The Analysis of Risk Factors to Hypotension Occurring after Caesarean Spinal Anesthesia for Parturients with Scarred Uterus

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Abstract

Background This study aims to discuss the risk factors to hypotension for caesarean parturients with scarred uterus when low dose of bupivacaine and sulfentanyl are used in spinal anesthesia.

Methods A total of 322 singleton-pregnancy parturients with scarred uterus who had been scheduled for caesarean spinal anesthesia were randomly sampled. The data about the basic information of the parturients, the gestation, the fetus and the anesthesia has been recorded and filed according to the clinical questionnaires about hypotension in caesarean section. The parturients whose systolic pressure drops below 90mmHG or decreases by 20% during the time from the completion of anesthesia until the delivery of infant were classified to be Group Hypotension (Group H) and the rest are in Group non-hypotension (Group N). This study analyzes the correlation of 39 factors to the occurrence of hypotension and then further analyzes the statistically significant factors through binary classification logistic regression.

Results Of the 322 sampled parturients, 148 parturients suffered hypotension. The incidence of hypotension in this study is 45.96%. The result of univariate analysis shows that the differences in the factors including height (p=0.005), post-pregnancy Body Mass Index (BMI) (p=0.00), weight gain in gestation (p=0.000), fundal height(p=0.047), fasting time (p=0.031), exercise history in gestation (p=0.006) and dermatomal level of analgesia (p=0.000) between two groups are statistically significant. The variables with statistical significance are analyzed by multivariate logistic regression model. The result shows that BMI in gestation (OR=1.146 95%, CI 1.041-1.262, p <0.05), weight gain in gestation (OR = 1.126 95%, CI 1.060-1.198, p <0.001), exercise history in gestation (OR = 0.399, 95% CI 0.205-0.778, p = 0.007), dermatomal level of analgesia (OR = 2.248, 95% CI 1.645-3.074, p <0.001) are risk factors to hypotension occurrence after caesarean spinal anesthesia for parturients with scarred uterus.

Conclusion The incidence of hypotension occurring after caesarean spinal anesthesia for parturients with scarred uterus is relatively high. Factors including post-pregnancy BMI, weight gain in gestation, exercise history in gestation and dermatomal level of analgesia after anesthesia are risk factors to hypotension occurring after caesarean spinal anesthesia for parturients with scarred uterus. The result plays an important role in predicting the occurrence of hypotension after spinal anesthesia by parturients with scarred uterus in clinic.

Trial registration Chinese Clinical Trial Registry(chiCTR-ROC-17011251)

Background

Spinal anesthesia has been more and more universally selected for caesarean section, and one of the commonly seen complications is hypotension. The incidence of hypotension for parturients is much higher than that for non-gestational women. The incidence of hypotension after spinal anesthesia in caesarean section can even reach 20%-100%[(1–3)]. Hypotension can cause nausea, vomiting, or even maternal consciousness loss and respiratory depression, increasing the risk of aspiration. Severe

hypotension even declines uteroplacental blood flow, leading to fetal acidosis, and further damages the central nervous system and puts the fetus in life risk[4–5]. These are the major complications and challenges faced by parturients when spinal anesthesia is used in caesarean section. Previous study finds that factors including age (≥35 years old), obesity, higher blockade, over-size fetus and twin fetus are critical factors causing hypotension after spinal anesthesia for parturients[6]. Some studies indicate that the incidence of hypotension suffered by parturients with multiple caesarean sections increases as well[7]. Thereby, this study sampled the parturients with scarred uterus due to multiple caesarean section so as to investigate the risk factors in relation to the mother, the fetus, and anesthesia. This study aims to provide theoretical basis for better prevention of hypotension to occur to this group of patients in clinic.

