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Original Article

Clinical effect of different concentrations of ropivacaine with the same dosage on cesarean section under epidural analgesia

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Abstract: Objective: The aim of this study was to compare anesthetic and analgesic effects of different concentrations of ropivacaine with the same dosage on primiparas underwent cesarean section and provide clinical guidance for cesarean section with epidural anesthesia. Methods: During December 2015 to December 2016, 90 full-term singleton primiparas who underwent cesarean section were included and divided into three groups randomly and double-blindly. Each group has 30 puerperae. After entering the room, the primipara received the combined spinal and epidural analgesia (CSEA) in the L3~4 space. 10 mg ropivacaine was injected into the subarachnoid space (diluted with normal saline to 2 ml) after confirming the proper space, and epidural catheter was inserted 4 cm into the epidural space. After labor, puerperae by PCEA received 0.1% ropivacaine containing sufentanil 0.4 μg/ml at 3 ml/h in Group HC, or 0.075% ropivacaine containing sufentanil 0.3 μg/ml at 4ml/h in Group MC, or 0.05% ropivacaine containing sufentanil 0.2 μg/ml at 6ml/h in Group LC. All PCEA pumps were equipped with fluid volume enough for 40 hours (h), and the dosage of ropivacaine was 3 mg per hour. When pressed PCEA pump, the additional bolus of 1 h dosage was infused, and the lock time was 30 minutes (min). The characteristics of puerperae including age, height, weight and gestational weeks were recorded; At the different time points, including before anesthesia (T1), 1 min after anesthesia (T2), skin incision immediately (T3), fetal delivery immediately (T4), 5 min after labor (T5) and 30 min after skin incision (T6), the systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), heart rate (HR) and pulse blood oxygen saturation (SpO_2) were measured to evaluate the changes of hemodynamics; The highest level of sensory block was measured at the skin incision immediately (T3) and out of the operation room (T7); Modified Bromage motor block scores and visual analogue scale (VAS) scores was tested at the skin incision immediately (T3), out of the operation room (T7), 6 h after operation (T8), one day after operation (T9) and three days after operation (T10); The press frequency of PCEA pumps, maternal satisfaction, perioperative adverse effects and neonatal Apgar scores were recorded. Results: (1) There were no statistically differences between the three groups in the characteristics of puerperae ($P > 0.05$); (2) There were no statistically differences between the three groups in the hemodynamic parameters at T1-T6 ($P > 0.05$); (3) The medians of the highest level of sensory block between the three groups at T3 and T7 were not statistically significant ($P > 0.05$). There was statistically significant difference in modified Bromage scores between the Group MC and Group LC at T8 as the cases in Group LC whose modified Bromage scores recovered to 0 was significantly lower than that in Group MC ($P < 0.05$). VAS score of Group LC was significantly lower than that in Group HC and B on 1 day after operation (T9), with statistically significant ($P < 0.05$). Besides, the comparison of press frequency of PCEA pumps was as following: the Group HC > Group MC > Group LC, and there were statistical differences ($P < 0.05$); (4) The incidences of perioperative adverse effects including the nausea and vomiting, stretch reflex, hypotension, urinary retention in Group LC were higher than those observed in Group HC and Group MC, but there were no statistical differences ($P > 0.05$). (5) The neonatal Apgar scores in three groups were not statistically significant ($P > 0.05$). Conclusion: In the same dosage, 0.1%, 0.075% and 0.05% ropivacaine with PCEA could meet the anesthetic and analgesia in cesarean section. The hemodynamic index was stable during the operation. The different concentrations have no adverse effects on the neonatal Apgar scores. 0.075% ropivacaine is recommended for optimal concentration with a better effect on epidural anesthesia in cesarean section, feeble motor block, less adverse effects during perioperative period.

