ORIGINAL ARTICLE

The Choice of Anesthesia after First Failed Spinal Block and Its Impact on Maternal and Neonatal Outcomes in Cesarean Delivery: A Cross-Sectional Study

Kwanruthai Narunart, MD[1], Wirat Wasinwong, MD[1], Tippawan Liabsuetrakul, MD, PhD[2]

[1] Department of Anesthesia, Faculty of Medicine, Prince of Songkla University, Hat Yai, Songkhla, Thailand; [2] Epidemiology Unit, Faculty of Medicine, Prince of Songkla University, Hat Yai, Songkhla, Thailand

Objective: The preferred choice of anesthesia for cesarean delivery is spinal block, which has a failure rate of 0.5% to 17.0%. The present study investigated the incident rate of second choice of anesthesia following a failed block, as well as the factors influencing the anesthesiologist's selection.

Materials and Methods: A single-center, retrospective cross-sectional study was conducted using electronic medical records of parturients who had experienced a failed spinal block for cesarean deliveries between 2014 and 2019. Each rate of repeated spinal block and the conversion to general anesthesia were calculated. Factors associated with the decision-making were examined, and maternal and neonatal outcomes were reviewed.

Results: Three hundred four women were recruited. The rates of repeated block and conversion to general anesthesia were 81.2% and 18.8%, respectively. Dural puncture with more than one attempt (p=0.022) and anesthesia level at the thoracic dermatome (p<0.001) were associated with a lower decision to repeat the block. Maternal in the repeated block group had a higher incidence of hypotension at 59.5% (p<0.001) and shivering at 16.2% (p=0.008). Neonates in the repeat block group had a lower incidence of any complications than those in the conversion to general anesthesia group at 4% versus 29.8% (p<0.001).

Conclusion: Following an unsuccessful spinal block for cesarean section, the repeated block was still preferred. The level of anesthesia and the spinal attempts were the significant factors in this choice.

Keywords: Cesarean delivery; Conversion to general anesthesia; Failed spinal block; Maternal and neonatal outcomes; Repeat block

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Cesarean delivery is the most common operational treatment used to save the lives of pregnant mothers and their babies[1]. Because of the simple, predictable, and reliable anesthesia, as well as the potential of adding intrathecal morphine for postoperative pain management, spinal block is the preferred anesthetic technique for cesarean delivery[2,3]. Therefore, for most cesarean sections, obstetric anesthetic guidelines advocate spinal and epidural anesthesia over general anesthesia (GA)[4]. The optimal level of anesthesia is at the sixth thoracic dermatome to prevent maternal discomfort during surgical traction[5]. However, spinal anesthesia has a failure rate of 0.5% to 17.0%[6-8], which can be as high as 25.0% in a training environment[9]. Failed spinal block is defined as an inadequate level of anesthesia to perform surgery or unsatisfactory intraoperative maternal comfort that is unsuitable for surgery[10]. Technical errors and chemical interactions and errors are common causes of failed spinal blocks[9].

Selection of either repeat block or conversion to GA is not a consensus as it depends on maternal and fetal conditions as well as the anesthesiologist's experiences[2]. Repeated block may result in a high or total spinal block, worsening maternal and neonatal outcomes[9]. In a conversion to GA, pregnant women will receive anesthetic agents as propofol and sevoflurane, muscle relaxants as succinylcholine and cis-atracurium before delivery and will receive opioid and midazolam after delivery. Therefore, women will take a higher risk of complications from GA such as difficult intubation, aspiration, airway

Correspondence to:

Narunart K.

Department of Anesthesia, Faculty of Medicine, Prince of Songkla University, Hat Yai, Songkhla 90110, Thailand.

Phone: +66-74-451658

Email: doctormilk.anes@gmail.com

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trauma, awareness, allergy, and birth asphyxia[11]. Evidence in the literature regarding the safety of repeating spinal blocks is conflicting[9]. The present study aimed to examine the rates of decision-making for choice of anesthesia in pregnant women with failed spinal anesthesia, explore the associated factors for making the decision to repeat the block, and assess the maternal and neonatal outcomes of either decision to repeat the spinal block or conversion to GA.

