient.

2.1.1. Inclusion criteria

We retrospectively included all emergency CS, i.e. those indicated for haemorrhage from placenta praevia, placental abruption, umbilical cord prolapse, suspected uterine rupture, failure of operative vaginal delivery, acute foetal bradycardia without recovery, persistent abnormal foetal heart rhythm and maternal seizure related to eclampsia. The non-urgent CS and those with unknown DTDIs were excluded.

Though the aim of this study was not to determine the effect of DTDIs on mother or infant, it was important to confirm that the introduction of the code did not have adverse effects. Thus, three neonatal criteria (neonatal death, umbilical artery pH < 7.00 and 5-min Apgar scores < 5) and three maternal criteria (maternal death, rate of transfusions and rate of re-interventions) were recorded from medical files.

2.2. Definitions

Prophylactic CS were defined as CS carried out before labour. CS performed during labour were classified according to degree of urgency into three groups: non-urgent, urgent and very urgent. The urgent and very urgent groups were considered emergency CS.

The following code procedures were defined: red CS indicated immediate life-threatening maternal or foetal situations with an ideal DTDI of 15 min; green CS indicated non-urgent situations with a DTDI of 60 min. All other cases were considered to be orange CS, indicating urgent situations with an ideal DTDI of 30 min. It was suggested that the red code be used in seven situations: haemorrhage from placenta praevia, placental abruption, umbilical cord prolapse, suspected uterine rupture, failure of operative vaginal delivery performed for abnormal foetal heart rhythm, acute foetal bradycardia without recovery and maternal seizure related to eclampsia. Use of an orange code was suggested for cases of operative vaginal delivery failure and for cases of persistent abnormal foetal heart rhythm. Use of a green code was suggested for CS performed due to failure to progress or to abnormal presentation. The on-call obstetrician used the above guidelines to determine the colour code he/she thought appropriate.

Four time intervals were defined. The DTDI (time elapsed between the decision to perform the CS and birth) was divided into subintervals: decision-to-operating theatre interval, preparation interval (from the arrival of the patient at the operating theatre to the incision) and incision-to-delivery interval.

The ''modified Joel-Cohen'' incision is defined by a skin incision performed at a lower level than that described by

Table 1
Very urgent and urgent CS: demographic, maternal and neonatal characteristics

	Stage I: without colour code ($n = 96$)	Stage II with colour code ($n = 78$)	p-Value[a]
Neonatal characteristics			
Children	99	78	
Birth weight in g (mean(S.D.))	3044 (792)	3028 (869)	0.90
Umbilical artery pH < 7	4/89 (4.5)	1/74 (1.3)	0.38
5-min Apgar score < 5	3/99 (3.0)	1/77 (1.3)	0.63
Maternal characteristics			
Age in years (mean(S.D.))	30.7 (4.8)	31.2 (4.5)	0.51
Parity (mean(S.D.))	0.46 (0.79)	0.36 (0.58)	0.37
Gestational age in weeks (mean(S.D.))	38.9 (3.3)	38.7(3.4)	0.72
Blood transfusion	2/96 (2.1)	2/77 (2.6)	1.00
Re-intervention	1/96 (1.0)	3/76 (3.9)	0.32
Multiple pregnancies	3/96 (3.1)	0/78 (0.0)	0.25
Previous Caesarean section	10/96 (10.4)	14/77 (18.1)	0.18
Modified Joel-Cohen's incision	47/96 (49.0)	65/77 (84.4)	**<0.001**
Epidural analgesia established at time of decision	70/96 (72.9)	59/78 (75.6)	0.73
Analgesia during Caesarean section			0.92
Top-up epidural analgesia	68/96 (70.8)	58/78 (74.4)	
Primary spinal analgesia	20/96 (20.8)	14/78 (18.0)	
Primary general anaesthesia	5/96 (5.2)	3/78 (3.9)	
Secondary general anaesthesia	3/96 (3.1)	3/78 (3.9)	

Values are n(%) unless specified otherwise.
[a] Student's t-test for quantitative variables and fisher exact test for qualitative variables.

Joel-Cohen, the other steps were performed as described by Joel-Cohen in [18].

2.3. Statistical analysis

Analyses were performed using SAS® software (version 9, SAS Institute Inc., Cary, NC, USA). Descriptive results were expressed in terms of percentages for qualitative data, and means and standard deviations for numeric data. Durations were also expressed in medians. The Student's t-test was used for analysis of the quantitative variables and the Fisher exact test for the qualitative variables. We studied the impact of the introduction of the colour code on the DTDI by comparing the primary outcome before and after introduction of the code using a Mann–Whitney test. The threshold for statistical significance was set at the 5% level ($p < 0.05$). The primary outcome was the mean DTDI. Secondary outcomes were decision-to-operating theatre interval, preparation and incision-to-delivery intervals.