Method

In this study, all the participants are singleton-pregnancy parturients with scarred uterus. The parturients with high risk pregnancy, twins, congenital malformation fetus and fetal distress are excluded. The participants were recruited from January to December 2019 from Yijishan Hospital of Wannan Medical College. The following information about the parturients had been collected before spinal anesthesia: age, height, pre-pregnancy weight. pre-pregnancy BMI, post-pregnancy weight, post-pregnancy BMI, weight gain in gestation, days of pregnancy, fasting time, smoking history, anxiety history, exercise history in gestation, hypertension history, diabetes history, hypothyroidism history, premature rupture of membrane, preferred sleeping posture in gestation, the volume of preoperative fluid infusion, basal heart rate, basal blood pressure, fundal height, abdominal circumference, fetal ultrasound data (including fetal biparietal diameter (BPD), fetal femur length (FL), amniotic fluid index, maximum vertical pocket depth, hepatic dysfunction, anemia in gestation (Hb < 110 g/L, Hct < 0.33%), hypoproteinemia (Total Protein tested in laboratory in gestation < 60 g/L or albumin < 35 g/L), and electrolyte disturbances (serum potassium < 3.5 mmol/L, serum calcium < 2.2 mmol/L). Heart rate and blood pressure were measured three times consecutively every two minutes when parturients lay on the operation table, and the mean value was the basal systolic blood pressure and the basal heart rate. To measure the fundal height and abdominal circumference, the parturients shall lie in supine position on operation table after urination. The height from the symphysis pubis to the uterine fundus measured by soft ruler is the fundal height. The perimeter of the waist and abdomen at the level of umbilicus is the abdominal circumference.

The temperature of operating room was kept between 22℃ and 24℃ and the relative humidity was between 50% and 60%. Parturients were in supine position. When the parturients' breathing became stable, they were supplied with oxygen mask for oxygen inhalation at 3 L / min and the heart rate, blood pressure and oxygen saturation were monitored. When the vein was ready, the parturients were given intravenous infusion in supine position. Anesthetist with rich clinical experience executed the subarachnoid block and paruturients were given a puncture in the place between L3 and L4 in left-recumbent position. After successful puncture, parturients received 9 mg bupivacaine and 2.5ug sulfentanyl. The anesthetic injection time was recorded. After anesthesia, the parturients were tilted 15° leftward. The blood pressure and heart rate were measured every 2 minutes. From the completion of

anesthesia to the delivery of fetus with umbilical cord cut off, a drop of 20% SBP from baseline or the blood pressure lower than 90 mmHg shall be defined as hypotension. In the presence of hypotension, the anesthesiologist should administer 5–10 mg ephedrine or 50-100*ug* norepinephrine. The dosage of vasoactive agent used in the operation was recorded. After 10 minutes, the dermatomal level of analgesia was measured with alcohol test method and the highest level of analgesia was recorded. After delivery, the fetal position, the sex and the weight of the newborn infant were recorded.

Statistical analysis

Statistical analysis was performed with the SPSS 22.0. The dichotomous variable Hypotension after spinal anesthesia (yes/no) was used as the target criterion.

First, univariate analysis method was used to analyze the correlation of variables with hypotension, and then the mean value and standard deviation were calculated. Then, chi-square test or Fisher's exact test were adopted to analyze the correlation of categorical variables with hypotension. $p < 0.05$ means the difference is statistically significant .

Second, statistically significant factors were analyzed with univariate analysis method. In analysis, independent variables were selected through stepwise selection function in logistic regression model. The boundary-value ($\alpha \leq 0.05$) and the elimination-value ($\alpha \geq 0.10$) of the selected variables were determined. The independent risk factors correlated to hypotension occurrence after spinal anesthesia for parturients with scarred uterus were screened. The odds ratio (OR) and the calculation difference at 95% confidence interval (CI) were compared. $p < 0.05$ means the difference was statistically significant .

Results

A total of 322 parturients are sampled in this study. According to the definition of hypotension, the parturients are divided into two groups, Group Hypotension (Group H) and Group Non-hypotension (Group N). Of the 322 parturients, 148 parturients suffered hypotension. The incidence is 45.96%.