Materials and Methods

A retrospective cross-sectional study was conducted at Songklanagarind Hospital between October 1, 2019 and September 30, 2020. Songklanagarind Hospital is a tertiary hospital in the southern part of Thailand that has approximately 3,000 deliveries per year and a cesarean section rate of 55.5%[12]. All singleton pregnant women with class 2-3 American Society of Anesthesiologists (ASA) physical status who had a failed spinal block and required a repeat block or conversion to GA with oroendotracheal intubation were included. Failed spinal anesthesia was defined as an inadequate or no sensory analgesia level to perform an incision for surgery after 15 to 20 minutes following the intrathecal injection of 10 to 11 mg of 0.5% bupivacaine[7] through a 27-gauge Quincke spinal needle. The anesthetic level was assessed by loss of the pin-prick sensation. Those who had life-threatening fetal conditions, received perioperative intravenous sedative/analgesic agents, or converted to general anesthesia using the laryngeal mask technique were excluded. The present study was approved by the Institutional Review Board (REC 62-347-8-1).

Sample size was calculated using a formula of one-group precision. Given that the percentage of women who underwent GA after a failed spinal block was 20%, a pilot review in the authors' hospital with a 95% confidence interval and an acceptable error of 5% required at least 246 failed spinal blocks. To achieve the samples calculated, the anesthetic and medical records of pregnant women with failed spinal block between January 1, 2014 and December 31, 2019 were reviewed from the Hospital Information System (HIS).

The main outcomes of interest were either the repeat block or the conversion to GA after a failed spinal block. Variables of the patients in the present study included pregnant characteristics, anesthetic factors, the anesthesiologist's experience, and perioperative maternal and neonatal outcomes. The pregnant characteristics were age, body mass index (BMI), preexisting problems, gestational age, and indication of cesarean delivery. Anesthetic factors included fasting time, ASA physical status, dural puncture attempts, levels of anesthesia, and levels of analgesia. The anesthesiologist's characteristics were gender, experience years, which varied from 1 to 25 years, and the number of failed spinal block cases.

Perioperative maternal outcomes included hypotension, hypoxemia, shivering, nausea and/or vomiting, difficult intubation, airway trauma, and high or inadequate block if the repeat spinal block were selected. Neonatal outcomes included birth asphyxia, neonatal requirements for respiratory assistance, resuscitation, intubation, oxygen, and intensive care unit (ICU) admission. Hypotension was defined as mean arterial pressure (MAP) below 65 mmHg. Hypoxemia was defined as the pulse oxygen saturation below 94%. Airway trauma was considered if the patient had a sore throat, lip trauma, or dental injury. High block was defined as an anesthesia level above the fourth thoracic dermatome level and inadequate block was defined as the anesthesia level providing unsatisfactory intraoperative maternal comfort or unsuitable for surgery. Birth asphyxia was diagnosed if the neonatal Apgar score at 1 and 5 minutes was below 7[13].

R 3.6.1 software (R foundation for statistical Computing, Vienna, Austria 2019) was used to analyze the data. Patient's characteristics and anesthetic factors were descriptively calculated. Patient characteristics in parturient after failed spinal block for cesarean section between the conversion to GA group and the repeat block group were analyzed by t-test, chi-square test, Fisher's exact test, and Ranksom test. The factors associated with the decision of either repeat block or conversion to GA were analyzed by a multiple logistic regression model. The multiple logistic regression model, rather than a multi-level model, was selected because the intra-class correlation coefficient in multi-level analysis was 0.05. Any maternal or neonatal complications were calculated based on any one of the complications that occurred. Rates of maternal and neonatal outcomes due to either repeat block or conversion to GA considering intention to treat were analyzed using chi-square tests. The p-value of less than 0.05 was considered significant.

Results

During the study period, there were 304 eligible patients based on inclusion and exclusion criteria. The patient's characteristics are shown in Table 1.