Keywords: Ropivacaine, caesarian section, epidural anesthesia, different concentration

Introduction

In China, cesarean section is a popular way for delivery. Researches show that during 2008 to 2014, the total cesarean section rate in China increased from 28.8% to 34.9% [1]. The rate of cesarean section in most hospitals is 40%, especially in some hospitals, even up to 80% [2, 3]. As an important midwifery, cesarean section not only relieve the pain of puerperae, but also save the fetuses and the mothers in time when they are in a difficult situation such as dystocia or fetal distress [4]. With the advance of science and technology, cesarean section is also improving, and its demand for anesthesia is also increasing. Perfect anesthesia is very important for the success of cesarean section, providing ideal conditions for surgery, and ensuring the safety of mothers and fetuses. How to reduce the complications of anesthesia, improve the effect of anesthesia, ensure the success of the operation and guarantee the safety of fetuses and mothers body are particularly important.

So far, the main anesthesia methods for cesarean section are intraspinal anesthesia and general anesthesia [5]. General anesthesia (GA) has better analgesic and muscle relaxation, and the blood pressure is easy to control, but capillary dilatation during pregnancy causes oral bronchial mucosa edema, especially in preeclampsia patients, which could easily cause failure or difficulty in intubation. The puerperae are prone to reflux, aspiration. The newborns who absorb general anesthesia drugs could cause respiratory depression. For these reasons, only has the failure of intraspinal anesthesia or has contraindication of intraspinal anesthesia, such as coagulation dysfunction of puerperae, bleeding tendency, vertebral canal deformity, infection near the puncture point, or serious nervous system disease, we may choose the general anesthesia for cesarean section [6, 7]. But intraspinal anesthesia is relatively simple, inexpensive, and has little impact on the fetus. The study showed that the Apgar scores of the newborns delivered by intraspinal anesthesia were higher than that of the newborns who were delivered by general anesthesia. In view of the above advantages and disadvantages, intraspinal anesthesia was often used as the first choice of anesthesia for clinical cesarean section [8, 9]. Intraspinal anesthesia includes subarachnoid anesthesia (SA), epidural anesthesia (EA), and combined spinal epidural anesthesia (CSEA). The subarachnoid anesthesia (SA) is punctured through the L2~3 or L3~4, injecting the local anesthetic into the subarachnoid cavity and the cerebrospinal fluid, which directly acts on the spinal cord and the spinal nerve root through planar diffusion and causes them to weaken or lose the conduction function, which produces sensory and motor block. This method has short onset time, good muscle relaxation and perfect analgesic. On the other hand, the plane is not easy to control; The influence of the hemodynamics is obvious with maternal hypotension and reduced placental blood flow to affect the condition of fetus, which limits the clinical application of SA [10, 11]. Epidural anesthesia (EA) needs to inject the local anesthetics into epidural space, which could extend outward through epidural space and intervertebral foramen to block the area of spinal nerve root and its domination. During anesthesia, the dosage can be increased with the operation time or pain level, which is more controllable and could effectively relieve the pain of cesarean section [12, 13]. The combined spinal and epidural anesthesia (CSEA) has the dual advantage of spinal and epidural anesthesia. Hence, the subarachnoid block quickly starts and provides sufficient analgesic and perfect muscle relaxation to meet the smooth of operation, and the primipara can use a micropump connected to the epidural catheter after the operation to control the patient's self-controlled analgesia [13]. In this study, we conducted CSEA in L3~4 space. After successful subarachnoid injection, 10 mg ropivacaine (diluted to 2 ml) was injected into the subarachnoid space. Epidural catheter was inserted 4 cm into the epidural space, and the mixture of ropivacaine mixed with different concentrations was used. After fetus delivery, PCEA pump was used to evaluate the epidural anesthesia of different concentrations of ropivacaine, analgesic effect and safety.

