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A study of factors influencing surgical cesarean delivery times in an academic tertiary center

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Abstract

Background: Knowledge of hospital-specific average cesarean delivery operative times, and factors influencing length of surgery, can serve as a guide for anesthesiologists when choosing the optimal anesthetic technique. The aim of this study was to determine operative times and the factors influencing those times for cesarean delivery.

Methods: We conducted a retrospective review of all 1348 cesarean deliveries performed at an academic hospital in 2011. The primary outcome was mean operative time for first, second, third and fourth or more cesarean deliveries. The secondary goal was to identify factors influencing operative time. Variables included age, body mass index, previous surgery, gestational age, urgency of cesarean delivery, anesthesia type, surgeon's seniority, layers closed, and performance of tubal ligation.

Results: Mean (standard deviation) operative times for first (n=857), second (n=353), third (n=108) and fourth or more (n=30) cesarean deliveries were 56 (19), 60 (19), 69 (28) and 82 (31) minutes, respectively ($P < 0.0001$, all groups different). Emergency status of the case and later gestational age were associated with shorter operative times. Higher body mass index, a less senior surgeon, the number of layers closed, and tubal ligation, increased operative times. These factors accounted for 18% of the variability.

Conclusions: Third and fourth cesarean delivery or the presence of other factors that could increase operative time may warrant catheter-based anesthetic techniques or the addition of

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Conflicts of interest
None.

adjunctive medications to prolong spinal anesthetic block. Institutional and individual surgeon factors may play an even more important role in determining surgical time.

Keywords

Cesarean delivery; Neuraxial anesthesia; Operative time

Introduction

Cesarean delivery (CD) is the most common surgical procedure performed in the United States, and neuraxial anesthesia is the preferred anesthetic technique for CD.^{1,2} The preference for neuraxial anesthesia for CD is due to increased morbidity and mortality associated with general anesthesia (GA) for CD.³ General anesthesia is usually reserved for patients with contraindications to neuraxial anesthesia, for cases requiring rapid induction of anesthesia and for cases in which the neuraxial anesthesia has ceased working or failed. In order to avoid an unplanned conversion from neuraxial anesthesia to GA, the neuraxial technique chosen (spinal, epidural or combined spinal-epidural [CSE]) must take into consideration patient features (e.g. body mass index (BMI)),⁴ the surgeon,⁵ and other factors that may impact cesarean delivery operative times.

Factors affecting CD times, such as the surgeon's experience, the patient's BMI and race/ethnicity, the fetal gestational age, a history of a previous CD, concurrent bilateral tubal ligation, previous abdominal surgery other than CD, the CD indication and urgency, and the type of uterine incision (vertical versus low transverse), have been described^{4,6,7} but differences in practices exist that make such results only moderately generalizable. In this single-center study, our primary aim was to determine institutional operative times for first, second, third and fourth or more CDs at our institution, which is a tertiary/quaternary care urban academic medical center. A secondary aim was to define and quantify institutional factors that influence operative times and anesthetic preferences among providers.

Methods

After Institutional Review Board approval, a retrospective review of all CDs performed from January 2011 to December 2011 was conducted. A total of 1348 CDs were performed in the defined study period. Using electronic anesthesia records and electronic medical records, patient data were collected and factors that might plausibly affect CD operative times were analyzed. Data collected included age, height, BMI, number of previous CDs, previous abdominal surgery, gestational age, trial of labor, urgency status, type of anesthesia, number of surgeons and level of training of the primary operating surgeon, anatomic layers closed and type of surgical closure, and performance of tubal ligation.

Total time from skin incision to time of skin closure was defined as the operative time. Cases were defined as elective CD or emergency CD. Elective CD included all cases performed as scheduled for the day, i.e. on the printed schedule. All non-scheduled CD were considered "emergency" cases. Surgeon experience was categorized using three groups that reflected the surgeon's level of training. Group 1 consisted of physicians in the first or second postgraduate year (PGY), group 2 consisted of surgeons in the third or fourth PGY and

group 3 consisted of maternal fetal medicine fellows, attending physicians or physician assistants. At our institution, groups 1–3 (excluding physician assistants), as described above, perform surgery as primary surgeons under the direct supervision of the admitting attending. Under certain circumstances, for example in early July, the admitting attending will act as the primary surgeon, whereas the PGY1 will mainly act as the assistant. The same applies for any surgical technique for which the admitting attending deems that the training physician is not equipped or skilled enough to perform. Operative reports were examined to identify the anatomical layers closed (Camper's fascia, Scarpa's fascia, muscle or peritoneum) and type of surgical closure (subcuticular versus staples). Additionally, the need to excise or revise a previous scar incision, if present, was noted.