3. Results

There were 1548 deliveries during stage I. Of these, 274 were by CS. We did not include 111 cases of prophylactic CS, 57 non-urgent cases and 10 cases with unknown DTDIs. Thus, 96 cases were included: 15 very urgent and 81 urgent CS.

There were 1390 deliveries during stage II. Of these, 273 were by CS. We excluded 114 cases of prophylactic CS, 71 non-urgent cases and 10 cases with unknown DTDIs. Of the 78 cases included, 14 were very urgent and 64 were urgent CS. In all, we studied 174 cases (145 urgent and 29 very urgent CS).

3.1. Patient characteristics (Table 1)

The demographic, organisational and neonatal characteristics of the stages I and II groups were similar. Anaesthesia methods were similar in both groups. The scarred uterus rate was not significantly different during stages I and II. The rate of modified Joel-Cohen's incision was significantly higher

Table 2
Comparison of time intervals for stages I and II (with colour code)

Mean interval time (min)	Stage I: without colour code $n = 96$		Stage II: with colour code $n = 78$		Mann–Whitney p-value
	Median	Mean (S.D.)	Median	Mean (S.D.)	
All Caesarean sections					
Decision-to-delivery	31	39.6 (31.5)	28	31.7 (16.0)	0.02
Decision-to-operating theatre	15	17.6 (15.1)	13	14.6 (9.7)	0.08
Preparation time	10	11.5 (6.8)	10	11.9 (8.3)	0.83
Incision-to-delivery	5	6.6 (3.5)	4	5.2 (2.8)	<0.001

Table 3
Comparison of time intervals for stages I and II (with colour code) for Cohen's incision

Mean interval time (min)	Stage I, $n = 65$		Stage II, $n = 47$		Mann–Whitney p-value
	Median	Mean (S.D.)	Median	Mean (S.D.)	
Cohen's sections					
Decision-to-delivery	30	37.4 (36.5)	27	28.7 (16.0)	0.22
Decision-to-operating theater	15	16.5 (13.4)	10	13.3 (7.6)	0.34
Preparation time	10	10.6 (6.3)	10	10.9 (7.0)	0.85
Incision-to-delivery	5	5.6 (3.3)	4	4.45 (2.2)	0.005

Table 4
Comparison of decision-to-delivery interval for stages I and II (with colour code) for "urgent" and "very urgent" cesarean section

DTDI (min)	Stage I				Stage II				p[a]
	n	Median	Mean	S.D.	n	Median	Mean	S.D.	
Urgent	81	35.0	42.5	32.93	64	30.0	34.4	16.21	<0.05
Very urgent	15	20.0	21.3	6.30	14	19.5	19.1	6.09	0.43

Legends: DTDI = decision-to-delivery interval.
[a] Mann–Whitney p-value.

during stage II (84.4%, $p < 0.001$) than stage I (49%). No maternal and two neonatal deaths occurred during each period. There was no significant change in maternal morbidity associated with the introduction of the colour code.

3.2. Interval time (Tables 2–4)

The decision-to-operating theatre interval represented 44.4% of the DTDI during stage I and 46% during stage II. The preparation interval represented 29% of the DTDI during stage I and 38.2% during stage II. The incision-to-delivery interval represented 16.6% of the DTDI during stage I and 16.4% during stage II.

After introduction of the code (stage II), the mean DTDI was up to 20% lower than during stage I (Table 2) and the incision-to-delivery interval was up to 21.2% lower.

If we restricted statistical analyses to include CS performed with Cohen's incision, we observed shorter intervals during stage II for incision-to-delivery (20.5% shorter, 4.45 ± 2.2 min during stage II and 5.6 ± 3.3 min during stage I, $p < 0.01$).

Sub-analyses were performed for very urgent and urgent CS independently (Table 4). The decision-to-delivery interval decreased significantly in the "urgent" group ($p < 0.05$), but the difference was not significant for the "very urgent" cases.

4. Discussion

This study suggests that the DTDI can be shortened by using a code designed to improve communication of the degree of CS urgency to the perinatal team.

The global decrease in the DTDI concerns two components of this time interval: decision-to-operating theatre interval as well as incision-to-delivery interval. However, the preparation interval remained without significant change. Decision-to-operating theatre, preparation and incision-to-delivery intervals composed a decreasing rate of the global DTDI, respectively. Our findings are consistent with previous reports [7,8]. Thus, factors that shorten the decision-to-operating theatre interval or the preparation interval should have a large impact on the global DTDI. Factors that modify only the incision-to-delivery interval should have limited impact. It has effectively been shown that Cohen techniques only shorten the time from incision to delivery by between 50 s and 2 min [19,20], whereas implementing the code decreased the time in the decision-to-operating theatre interval by 3 min. These three intervals also differ from each other because there are different numbers of personnel involved during the various intervals: whereas midwives, an anaesthesia nurse, anaesthesiologists, nursing auxiliary, and obstetricians are involved during the decision-to-operating theatre interval and the preparation interval, the obstetrician is the only person involved in the incision-to-delivery interval.