The common drugs for intraspinal anesthesia in China include local anesthetics such as bupivacaine, ropivacaine, and traditional opioid receptor agonists, such as morphine, piperidine and fentanyl. The analgesic effect of opioids is individual difference, and the incidence of adverse effects such as nausea and vomit-

ing are higher [14-16]. Bupivacaine, as the past usual local anesthetic, has been proved to be toxic to the heart and central nervous system, which limits the clinical use [17, 18]. Ropivacaine is a long-acting amide local anesthetic drug [19, 20]. Its remarkable characteristics are fast onset, long duration of anesthesia, definite anesthetic effect, minimal cardiac toxicity and sensory and motor block separation when it is in low concentration. The structure and physicochemical properties of ropivacaine and bupivacaine are similar. However, the toxicity of ropivacaine to the heart and central nerve system is lower, and it is superior in the recovery from local anesthetic poisoning. Ropivacaine has obvious sensory and motor separation when used at low concentration, especially be suitable for postoperative analgesia to get exercise as early as possible. Moreover, ropivacaine has a slight effect on the blood vessels of the uterus and has little influence on the blood flow of the placenta, so it is safer for the mothers and newborns. It is often used as a local anesthetic, which is ideal for obstetric anesthesia and labor analgesia [21]. However, the current standard of clinical analgesia is diverse, resulting in the waste of anesthetics. Although studies about the effect of subarachnoid ropivacaine on its dosage, concentration, proportion of drug and solution and speed of injection had been explored [22], the effect and safety of epidural anesthesia in caesarean section with different concentrations of ropivacaine under the same dosage still need the further investigation [23]. In this study, ropivacaine was pumped into the same dosage but different concentrations during the cesarean section. The epidural anesthesia and analgesic of ropivacaine with different concentrations were compared, and the safety assessment was carried out through the occurrence of adverse effects and the condition of the newborn. It may provide guidance for clinical use of drugs.

Materials and methods

General information

The experiment was approved by the hospital's ethics research committee of Maternity and Child Care Center, Dongchang district, Liaocheng, Shandong. The study includes 90 single full-term pregnancy puerperae who underwent lower segment cesarean section between December 2015 and December 2016. All the procedures were instructed by the senior anesthetists, and the safety of patients could be ensured.

Inclusion criteria

1) The primiparas who plan to have a cesarean section. 2) Single full-term pregnancy. 3) ASA level I-II. 4) With patients' consent.

Exclusion criteria

1) Twin or multiple pregnancies. 2) Severe obstetric complications, like pregnancy-induced hypertension. 3) Congenital heart disease. 4) Hypnotics and Sedatives medication history prenatally. 5) Coagulation disorders. 6) L3-4 lumbar gap puncture failure. 7) Drug allergy.

Dropout criteria

1) Failure to L3-4 space puncture. 2) Allergy to drugs used in the study during the operation. 3) The one who is a dropout.

Study group

As a prospective clinical research, it follows the random, double blind rules strictly. 90 patients were numbered by an anesthetist who was not involved in the trial. Consecutive numbers were labeled on the case of patient-controlled epidural analgesia (PCEA) from 1 to 90, which were generated randomly by computer. 1 to 30 were Group HC with high concentration (group HC), 31 to 60 were group with median concentration (group MC) and 61 to 90 were group with low concentration (group LC). Three concentrations of ropivacaine were loaded in the cases according to their groups, then, setting up the analgesia pump parameters. Puerperae were blind to the groups and the concentrations of ropivacaine, while the researcher set the pump for them.

Group HC were mixed with 0.1% ropivacaine and 0.4 ug/ml sufentanil, 120 ml in total, 3 ml/h.

Group MC were mixed with 0.075% ropivacaine and 0.3 ug/ml sufentanil, 160 ml in total, 4 ml/h.

Group LC were mixed with 0.05% ropivacaine and 0.2 ug/ml sufentanil, 240 ml in total, 6 ml/h.