Table 1. Patient characteristics in parturient after failed spinal block for cesarean section

	Patients (n=304)
Age group; n (%)	
13 to 24 years	26 (8.6)
25 to 34 years	190 (62.5)
35 to 45 years	88 (28.9)
Body mass index; n (%)	
<25 kg/m^2	65 (21.4)
25 to 29.9 kg/m^2	150 (49.3)
≥30 kg/m^2	89 (29.3)
Comorbidities; n (%)	
Preeclampsia	11 (3.6)
Gestational diabetes mellitus	32 (10.5)
Upper respiratory tract infection	4 (1.3)
Chronic hypertension	5 (1.6)
Gastroesophageal reflux	6 (2.0)
Asthma	3 (1.0)
Others	6 (2.0)
Gestational age (weeks); mean±SD	38.4±1.1
Labor; n (%)	
No labor	136 (44.7)
Spontaneous	141 (46.4)
Induced	27 (8.9)
Indication; n (%)	
Previous cesarean section	162 (53.3)
Failed induction	29 (9.5)
Cephalopelvic disproportion	52 (17.1)
Fetal malposition	35 (11.5)
Others	26 (8.6)
Fasting time; n (%)	
<8 hours	52 (17.1)
≥8 hours	238 (78.3)
NA	14 (4.6)
ASA class; n (%)	
2	80 (26.3)
2E	201 (66.1)
3	9 (3.0)
3E	14 (4.6)

ASA=American Society of Anesthesiologists; E=emergency; NA=not available; SD=standard deviation

Advanced maternal age of 35 years or more, and obese women were found in approximately 30%. One of ten women had gestational diabetes mellitus (GDM). The rate of the repeated block was 81.2% (247/304), and the rate of conversion to GA was 18.8%. Of the 247 patients with repeat block, 16 patients (6.5%) experienced failure of the repeat block and underwent GA finally.

Table 2 statistically compares the patient characteristics in parturient between the conversion to GA group and the repeat block group. There were no statistical differences between the two groups.

The patients' and anesthesiologist's factors were not significantly associated with the decision of the repeat block after a failed spinal block. Only two anesthetic factors, dural puncture attempt and level of anesthesia were shown to be significant. Women who had more than one dural puncture attempt (p=0.022) or anesthesia at a thoracic level (p=0.001) from the first block were less likely to have a repeat block (Table 3).

Figure 1 shows the proportion of each anesthesiologist's repetition block. The percentage ranged from 0% to 100% among 34 anesthesiologists. They preferred to repeat the spinal block again. The higher the number of cases, the higher the rate of repeat blocks.

Table 4 shows the perioperative maternal outcomes by the conversion to GA and the repeated block. There was no significant difference in the rates of any maternal complications between the two groups. When comparison with patients who underwent the conversion to GA, the repeated spinal block patients had significantly higher rates of hypotension at 59.5% versus 22.8% and shivering at 16.2% versus 1.8%. The patients in the conversion to GA group had a significant rate of airway injuries at 36.8% compared to those in the repeated block group at 2.8%. Inadequate and excessive block were detected in 7.3% and 1.6% of the cases, respectively.

As demonstrated in Table 5, the rates of any neonatal complications were significantly greater in the conversion to GA group at 29.8% than in the repeated block group at 4.0%. At delivery, neonates in the conversion to GA group had a higher rate of birth asphyxia at 1 and 5 minutes Apgar (p<0.001), respiratory assistance (p<0.001), oxygen requirement (p=0.007), and ICU requirement (p=0.007) than those in the control group.