1) Among the variables related to maternal basic information, height ($p = 0.005$),

fasting time ($p = 0.031$), and exercise history in gestation ($p = 0.006$) are in correlation with the high incidence of hypotension occurring after spinal anesthesia for parturients with scarred uterus, as shown in table 1.

Among the variables related to gestation, post-pregnancy BMI ($p = 0.000$), fundal height ($p = 0.047$), weight gain in gestation ($p = 0.000$) are related to the high incidence of hypotension occurring after spinal anesthesia for parturients with scarred uterus., as shown in table 2.

Among the variables related to fetus, biparietal diameter (BPD), biparietal diameter (FL), neonatal weight and sex are not statistically significant to the incidence of hypotension occurring after spinal anesthesia for parturients with scarred uterus, as shown in table 3.

Among the variables related to anesthesia, dermatomal level of analgesia is the only one factor related to the high incidence of hypotension occurring after spinal anesthesia for parturients with scarred uterus, as shown in table 4.

2) The variables with statistical significance are analyzed by multivariate logistic

regression. Among the variables analyzed, the weight gain in gestation (OR / 95% CI: 1.127 (1.06-1.198)), post-pregnancy BMI (OR/95% CI:1.146 (1.041-1.262)), exercise history in gestation (OR / 95% CI: 0.399 (0.205-0.778)) and the dermatomal level of analgesia (OR / 95% CI:2.248 (1.645-3.074)) are independent risk factors leading to the occurrence of hypotension after spinal anesthesia for parturients with scarred uterus. Due to the lack of significant correlations shown in the model, all other indicators are excluded from the logistic regression model, as shown in table 5.

Table 1
The variables related to the basic information of parturients (χ2 test or Fisher's exact test)

	Group H	Group N	*P*
Age (year)	98	116	0.93
≤35	50	58	0.005**
35	158.96 ± 4.31	160.37 ± 4.55	0.30
Height	55.73 ± 7.60	56.66 ± 8.40	0.85
Pre-pregnancy Weight (kg)	22.05 ± 2.87	21.99 ± 2.81	0.031*
Pre-pregnancy BMI (kg/m2)	11.94 ± 3.25	11.08 ± 3.90	0.69
Fasting time (h)	28	36	0.41
sickness history	120	138	0.61
Yes	2	0	0.006**
No	146	174	0.17
Smoking history	18	18	0.36
Yes	130	156	0.39
No	34	20	0.12
Anxiety history	114	154	0.37
Yes	10	6	0.14
No	138	168	0.85
Exercise history	29	30	0.91
Yes	128	144	
No	8	6	
Hypertension	140	168	
Yes	24	18	
No	124	156	
Diabetes	6	4	
Yes	142	170	
No	56	8	
Hypothyroidism	92	94	

Note: p 0.05 represents that the difference is statistically significant. Pre-pregnancy weight = the weight before pregnant.*p 0.05 VS Group N;**$p < 0.01$ vs Group N.

	Group H	Group N	*P*
Yes	132	154	
No	16	20	
Single child	6	2	
Yes	142	172	
No			
Liver Function			
Yes			
No			
Anemia			
Yes			
No			
Hypoproteinemia			
Yes			
No			
Electrolyte disturbances			
Yes			
No			

Note: p 0.05 represents that the difference is statistically significant. Pre-pregnancy weight = the weight before pregnant.*p 0.05 VS Group N;**$p < 0.01$ vs Group N.