Table 1. General characteristics of puerperae ($\bar{x}$ ± s, n=30)

Characteristic	Group			*F*	*P*
	HC	MC	LC		
Age (y)	29.30±4.05	30.00±4.44	29.23±4.25	0.300	0.742
Height (cm)	160.77±3.47	159.80±4.66	160.42±4.28	0.413	0.663
Weight (kg)	75.16±10.38	77.20±8.78	74.95±9.94	0.487	0.616
BMI (kg/m^2)	29.05±3.64	30.22±3.17	29.07±3.18	1.031	0.448
Gestational weeks (w)	39.19±0.61	39.25±1.18	39.33±1.12	0.147	0.864

Methods

1) The upper limb liquid channel was established after the puerperae entering operation room, 10 ml/kg Ringer's was given by intravenous before anesthesia. 2) Systolic blood pressure, diastolic blood pressure, mean arterial pressure, heart rate and pulse oxygen saturation were monitored via standardized non-invasive way. 3) Mask oxygen-inspiration, 4 L/min, Placing the puerperae on the left supine position. 4) Anesthesia methods, combined spinal-epidural anesthesia at the space of L3 and L4 firstly, then 10 mg ropivacaine was injected to the subarachnoid space (the original concentration of ropivacaine was 100 mg/ml, diluting 1 ml of it with saline to 2 ml), making sure that the needle was around 4 cm and no blood or cerebrospinal fluid appear when operator withdraws. Patient-controlled epidural analgesia was set up for the Group HC, Group MC and Group LC puerperae. When their fetuses were born, the concentrations of ropivacaine were 0.1%, 0.075% and 0.05% respectively. Patient-controlled analgesia (PCA) setting were as follows, PCEA was continuously pumped at 3 ml/h for Group HC, 4 ml/h for Group MC and 6 ml/h for Group LC, the dosage of ropivacaine of one hour was 3 mg for each group. An extra hour dosage was counted when the patient presses the button, 30 minutes for the procedure.

Data collecting

Clinical characteristics of the study participants, including age, height, weight, gestational weeks.

The hemodynamics responses during the surgery, SBP, DBP, MAP, HR and SpO_2 were recorded at the timing of pre-anesthesia (T1), 1 minutes after anesthesia (T2), skin incision (T3), the moment of baby delivery (T4), 5 minutes after baby delivery (T5) and 30 minutes after skin incision (T6).

Perioperative anesthetic effects

Sensory block level measurement: The acupuncture method was used for the maximum sensory block level at the timing of T3 and out of operation room (T7).

Measurement of motor block: Modified Bromage motor block score was used as follows: Level zero, the normal muscle strength, no lower limb motor nerve block. Level one, one could not raise leg straight, but knees could be bent. Level two, one could not bend knees. Level three, ankle, foot and knee could not be bent.

Visual analogue scale (VAS): The degree of pain of puerperae was measured by observation, including T3, T7, 6 hours after surgery (T8), one day after surgery (T9), three days after surgery (T10). The VAS measurement was equally divided into 10 parts on a 10 centimeters line, from no pain (0) to severe pain (10). Puerperae selected their score according to the feeling, recorded as the score of VAS.

The numbers of PCEA pump pressing: Recording the total numbers of PCEA pump pressing between fetus delivery and three days after surgery.

Anesthesia satisfactory score: Collecting the satisfactory scores of the Group HC, Group MC and Group LC at three days after surgery. Likert 5-points scale was adopted, five levels could be described as quite satisfied, satisfied, okay, unsatisfied and disappointment. A represents quite satisfied and satisfied, B contains okay, unsatisfied and disappointment, the rate of satisfaction=A/(A+B) × 100%.

Adverse effect

Adverse effect during surgery: Recording the situation of nausea, vomit, stretch reflex and hypotension between T3 and T6.