Discussion

The present study showed that the rate of conversion to GA was only one-fifth of the rate of repeated spinal block. This reflects the preference of most anesthesiologists to repeat the spinal block to minimize maternal and fetal complications associated with GA. This approach aligns with the 2007 ASA Practice Guideline in Obstetric Anesthesia. However, it is worth noting that despite this preference, there was no significant difference in maternal and neonatal outcomes between regional and

Table 2. Patient characteristics in parturient after failed spinal block for cesarean section between the conversion to general anesthesia group and the repeat block group

	Conversion to GA (n=57)	Repeat block (n=247)	p-value
Age (years); mean±SD	31.8±5	32.8±4.9	0.144
Age group; n (%)			0.653
13 to 25 years	6 (10.5)	20 (8.1)	
26 to 35 years	37 (64.9)	153 (61.9)	
36 to 45 years	14 (24.6)	74 (30.0)	
Body mass index; n (%)			0.725
≤25	10 (17.5)	55 (22.3)	
25.1 to 30	30 (52.6)	120 (48.6)	
>30	17 (29.8)	72 (29.1)	
Comorbidities; n (%)			
Preeclampsia	2 (3.5)	9 (3.6)	1
Gestational diabetes mellitus	4 (7.0)	28 (11.3)	0.473
Upper respiratory tract infection	0 (0.0)	4 (1.6)	1
Chronic hypertension	1 (1.8)	4 (1.6)	1
Gastroesophageal reflux	2 (3.5)	4 (1.6)	0.314
Asthma	0 (0.0)	3 (1.2)	1
Others	2 (3.5)	4 (1.6)	0.314
Gestational age (weeks); median (IQR)	38.4 (37.9, 39)	38.3 (37.9, 39.1)	0.932
Labor; n (%)			0.51
No labor	28 (49.1)	108 (43.7)	
Spontaneous	26 (45.6)	115 (46.6)	
Induced	3 (5.3)	24 (9.7)	
Indication; n (%)			0.827
Previous cesarean section	32 (56.1)	130 (52.6)	
Cephalopelvic disproportion	10 (17.5)	42 (17.0)	
Failed induction	3 (5.3)	26 (10.5)	
Fetal malposition	7 (12.3)	28 (11.3)	
Others	5 (8.8)	21 (8.5)	
NPO time; n (%)			0.288
<8	6 (10.5)	46 (18.6)	
≥8	49 (86.0)	189 (76.5)	
NA	2 (3.5)	12 (4.9)	
ASA class; n (%)			0.294
2	20 (35.1)	60 (24.3)	
2E	32 (56.1)	169 (68.4)	
3	2 (3.5)	7 (2.8)	
3E	3 (5.3)	11 (4.5)	

ASA=American Society of Anesthesiologists; E=emergency; NA=not available; SD=standard deviation

Table 3. Factors influencing the decision to repeat a spinal block after a failed attempt

Anesthetic factors	Crude OR (95% CI)	Adjusted OR (95% CI)	p-value
Dural puncture (ref.=1 attempt)			
2 attempts	0.41 (0.2 to 0.82)	0.42 (0.19 to 0.94)	0.035
3 or more attempts	0.44 (0.19 to 1.04)	0.28 (0.1 to 0.84)	0.023
Level of anesthesia (ref.=no level)			
Thoracic level	0.16 (0.08 to 0.32)	0.16 (0.07 to 0.39)	<0.001
Lower than thoracic level	0.5 (0.23 to 1.12)	0.73 (0.28 to 1.9)	0.525