Table 2
The variables related to gestation (χ2 test or Fisher's exact test)

	Group H	Group N	*P*
Post-pregnancy weight (kg)	71.57 ± 8.18	69.94 ± 8.44	0.08
Post-pregnancy BMI (kg/m2)	28.31 ± 2.99	27.15 ± 2.68	0.00**
Weight gain in gestation (kg)	15.85 ± 4.11	13.28 ± 4.51	0.00**
Fundal height (cm)	33.96 ± 2.79	33.76 ± 2.53	0.047*
Abdomen circumference (cm)	101.42 ± 5.22	101.17 ± 6.48	0.71
Gestational age (week)	14	16	0.94
37	134	158	0.20
≥37	51.50 ± 19.26	54.48 ± 22.10	0.16
Amniotic fluid index	119.22 ± 42.30	112.67 ± 41.15	0.11
Maximum vertical Pocket depth (cm)	8	18	0.66
Premature rupture of membrane	140	156	0.086
Yes	138	160	
No	10	14	
Fetal position	60	64	
L	12	22	
R	22	40	
Preferred sleeping posture in gestation	54	48	
L1			
R1			
S			
No			

Note: Post-pregnancy BMI = the weight of parturients in caesarean section; L = fetal position is on the left side of pelvis; R = fetal position is on the right side of pelvis; L1 = sleeping on left side is preferred in gestation; S = supine position in sleeping is preferred in gestation; *p 0.05 VS Group N;**$p < 0.01$ vs Group N.

Table 3
Variables related to fetus (χ2 test or Fisher's exact test)

	Group H	Group N	*P*
BPD(cm)	92.96 ± 4.16	93.38 ± 3.67	0.34
FL(cm)	72.53 ± 3.77	73.14 ± 3.27	0.12
Neonatal weight(g)	16	12	0.36
2500	122	146	0.32
2500–4000	10	16	
4000	78	82	
Fetal sex	70	92	
Male			
Female			

Note: BPD = fetal biparietal diameter; FL = fetal femur length; *p0.05 VS Group N;**p < 0.01 vs Group N.

Table 4
Variables related to anesthesia χFisher's exact test)

	Group H	Group N	*P*
Volume of fluid infusion (ml)	134	158	0.94
500	14	16	0.23
≥500	66	66	0.62
Blood pressure before anesthesia (mmHg)	82	108	0.00**
120	100	122	0.84
≥120	48	52	
Heart rate before anesthesia (bpm)	12	34	
≤100	58	86	
100	52	48	
Dermatomal level of analgesia	26	6	
T10	130	144	
T8	22	26	
T6			
T4			
The time of anesthetic injection (s)			
≤15			
15			
Note: **$p < 0.01$ vs Group N.			

Table 5
Analysis of risk factors by multivariate logistic regression

Variables	*B*	SE	*p-Value*	*OR*	*CI*
Weight gain in gestation	0.119	0.049	0.000**	1.127	1.060–1.198
Post-pregnancy BMI	0.136	0.049	0.005**	1.146	1.041–1.262
Exercise history	-0.91-	0.341	0.007**	0.399	0.205–0.778
Dermatomal levels of analgesia	0.810	0.16	0.00**	2.248	1.645–3.074
Constant	-6.82	1.46	0.000		
Note:SE standard error, CI 95% confifidence interval;*OR*:Odds-ratio					

Discussion

So far, most studies have been believing that reducing the does of local anesthetic in spinal anesthesia can effectively decrease the incidence of hypotension occurring to parturients. In Van de Velde's study, the parturients in high-dose group has been injected with 9.5 mg bupivacaine into subarachnoid cavity while the dosage of bupivacaine in low-dose group are reduced to 6.5 mg. Additionally, 2.5ug sulfentanyl are added in both groups. The result shows that the mean minimum systolic blood pressure in low-dose group is apparently higher than in high-dose group, and the incidence of hypotension in low-dose group is distinctly lower than in high-dose group. Due to the use of opioid analgesic, all parturients have received satisfactory anesthetic effect[8]. Farzi analyzes the analgesia duration and spinal anesthesia complications affected by the use of bupivacaine with fentanyl, sulfentanyl, and placebo. The result shows that the use of bupivacaine with 25 μg fentanyl or 2.5 μg sulfentanyl as intrathecal drug can increase the analgesia duration and hemodynamic stability without causing serious complications. Therefore, this study adopts low dose of bupivacaine (9 mg) and sulfentanyl (2.5 μg) as the intrathecal drug[9]. In this way, it can not only reduce the incidence of hypotension but ensure better analgesia effect.