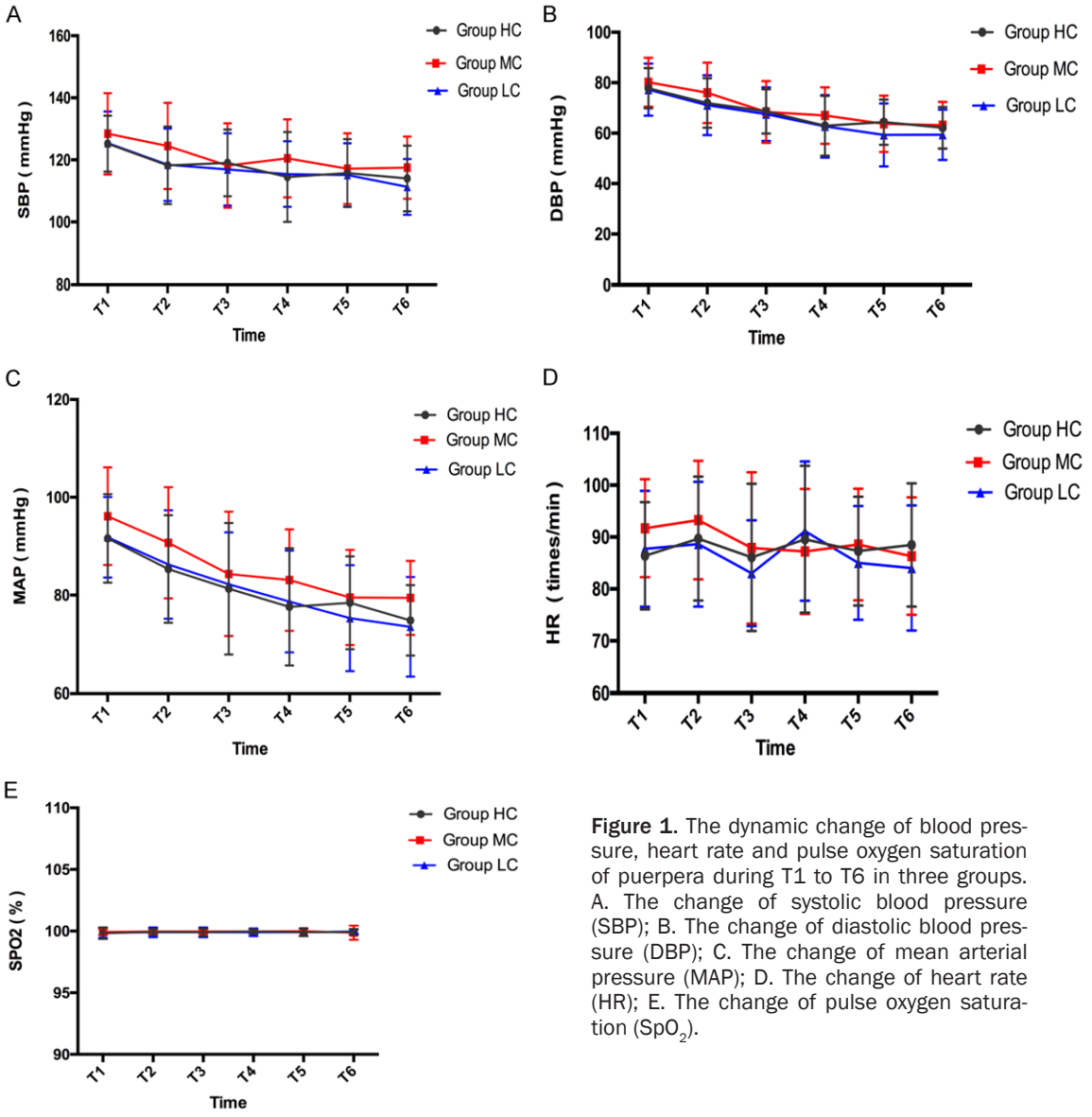

Figure 1. The dynamic change of blood pressure, heart rate and pulse oxygen saturation of puerpera during T1 to T6 in three groups. A. The change of systolic blood pressure (SBP); B. The change of diastolic blood pressure (DBP); C. The change of mean arterial pressure (MAP); D. The change of heart rate (HR); E. The change of pulse oxygen saturation (SpO_2).