Statistical methods and analysis

Data are presented as mean ($\pm$ standard deviation (SD)). The effects of first versus number of previous CDs on surgical times were compared by ANOVA. After the ANOVA, the means were compared using the Scheffe's hoc test. Other variables that could affect CD time were analyzed for an association with CD time with bivariate analysis. All factors with $P < 0.2$ for association were added to a linear regression model and those with $P < 0.05$ in the combined model, were retained in the final model. A t-test was performed to compare the association of type of anesthesia (CSE versus spinal anesthesia), and academic time of year (January–June versus July–December) on operative times.

Results

Over the study time period of January 2011 to December 2011, 1348 CD cases were analyzed. The operative times of 857 first, 353 second, 108 third and 30 fourth or more CDs were assessed. Total operative time in minutes was $56 (\pm 19)$, $59.9 (\pm 19)$, $69.3 (\pm 28)$, and $81.7 (\pm 31)$ for first, second, third and fourth or more cesarean deliveries respectively. Skin to uterine incision times were $9 (\pm 4)$, $13 (\pm 6)$, $15 (\pm 6)$ and $17 (\pm 9)$ min (Fig. 1). All groups were statistically significantly different from each other for both outcomes ($P < 0.0001$, Fig. 1). When comparing all emergency versus elective CD, a 3.5 min difference was noted ($P = 0.0004$). However no difference was noted when comparing elective versus emergency CD within the first, second, third or fourth or more CD groups. No significant difference was noted when comparing operative times between the first and last six months of the academic year: $59.5 (\pm 20)$ min and $57.9 (\pm 22)$ min respectively, $P = 0.16$.

Spinal anesthesia was the most commonly used method of anesthesia for elective first and second CDs, whereas a catheter-based technique (CSE) was preferred for third and fourth or more CDs. A total of 93 cases had operative times > 90 minutes. Of these cases with long operative times, 29 were first CD, 33 were second CD, 22 were third CD and 9 were fourth cesarean deliveries. Detailed data for type of anesthesia are presented in Table 1. Combined spinal-epidural techniques were associated with longer operative times [$65 (\pm 25)$ min] when compared to epidural [$55 (\pm 18)$ min] and spinal anesthetic techniques [$57 (\pm 18)$ min], both $P < 0.0001$.

Linear regression demonstrated that BMI, performance of tubal ligation, closure of Camper's and/or Scarpa's fascia and less surgical experience contributed to increased operative times (Table 2).

Body mass index was noted to increase operative time by approximately two minutes per 10 BMI points ($\beta = 0.23$ 95% CI 0.07 to 0.38, $P=0.01$). The addition of a tubal ligation added approximately seven minutes of operative time ($\beta = 6.73$, 95% CI 3.13 to 10.34, $P=0.00$). Closure of Camper's/Scarpa's fascia increased operative time by seven minutes ($\beta = 7.06$ 95% CI 5.0 to 9.2, $P=0.00$). When the most junior surgeon assisting the primary attending was a PGY1 or PGY2, the operative time was increased by 14 minutes when compared to cases where the first assistant was an attending, fellow or physician's assistant ($\beta = 14$ 95% CI 11.1 to 16.8, $P=0.00$). Similarly, the operative time was increased by approximately five minutes when an attending operated with a PGY3 or 4, compared to a fellow or physician assistant ($\beta = 4.8$ 95% CI 1.78 to 7.72, $P=0.00$). Emergency status of the CD and higher gestational age were associated with decreased operative times. These independent factors together account for only 18% of the variance.

Discussion

Cesarean delivery is the most commonly performed surgery but the length of the procedure can vary greatly. Neuraxial anesthesia is the preferred mode of anesthesia for the vast majority of CDs in the developed world, due to safety concerns, and maternal and obstetric care provider preferences.⁶ Anesthesiologists use the anticipated duration of a CD to guide the choice of specific neuraxial technique for CD. Accurate information about CD operative times can aid in selecting the optimal anesthetic plan. Knowledge of factors that can influence CD operative times may limit the need to convert a neuraxial technique to GA, or unnecessary complications related to a catheter-based technique (e.g. accidental dural puncture).

Our findings provide institutional mean operative times, factors influencing operative times and type of anesthesia preference for CD. The data show that at our institution the mean CD operative times were less than 90 minutes for all CD, even fourth or greater repeat operations. Although mean operative times did not exceed this time mark, 3%, 9%, 20% and 30% of first, second, third, and fourth CDs respectively, surpassed this time. A fairly linear correlation between operative times and number of previous CDs was noted. A similar pattern was noted for time lapsed between skin to uterine incision. This increase in operative times could be explained partially by the presence of adhesions, the incidence of which fluctuates between 24% and 65% for secondary to quaternary or more CD.^{8,9} Tulandi et al.⁸ demonstrated that the presence of adhesions resulted in an increased time to delivery, as well as total operative times.