OR=odds ratio; CI=confidence interval

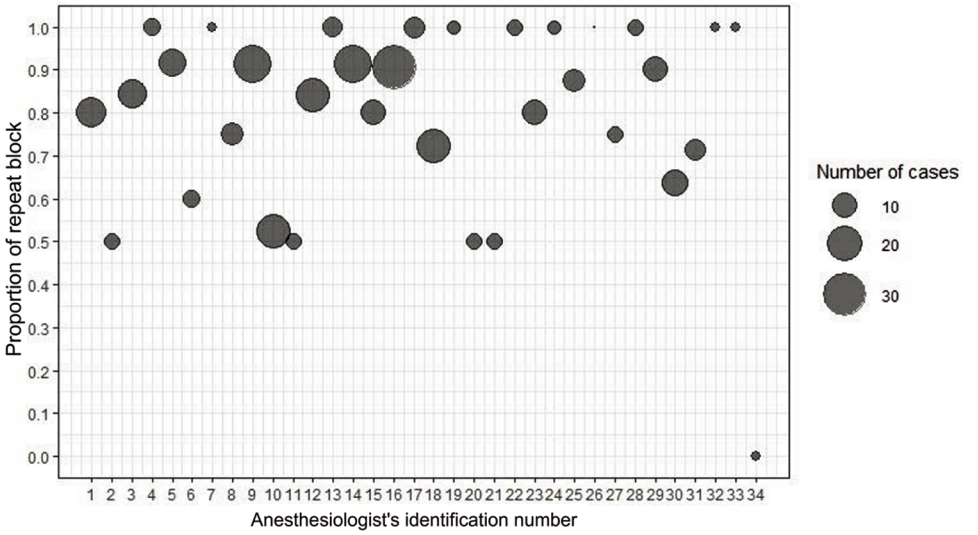

Figure 1. The proportion of each anesthesiologist's repeating block.

Table 4. Maternal outcomes in cesarean section patients after a failed spinal block

Maternal outcomes	Conversion to GA (n=57); n (%)	Repeat block (n=247); n (%)	p-value
Any complications	35 (61.4)	185 (74.9)	0.059
Hypotension	13 (22.8)	147 (59.5)	<0.001
Hypoxemia	4 (7.0)	5 (2.0)	0.067
Shivering	1 (1.8)	40 (16.2)	0.008
Nausea and vomiting	4 (7.0)	25 (10.1)	0.639
Difficult airway	1 (1.8)	0 (0.0)	0.188
Airway trauma	21 (36.8)	7 (2.8)	<0.001
Inadequate block		18 (7.3)	
High block		4 (1.6)	

GA=general anesthesia

Table 5. Neonatal outcomes in cesarean section patients after a failed spinal block

Neonatal outcomes	Conversion to GA (n=57); n (%)	Repeat block (n=247); n (%)	p-value
Any complications	17 (29.8)	10 (4.0)	<0.001
Birth asphyxia by Apgar score at 1 minute	15 (26.3)	6 (2.4)	<0.001
Birth asphyxia by Apgar score at 5 minutes	6 (10.5)	1 (0.4)	<0.001
Required respiratory assistant	19 (33.3)	10 (4.0)	<0.001
Required resuscitation	2 (3.5)	1 (0.4)	0.091
Oxygen requirement	5 (8.8)	3 (1.2)	0.007
Required intubation	2 (3.5)	1 (0.4)	0.091
Required intensive care unit	6 (10.5)	5 (2.0)	0.007

GA=general anesthesia

general anesthetic techniques for cesarean section, as supported by existing consensus. Furthermore, the recommendation of the choice of anesthesia after failed spinal block was not mentioned in the guideline. However, the difficult airway and risk of aspiration from physiologic changes during pregnancy are still the main concerns for avoiding general anesthesia technique. For nearly one-third of the patients in the present study, BMI before cesarean delivery was obesity. This would increase

the risk of difficult intubation[14]. It may be the reason anesthesiologists prefer to perform spinal anesthesia again after a failed spinal block.

The most common preexisting problem of women in the present study is GDM. GDM is associated with maternal obesity and fetal macrosomia, which would increase the rate of cesarean delivery to prevent maternal and fetal trauma[15].

Level of anesthesia after a failed spinal block was another consideration of a decision-making for choices of anesthesia. The level of anesthesia at the lumbar or sacral dermatome was easy to decide. On the contrary, the low thoracic dermatome was associated with fewer decisions for repeat blocks, which might be caused by fear of the excessive spread of local anesthetic agent resulting in high or total spinal anesthesia, and the estimation of the use of a safe repeated dose. Bhar et al. reported that spinal anesthesia can be safely repeated in cesarean delivery with 10 mg of 0.5% hyperbaric bupivacaine after a failed block when the level of sensory block is below L_4 and motor power on the Bromage scale is 0[16]. Pokharel suggested that patients who felt pain after a pin prick at the site of incision (lower thoracic dermatome) were considered to have failed spinal anesthesia. The spinal anesthesia was repeated by using Bupivacaine in a repeated dose of 9 mg or 1.8 mL, which showed an effectiveness of 94.5% without extra side effects[9]. However, in the partial failure of the spinal block, it would be appropriate to reduce the dosage by 25% to 30%[16].