Table 2. Comparisons of the highest level of sensory block in three groups (N, n=30)

Time	Group	Sensory nerve block							Median	χ^2	*P*
		T4 level	T5 level	T6 level	T7 level	T8 level	T9 level	T10 level			
T3	HC	0 (0.0%)	1 (3.3%)	23 (26.7%)	3 (10.0%)	3 (10.0%)	0 (0.0%)	0 (0.0%)	T6	0.851	0.653
	MC	0 (0.0%)	2 (6.7%)	17 (56.7%)	8 (26.7%)	3 (10.0%)	0 (0.0%)	0 (0.0%)	T6		
	LC	1 (3.3%)	1 (3.3%)	19 (63.3%)	3 (10.0%)	6 (20.0%)	0 (0.0%)	0 (0.0%)	T6		
T7	HC	0 (0.0%)	1 (3.3%)	21 (63.3%)	3 (10.0%)	4 (13.3%)	0 (0.0%)	1 (3.3%)	T6	0.081	0.960
	MC	0 (0.0%)	0 (0.0%)	21 (70.0%)	7 (23.3%)	2 (6.7%)	0 (0.0%)	0 (0.0%)	T6		
	LC	1 (3.3%)	1 (3.3%)	18 (26.7%)	4 (13.3%)	6 (20%)	0 (0.0%)	0 (0.0%)	T6		

Adverse effect after surgery: Recording the situation of nausea, vomit, headache, osphyalgia, paresthesia of low limb, respiratory depression and urinary retention from T6 to T10.

Table 3. Comparisons of motor block degree (modified Bromage score) in three groups (N, n=30)

	Group HC				Group MC				Group LC				χ^2	*P*
	Zero	One	Two	Three	Zero	One	Two	Three	Zero	One	Two	Three		
T3	0 (0.0%)	0 (0.0%)	0 (0.0%)	30	0 (0.0%)	0 (0.0%)	0 (0.0%)	30	0 (0.0%)	0 (0.0%)	0 (0.0%)	30	0.000	1.000
T7	0 (0.0%)	0 (0.0%)	0 (0.0%)	30 (100%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	30 (100%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	30 (100%)	0.000	1.000
T8	25 (83.3%)	5 (16.7%)	0 (0.0%)	0 (0.0%)	28* (93.3%)	2*1006.7	0 (0.0%)	0 (0.0%)	21 (70%)	9 (30%)	0 (0.0%)	0 (0.0%)	5.563	0.062
												B *vs* C		0.021
T9	30 (100%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	30 (100%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	30 (100%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0.000	1.000
T10	30 (100%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	30 (100%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	30 (100%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0.000	1.000

*Compared with C, $P < 0.05$.

Table 4. Comparisons of maternal VAS scores in three groups ($\bar{x}$ ± s, n=30)

	Group HC	Group MC	Group LC	*F*	*P*
T3	0.00±0.00	0.00±0.00	0.00±0.00	-	-
T7	0.00±0.00	0.00±0.00	0.00±0.00	-	-
T8	1.50±1.48	1.63±1.59	1.03±0.85	1.646	0.199
T9	1.80±1.22*	1.70±1.06*	1.17±0.75	3.315	0.041
				A *vs* C	0.019
				B *vs* C	0.047
T10	0.73±1.26	0.87±0.78	0.63±0.72	0.457	0.635

*Compared with Group LC, $P < 0.05$.

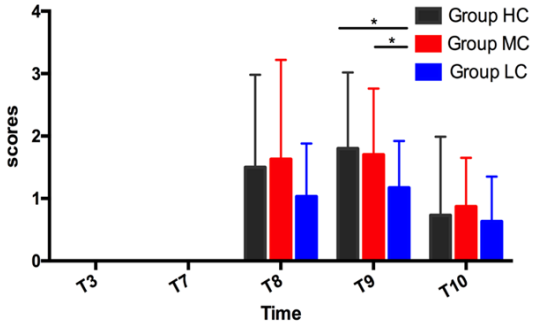

Figure 2. Comparisons of VAS score at different time-points in three groups. *compared with Group LC, $P < 0.05$.