According to statistics, the reasons behind the increasing caesarean section rate in Northern Europe lie in the rising the caesarean delivery rate (CDR) of primiparas and the growing proportion of parturients with caesarean history[10]. The uterus of parturient with caesarean section history has already been scarred, so caesarean section will probably be chosen in the next delivery. The operation of parturient with scarred uterus is tough and complicated and the difficulty of anesthesia is increased. Re-caesarean section obviously puts parturient and fetus in higher risk. One of the essential factors to operation success is anesthesia. At present, single-shot spinal anesthesia can be safely used in re-caesarean parturient. Nonetheless, due to a series of physiologic change occurring to expectant mother, hypotension is still the most common complication suffered by re-caesarean parturient[11–12].

In this study, the incidence of hypotension after spinal anesthesia for parturients with scarred uterus is 45.96%. The factors including height, post-pregnancy BMI, weight gain in gestation, fasting time, exercise in gestation and dermatomal level of analgesia are statistically related to hypotension occurrence after spinal anesthesia in caesarean section. But BMI (*OR* = 1.146), weight gain in gestation (*OR* = 1/127), exercise in gestation (*OR* = 0.399), and dermatomal level of analgesia (*OR* = 2.248) are predictors to hypotension occurrence after spinal anesthesia in caesarean section.

In this study the incidence of hypotension occurring after spinal anesthesia for parturients with scarred uterus is as high as 45.96%. The high incidence of hypotension is relatively contributed by physiological changes in gestation. In the meantime, this study finds that four independent variables are closely related to the high incidence of hypotension occurring after caesarean spinal anesthesia.

Consistent with previous studies[13], this study confirms that the increase of post-pregnancy BMI is a risk factor to hypotension triggered by spinal anesthesia (SA) in caesarean section. Pitkanen's study maintains that the diffusion of bupivacaine of equal dose is closely correlated to post-pregnancy BMI[14–

[15]. The increase of intra-abdominal pressure caused by cyesis or obesity can reduce the volume of CSF and increase dermatomal level of analgesia. Therefore, the dose of local anesthetic to be injected into subarachnoid cavity for parturients at full term is 1/3 less than that of non-pregnant patients. Meanwhile, larger rump of obese patient may result in higher inclination of lumbar and thoracic vertebra, and further accelerate the diffusion of local anesthetic from subarachnoid cavity to head. Under the combined effect of the two factors, the use of equal dose of local anesthetic probably leads to over blockade and results in higher incidence of hypotension.

Kitahara[16] believe that in supine position, the local anesthetic is concentrated in the lowest part of thoracic vertebra regardless of the height of patients. But Greene[17] believe that because taller patients have larger space of subarachnoid cavity and larger volume of cerebrospinal fluid, so, within the same distance from the injection site, the local anesthetic is supposed to reach lower dermatomal level of analgesia. In addition, cerebrospinal fluid can dilute the injection. The larger the volume of cerebrospinal fluid is, the thinner the injected drug will be. Hence, both factors limit the diffusion of local anesthetic in taller patients. It is consistent with the result of this study. This study believes that taller parturient has lower risk to suffer hypotension after spinal anesthesia in caesarean section. However, according to the result of multivariate logistic regression model, this variable is not statistically significant to the incidence of hypotension after spinal anesthesia in caesarean section.

The result of this study indicates that with the increase of weight gain in gestation, the risk of suffering hypotension rises. It is different from the result of previous study which maintains that weight gain in gestation less than 11 kg is a risk factor to hypotension triggered by spinal anesthesia[18]. But another study finds that weight gain in gestation more than 11 kg is a risk factor to hypotension occurring after spinal anesthesia[19].