The experience or seniority of the surgeon and/or surgical team has been shown to influence the duration of operative times.⁵ Three studies looking specifically at CD operative times showed that surgeon experience does influence operative times, though with conflicting results between studies.^{6,7,10} Our results are in agreement with those described by Doherty et al.⁷ and Wong et al.¹⁰ with training surgeons increasing CD operative times by 5–14

minutes depending on their level of training. In contrast, Wilson et al.⁶ showed decreased operative time when CD was performed by residents or fellows compared to attendings. This difference could be related to institutional protocols, some of which may call for a second attending to assist with challenging cases that are deemed inappropriate for training physicians, while the less complicated cases are performed by residents and fellows.

At our institution it is rare to have two attendings perform a CD together. Residents perform the majority of CDs, either as primary operating surgeon with attending supervision or as first assistant. First CDs are usually performed by a PGY1 resident whereas more complicated CDs (i.e. second CDs or higher, emergency CD) are performed by more experienced trainees. The additional 14 minutes during those less complicated CDs (first CD) could be related to inexperience, and intraoperative teaching and training. We speculate there is less active teaching or basic skills training involved during second or higher degree CD, but the time that is no longer used for teaching is utilized in performing more surgically complex or time consuming procedures such as lysis of adhesions or bilateral tubal ligation.

As expected, performance of a tubal ligation at the time of CD increased the total operative time, consistent with the findings of Doherty et al.⁷ and Wilson et al.⁶ The performance of tubal ligation was noted to be planned for 50% of patients undergoing a third or more CD, whereas 4% and 16% of patients undergoing a first or second CD, respectively, opted for this procedure. Tubal ligation adds about seven minutes to the total operative time, and is a procedure that usually takes place in parturients who have already had surgical deliveries. The adhesions encountered during these procedures may prolong the time to exposure of the fallopian tubes. Other factors, such as BMI and closure of Camper's/Scarpa's fascia may increase total operative times during repeat cesarean deliveries.

Our findings are in accordance with those of Girsan et al.,⁴ Doherty et al.,⁷ and Butwick et al.¹¹ showing increased total operative times in relation to BMI. In addition to longer skin to skin CD times, Doherty et al.⁷ also noted an increase in time from incision to delivery for obese patients. The anesthetic choice for parturients with a BMI greater than 30 should take into account longer total operative times as well as longer skin incision to delivery times.⁴ The latter is important to consider, particularly for emergency deliveries secondary to fetal compromise.

Later gestational age and emergency status were associated with decreased operative times. This decrease in operative times could be related to a decrease in the incision to delivery time, type of skin or uterine incision or other factors that we did not investigate. Cesarean delivery at earlier gestational ages may be more urgent or emergent than at term, so surgery may progress more quickly, although there is some increase in the need for a classical uterine incision which may take longer to suture. Doherty et al.⁷ showed an increased operative time when a uterine incision other than transverse was made. Performing a skin incision other than Pfannenstiel could also influence operative times. Wylie et al.¹² noted a decrease in the incision to delivery time and increased total operative times when a vertical skin incision was performed during emergency cases. Our data do not demonstrate a difference when comparing vertical incision versus a Pfannenstiel incision (55 min vs 58

min $P=0.6$), but we only captured 17 cases in the former group so this study was not powered to detect a difference between these two skin incision techniques.

Many practice patterns can affect surgical times, altering what would be seen if all cases were performed in a similar manner. It is quite possible that the attending physician entrusts less of the surgery to the junior surgeon when faced with an emergent case or a parturient of certain gestational age, or in technically demanding cases. There are certainly emergency cases performed for fetal compromise or maternal instability where surgical speed is paramount and shortcuts are taken to facilitate delivery that would not be acceptable in more elective procedures.

This study has some limitations as it is retrospective and observational. Several possible confounding factors that may contribute to operative time were not accounted for, including the severity of adhesions and type of uterine incision performed. We cannot exclude the possibility that surgeons feel less pressure to expedite a CD or may spend more time teaching during a CD when they are aware that a patient has an epidural catheter in place as opposed to a single shot spinal anesthetic. It is also quite possible that surgical teams operate faster (perhaps with a more senior surgeon operating) when general anesthesia is administered because of a perceived danger to the fetus from longer exposure to the GA. Our findings tend to refute the latter, as the use of GA when compared to neuraxial anesthesia showed no significant difference.