Apgar score of neonate

	0	1	2
Pulse	None	< 100/min	> 100/min
Respiration	None	Slow breathing without rules or crying weak	Normal breathing or crying loudly
Muscular tension	Limbs sagging	Limbs bent slightly	Limb moves normally
Nervous reflex	No reflex	Frown	Crying, sneezing, coughing
Appearance of skin	Cyanosis or pale	Normal except limbs	Normal skin

Score 8-10 was normal, 5-7 was slightly apnea, 0-3 was severe apnea. Apgar scores were administrated at 1 minutes, 5 minutes and 10 minutes after fetus delivery. Score of 1 minutes was for diagnosis and degree. Score of 5 minutes and 10 minutes was more useful for evaluating resuscitation effect and prognosis.

Statistical analysis

The measurement data was used as the mean ± standard deviation, the comparison among groups at the same time point was analyzed by one-way ANOVA, and the comparison among groups of enumeration data was used by chi-square test or Fisher's test. The comparison among groups of highest sensory block level and the degree of motor block was analyzed by Kruskal-Wallis H test. All analyses were performed using SPSS 13.0, *P* value less than 0.05 were considered to be statistically significant.

Results

Assessment of preoperative general characteristics

The age, height, weight and gestational weeks had been compared respectively, one-way ANOVA results indicated that there was no significant difference (**Table 1**).

The dynamic changes of intraoperative hemodynamics

SBP, DBP, MAP, HR and SpO_2 in Group HC, Group MC, Group LC were recorded at T1, T2, T3, T4, T5 and T6, comparison between the three groups at same time point was analyzed by one-way ANOVA, the results showed no significant difference in each time point above. Details in **Figure 1A-E**.

The effect of perioperative anesthesia

The highest sensory block level in Group HC, Group MC, Group LC were measured at the time points of T3 and T7, groups comparison at same time point was analyzed by Kruskal-Wallis H test, the results revealed that the average of highest sensory block level was T6 level in three groups at T3 and T7, no significant difference was found in comparison of groups. Details in **Table 2**.

The modified motor block Bromage score of three groups were measured at T3, T7, T8, T9

Table 5. Comparisons of the frequency of pressing PCEA pump in three groups ($\bar{x} \pm s$, n=30)

	Group HC	Group MC	Group LC	*F*	*P*
Frequency	10.40±4.21#,*	8.00±4.59*	5.30±3.72#	11.138	0.000
				A *vs* B	0.029
				A *vs* C	0.000
				B *vs* C	0.014

*Compared with Group LC, *P* <0.05; #compared with Group MC, *P* <0.05.

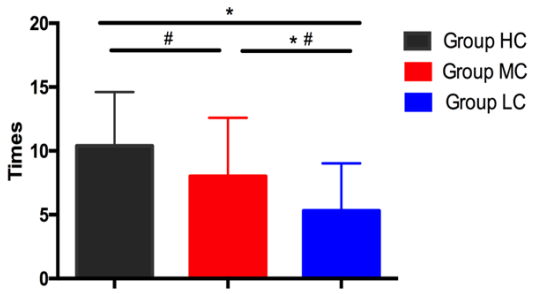

Figure 3. Comparisons of the perioperative frequency of pressing PCEA pump in three groups during. *compared with Group LC, *P* < 0.05, #compared with Group MC, *P* < 0.05.

and T10, comparison in groups at same time-point was analyzed by Kruskal-Wallis H test, results indicated that three groups' Bromage score reached to level 3, which meant knees cannot be bent, at time of T3 and T7, no statistical significance was found among groups. At T8, modified motor block Bromage score of three groups recovered to level 1 or 0. 25, 28 and 21 cases in Group HC, Group MC and Group LC respectively were on level 0, 5, 2 and 9 cases in Group HC, Group MC and Group LC reached level 1, comparison between groups showed significant difference in Group MC and Group LC (*P*=0.021), no statistical significance was found between Group HC and Group MC, Group HC and Group LC. At time of T9 and T10, Bromage score was on level 0 in all groups, which equals to no motor nerve blocking, no statistical significance was found among groups. Details in **Table 3**.