Normally, parturients are required to do fasting for caesarean section. Long-time fasting probably results in insufficient capacity, relatively being dehydration and leads to higher risk of hypotension. This study believes that over fasting is one of the risk factors leading to hypotension after spinal anesthesia. But according to multivariate logistic regression, this variate is not statistically significant to the incidence of hypotension after spinal anesthesia in caesarean section.

Buchheit's study has shown that exercise can intensify the overall heart rate variability and promote the activity of cardiac sympathetic nerve and parasympathetic nerve, facilitating the transmission from sympathetic-parasympathetic nerve balance to parasympathetic-enhanced nerve activity[20]. This study reveals that the change of sympathetic nerve activity might be related to the reduction of hypotension occurrence after spinal anesthesia for parturients with exercise history.

Intrathecal block usually causes varying degrees of blood pressure decline with heart rate slowing. These effects are proportional to the level and the degree of dermatomal analgesia. Vessel tension is determined by arterial and venous smooth muscles controlled by sympathetic fiber in T5-L1. Blocking the nerves might cause venous capacitance expansion, vessel vasodilation, hypostasis, venous return

decrease. Arterial vasodilation can even reduce systemic vascular resistance. When dermatomal level of analgesia exceeds T4, cardioacceleration fibers become blocked, resulting in heart rate decline and cardiac output decrease. Arteriectasis and venectasia combined with bradycardia might cause severe hypotension. Arterial vasodilation might be affected by compensatory vasoconstriction above blockade, especially when the analgesia dermatomal is limited within the lower thoracic segment. The result of this study is consistent with previous study[21]. Higher dermatomal level of analgesia after anesthesia results in higher risk of hypotension for parturients.

When Chung[22] evaluate the correlation of fundal height with dermatomal level of analgesia, they find that there is no clear correlation between them. But another study reveals that for parturients with higher fundal height and higher intra-abdominal pressure, the diffusion of local anesthetic in subarachnoid cavity in early stage has been accelerated, resulting in higher dermatomal level of analgesia[19]. In univariate analysis, it finds that fundal height is statistically significant to the incidence of hypotension after caesarean spinal anesthesia. But multivariate logistical regression model reveals that fundal height is not a risk factor to hypotension after caesarean spinal anesthesia for parturients with scarred uterus.

This study is a prospective study about hypotension occurring after caesarean spinal anesthesia. The samples are parturients with scarred uterus. It is the first study to discuss the risk factors to hypotension occurring after spinal anesthesia when low dose of local anesthetic is used with sulfentanyl, and it is also the first time that exercise history in gestation has been included in study. But this study also has limitations, such as the time consumption of collecting data and the failure of putting weight gain in stratification study.

Conclusion

When low dose of bupivacaine is used with sulfentanyl for parturients with scarred uterus, the incidence of hypotension occurring after spinal anesthesia is 45.96%. The factors including weight gain in gestation, post-pregnancy BMI, exercise history in gestation and the dermatomal level of analgesia are the risk factors to the occurrence of hypotension after caesarean spinal anesthesia for parturients with scarred uterus.

Abbreviations

BPD:biparietal diameter;FL:biparietal diameter;BMI:body mass index; Hb:hemoglobin;Hct:Hematocrit.

Declarations

Ethics approval and consent to participate

Ethical approval from China Ethics Committee of Registering Clinical Trials was obtained (ChiECRCT20190086). Written informed consents were obtained from participants before inclusion.

Consent for publication

Not applicable

Availability of data and materials

The data that support the findings of this study are available from The First Affiliated Hospital of Wannan Medical College; however, they are not publicly available. Data are however available from the authors upon reasonable request after permission of The First Affiliated Hospital of Wannan Medical College.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

WC was responsible for the conception and design of the study, analysis of the data, and writing the manuscript. YC,YQC shared in data collection. YL,FD shared in assessment and obstetric management of the patients. LG, FD made substantial contribution in the design of the study, writing and revising the manuscript.WC,YC,YQC,YL,FD,BW and LG shared in writing and revising the manuscript. All authors had read, revised and approved the final manuscript.