In conclusion, the mean time of all the CDs was less than 90 minutes, including fourth and higher order CD. Given that this operative time does not include the time to obtain a surgical level of anesthesia and prepare and drape the surgical area and other common pre-incision events, one might consider using a catheter-based neuraxial technique for a third or higher degree CD. An alternative would be to add an adjuvant medication such as epinephrine or clonidine to a spinal anesthetic^{13,14} or to give a higher dose of local anesthetic.¹⁵ Understanding an institution's mean CD operative times and factors contributing to operative time may aid in the construction of decision algorithms to provide the most appropriate type of anesthesia (Fig. 2). The decision about which neuraxial technique to use for a CD should be made after considering the patient, the operative times, and identified institutional factors (e.g. tubal ligation) influencing total operative times, as well as institutional complication rates (i.e. failed spinal, accidental dural puncture) associated with any given anesthetic technique.

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Fig. 1.

CD: cesarean delivery. Mean cesarean delivery times (total operative times) and skin to uterine incision ($\pm$ standard deviation) in minutes. *N*= number of cases per group. ANOVA demonstrated difference among groups ($P<0.0001$) and post hoc test (Scheffe) confirmed that all total operative times were different (C1 versus C2, $P=0.03$; C1 versus C3, $P<0.001$, C1 versus C4, $P<0.001$, C2 versus C4, $P<0.0001$, C3 versus C4, $P=0.034$)*. ANOVA demonstrated difference among all groups ($P<0.0001$) and post hoc test (Scheffe) confirmed that all groups were different for skin to uterine incision times (C1 versus C2, $P=0.000$, C1 versus C3, $P=0.000$, C2 versus C3, $P=0.05$, C2 versus C4, $P=0.002$)

Fig. 2.

Decision algorithm for type of anesthesia. CD: cesarean delivery; ~: approximately; BMI: body mass index; BTL: bilateral tubal ligation; PGY: postgraduate year. Algorithm created as an aid in a decision-making process that takes into account institutional operative times and factors influencing those times.

Table 1

Linear regression: skin to closure time ($R^2=0.18$)

Independent variables	Coefficient (β)	Standard error	p	95% Confidence interval
Body mass index	0.23	0.08	0.01	0.07 to 0.38
Bilateral tubal ligation	6.73	1.84	0.00	3.13 to 10.34
Most junior surgeon (PGY1 or 2)	14	1.46	0.00	11.1 to 16.8
Most junior surgeon (PGY3 or 4)	4.8	1.5	0.00	1.78 to 7.72
Closing of Camper's/Scarpa's	7.06	1.07	0.00	5.0 to 9.2
Emergency case	-2.9	1.25	0.02	-5.31 to (-0.39)
Gestational age	-0.79	0.19	0.00	-1.17 to (-0.42)
Constant	69.6	7.8	0.00	54.3 to 84.9

PGY: postgraduate year. In our institution, residents and fellows (PGY1–4) operate as primary surgeons while supervising attendings act as assistants. See methods for more information.

Table 2

Data summary by degree of cesarean deliveries and type of anesthesia

Degree CD (N)	Number (percentage)	Operative time 90 min	Type of anesthesia			
			CSE	Epidural	Spinal	General
First (N=857)		29 (3%)	147	288	372 ^{*f}	50 [‡]
Emergency	672 (78%)	23 (3%)	124	287	211 ^{*f}	50 [‡]
Elective	185 (22%)	6 (3%)	23	1	161	0
Trial of labor	455 (53%)	—	101	283	47	24
Bilateral tubal ligation	32 (4%)	—	—	—	—	—
Second (N=353)		33 (9%)	47	24 [£]	276 ^{**‡}	6
Emergency	149 (42%)	9 (6%)	18	21 [£]	106 [*]	4
Elective	204 (58%)	24 (12%)	29	3	170	2
Trial of labor	25 (7%)	—	4	19	0	2
Bilateral tubal ligation	55 (16%)	—	—	—	—	—
Third (N=108)		22 (20%)	69	3	33	3
Emergency	49 (45%)	6 (12%)	30	2	16	1
Elective	59 (55%)	16 (27%)	39	1	17	2 [‡]
Trial of labor	0	—	—	—	—	—
Bilateral tubal ligation	55 (51%)	—	—	—	—	—
Fourth or more (N=30)		9 (30%)	23	2	3	2
Emergency	12 (40%)	2 (17%)	7	1	3	1
Elective	18 (60%)	7 (39%)	16	1	0	1
Trial of labor	0	—	—	—	—	—
Bilateral tubal ligation	15 (50%)	—	—	—	—	—

CD: cesarean delivery; CSE: combined spinal-epidural.

^{*} 1 spinal catheter

^f 1 Epidural converted to spinal

[‡] 1 Epidural converted to general

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[‡] 1 spinal catheter.
[£] 1 failed spinal converted to epidural.
[‡] These two general anesthetics were originally spinal anesthetics, one converted to general anesthesia for extensive operative time and a second for failed spinal.