An anesthetic factor that was associated with the decision for repeat block was multiple dural puncture attempts from the first block. Generally, many attempts at a spinal block are related to challenging spinal anatomy such as local anesthetic resistance, morbid obesity, elderly, and other anatomical abnormalities[17]. In the case of spinal anesthesia, this would take a long time to succeed. Furthermore, because of the time it takes for sufficient analgesia to start to at least at T6 level, an anesthesiologist would be obliged to change the anesthetic approach to general anesthesia due to the stress of waiting to start the surgery and the possibility of problematic spinal blocks. Multiple attempts can further increase the risk of postdural puncture headache, vascular injury resulting in epidural hematoma, and direct nerve damage.

After a failed spinal anesthesia, there were no significant differences in maternal complications between the two groups. It is important to note that each type of anesthesia has distinct physiological effects on pregnant women. The repeat block group showed a higher incidence of hypotension and shivering due to the potent sympathetic block caused by local anesthetic. On the other hand, the GA group had the advantage of being able to adjust anesthetic agents to achieve the appropriate depth of anesthesia and desired physiological effects. The incidence of airway trauma was higher in the conversion to GA group, likely due to the differences in the procedures involved. However, it should be mentioned that some patients in the repeat block group experienced airway trauma because they had a second failed spinal block and subsequently received GA as the final choice of anesthesia. Therefore, airway trauma occurred in these cases as well.

Regarding neonatal outcomes, a Cochrane review indicated no significant differences in terms of neonatal Apgar scores at 5-minute and the need for neonatal resuscitation with oxygen between spinal and general anesthesia[3]. A meta-analysis comparing fetal outcomes between general, spinal, epidural, and combined spino-epidural anesthesia, showed significantly better Apgar scores at 1-minute and umbilical venous pH of the fetus in spinal and epidural anesthesia than in general anesthesia[18]. The later study is consistent with the neonatal outcomes of the present study, which preferred repeat block after a failed block in relation to neonatal outcomes. The newborn results of the present trial, which favored repeat block after an unsuccessful block in connection to neonatal outcomes, are similar with the findings of the later study.

The present study has limitations. It was a single-center retrospective trial. After a failed spinal block, fetal monitoring may be another crucial point to consider when choosing an anesthetic approach. The arterial blood gas examination for fetal acidosis was not included in the neonatal outcomes. Because it is not a common practice, it was not used in the study. Finally, the urgency and appropriateness for the selection of the choice of anesthesia was not assessed. For the time being, there is no standard approach or algorithm for the management of failed spinal anesthesia. This should be the focus of future research.

Conclusion

The rate of repeated blocks following a failed spinal block for cesarean delivery was higher than the rate of conversion to general anesthesia. However, opting for a repeated block showed similar maternal and neonatal outcomes compared to choosing general

anesthesia. The level of anesthesia and the number of dural puncture attempts were significant factors influencing this decision-making process.

What is already known on this topic?

The 2007 ASA Practice Guideline in Obstetric Anesthesia demonstrated that maternal and neonatal outcomes between regional and general anesthetic techniques for cesarean section were not different. However, the recommendation of the choice of anesthesia after failed spinal block was not mentioned in the guideline.

What does this study add?

This study demonstrated the rate of either repeat block or conversion to GA after failed spinal block and evaluated maternal and neonatal outcomes from each choice. It showed that parturient in the conversion to GA group had better outcome. However, neonates from the conversion to GA group had worse outcomes than those from repeat block group. It also showed the factor associated with decision making of anesthesiologists.

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Conflicts of interest

There are no potential conflicts of interests to declare.

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