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Figures

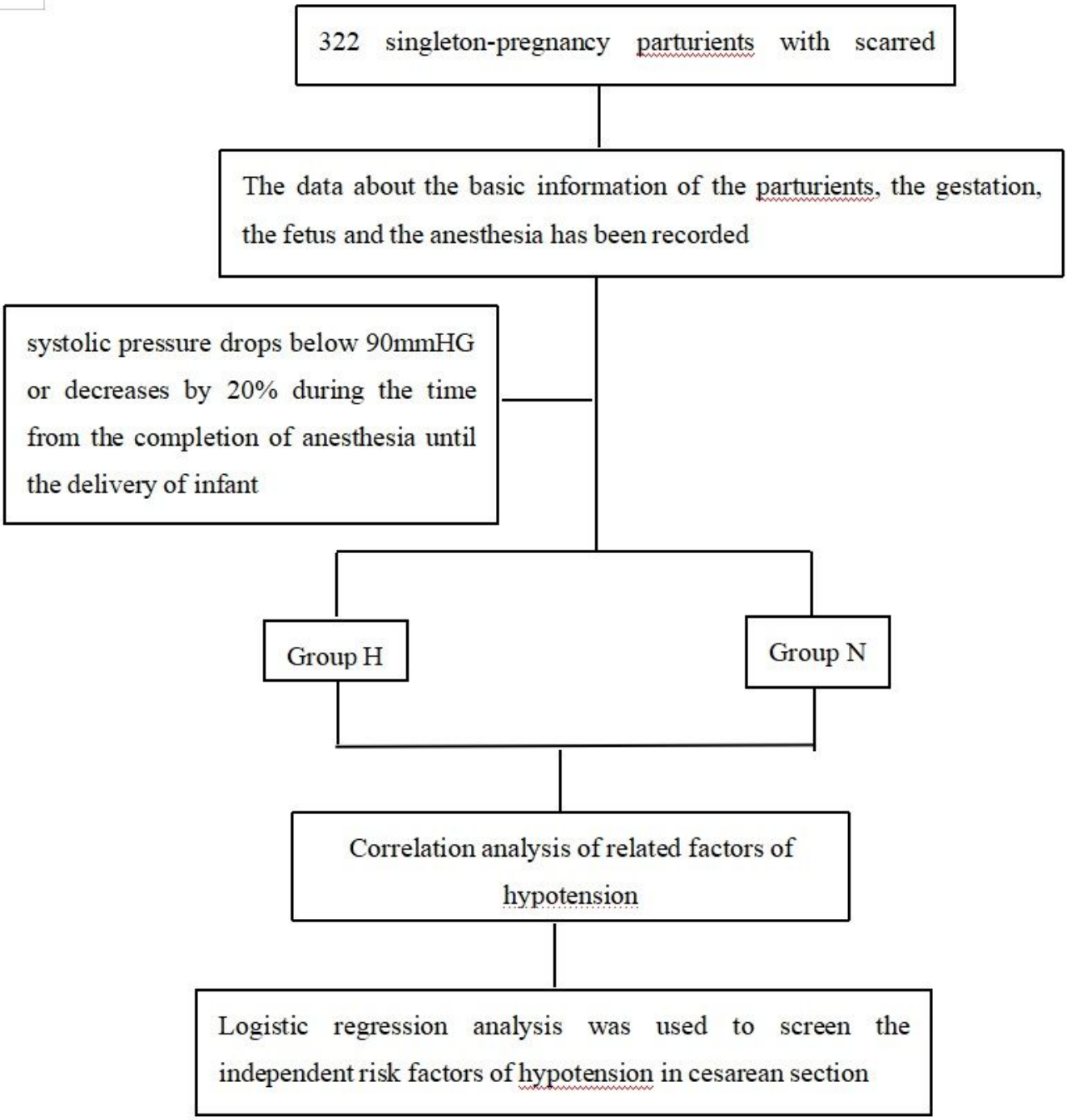

Figure 1

flow chart