During the decision-to-operating theatre interval, team members are called and the patient is prepared and moved into the operating theatre. This study suggested that a clear communication tool could help decrease the delivery-to-operating-theatre intervals. The time gained by appropriate communication of the degree of CS urgency may be due to rapid top-up of the epidural analgesia, prompt transport of the patient into the theatre and rapid bladder evacuation. Considering the importance of the decision-to-operating theatre interval, various authors have recommended that the emergency CS be performed in the delivery room. However, this may expose the patient to additional risks, including infection and the absence of anaesthesia equipment.

Preparation time includes preparation of an adequate analgesia by the anaesthesia team and preparation of the surgical equipment for CS. Implementing the colour code did not significantly shorten this interval. Various authors

have demonstrated how teams of anaesthesiologists influence the length of the DTDI. Tuffnell et al. [8] showed that 40% of DTDIs exceeding 50 min were associated with anaesthesia factors (e.g. waiting for epidural top-up or multiple attempts at spinal analgesia). In 1990, Morgan insisted that communication between the obstetrical and anaesthesia teams was an important factor [21]. Our study showed that use of the code did not significantly modify rates for general and local analgesia. Even if the colour code facilitated efficient communication of the degree of urgency to the anaesthesiology team, reducing this time interval remains an obstetrical challenge. Additional studies should focus on procedures designed to reduce this interval time (bladder empting, use of emergency surgical sets, etc.).

The incision-to-delivery interval is influenced by potential surgical problems. Incidence of scarred uterus did not significantly differ between stages I and II. Thus, surgical problems should not play a significant role. However, the rate of Cohen's incisions during stage II was significantly higher than during stage I, possibly explaining why the incision-to-delivery interval was shorter during stage II. Various studies have shown that use of Cohen's incision led to a gain of 50 s to 2 min [19,20]. This is why we restricted the analysis to the 113 CS performed with Cohen's incision. Our findings indicate that the communication tool has a direct impact on the incision-to-delivery interval.

This study is not without limitations. Its retrospective design could lead to several biases. The precision of the operating theatre record for timing relies both on the midwife who systematically fills in the appropriate form and on the appropriate synchronisation of the ward clocks. The Hawthorne effect could also potentially bias the study [22]. This effect refers to a phenomenon which is thought to occur when people observed during a study temporarily change their behaviour or performance. Because the head of the department implemented systematic recording by the midwife in charge of the surgical theatre of all Caesarean section time intervals (decision to operating theatre interval, preparation interval and incision to delivery interval) long before the beginning of the study, there is little chance that the study is affected by a Hawthorne-type effect. Every obstetrician knows that, in this department, time intervals for Caesarean sections have been recorded for many years. Except for the two on-call obstetricians involved in the study (OD, IS) the hospital staff was not aware that the decision-to-incision times were studied during stage I as well as during stage II. On the contrary we believe that the use of a prospective design would have increased attention on team performance and would have increased any Hawthorne-type effect. It is possible that the results obtained since the implementation of the colour code are due to the fact that with the code the team is continuously reminded of the importance of the DTDI. Two other studies have shown that simple audits led to significant shortening of the DTDI [8,10]. The use of this code could thus work as a permanent reminder. Further studies should be performed to confirm this hypothesis.

As the ratio of very urgent CS was higher in stage II than in stage I (18% *versus* 15.6%), this could have biased the results. However, sub-analyses performed for very urgent and urgent CS independently showed that the significant decrease in the decision-to-delivery interval was observed for the ''urgent cases''. For the ''very urgent'' cases, the difference was not significant, probably due to the small sample size. Finally, the precision of the operating theatre records for timing could be a limitation in this study. Nevertheless, in the unit, midwifes are used to filling in the ''Caesarean section file'' immediately and can rely on synchronised clocks all over the ward. Furthermore, the incision time is also written on the anaesthesiologist's file. It is therefore unlikely that the precision of the operating theatre record biased the study.

Our results were obtained in a level 3 maternity unit and may not be easily applied to level 1 maternity units. The availability of the medical staff and operating theatre play a major role in the DTDI in level 1 units [23].

This study only considered emergency CS and did not study the impact of the green code on non-urgent CS. More than one-third of CS performed during labour are non-urgent. The time gained during the DTDI for very urgent and urgent CS may be an indirect consequence of the use of the green code for non-urgent CS. Possibly, use of the green code for non-urgent CS avoids unnecessary team stress, improving the performance of the entire team during red- and orange-coded CS.

5. Conclusion

If an on-call obstetrician uses the three-colour code, the degree of urgency for CS may be efficiently communicated to the team. This is very important, especially in maternities where CS are commonly performed and could become commonplace [23]. Our findings suggest that clearly communicating the degree of urgency within the perinatal team could significantly shorten DTDIs. Further prospective studies are needed to confirm these results.

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