The VAS scores of three groups were measured at T3, T7, T8, T9 and T10, groups comparison at same time point was analyzed by one-way ANOVA test, comparison among groups were used via LSD way, results revealed that the VAS score of Group HC, Group MC and Group LC were 0 at time of T3 and T7, comparison among groups had no significant difference. VAS score in Group LC was the lowest at T8, which was 1.03±0.85; VAS score in Group HC and Group MC was 1.50±1.48, 1.63±1.59 respectively, there was no significant difference among groups (*P*=0.199). VAS score at T9 was Group HC > Group MC > Group LC, which had significant differences between all groups (*P*=0.041), with the differences between the Group HC and Group LC, between the Group MC and Group LC (*P* < 0.05). VAS scores of all groups at T10 were under 1 score, which was no significant difference (*P*=0.635). Details in **Table 4** and **Figure 2**.

The frequency of pressing PCEA pump in each group was recorded from T4 to T10, then conducted the one-way ANOVA analysis, results showed that the frequency of Group MC (*P*=0.029) and C (*P* < 0.01) were significantly less than Group HC, meanwhile, that of Group LC were significantly less than Group MC (*P*=0.014), details in **Table 5** and **Figure 3**.

The satisfactory score which evaluated by Likert 5-points scale were investigated for three groups at T10. The comparisons among groups were analyzed by Kruskal-Wallis H test, the rates of satisfaction were conducted by chi-square test, results indicated that 23 cases (76.67%) of satisfaction in Group HC, 25 cases (83.33%) of satisfaction in Group MC and 27 cases (90%) of satisfaction in Group LC, the comparison among groups had no significant difference (*P* > 0.05), details in **Table 6**.

The comparison of adverse effects

The adverse effects, such as nausea, vomit, stretch reflex and hypotension were recorded from T3 to T6, the comparisons of every single effect among groups were conducted by chi-square test or Fisher's test, results revealed that the rate of nausea-vomit and stretch reflex in Group LC were 23.33% and 20%, higher than that in Group HC (13.33%, 13.33%) and Group MC (13.33%, 13.33%), the lowest rate of hypotension was Group MC (10%) and the highest rate of hypotension was Group HC (26.67%), however, the comparison among groups had no significant difference (*P* > 0.05).

The adverse effects, such as nausea, vomit, headache, osphyalgia, paresthesia of low limb,

Table 6. Comparisons of the maternal anesthesia satisfactory score in three groups (N, n=30)

Satisfaction	Group HC	Group MC	Group LC	χ^2	*P*
Very Good	2	0	4	3.663	0.160
Good	21	25	23		
Neutral	4	4	3		
Bad	3	1	0	1.920	0.383
Very Bad	0	0	0		
Satisfaction rate	76.67	83.33	90.00		

respiratory depression and urinary retention were recorded from T6 and T10, the comparison of every single effect among groups were conducted by Fisher's test, results indicated that the rates of nausea-vomit and urinary retention in Group LC were 13.33% and 13.33%, higher than that in Group HC (6.67%, 10%) and Group MC (10%, 6.67%), however, the comparison among groups had no significant difference ($P > 0.05$). Headache, osphyalgia, paresthesia of low limb and respiratory depression had not been found in all groups after surgery, details in **Table 7**.

The comparison of newborn delivery

Apgar score of 1 minute, 5 minutes and 10 minutes after delivery was calculated, the comparison of each timepoint used one-way ANOVA analysis, results showed there was no significant difference among groups ($P > 0.05$), details in **Table 8**.

Discussion

With the advancement of human civilization and the continuous development of medicine, cesarean section is one of the most effective midwifery surgeries in obstetrics. It focuses on solving urgent and difficult obstetric complications and is a crucial way to save the lives of the mothers and the fetuses.

At present, intraspinal anesthesia is the first option of caesarean section in China. Subarachnoid anesthesia, epidural anesthesia, and combined spinal-epidural anesthesia belong to intraspinal anesthesia. Even though subarachnoid anesthesia has been used for years, the controllability of the anesthesia plane during the operation is limited, and the block level is easily excessing to cause hemodynamic fluctuations in the maternal. When the epidural anesthesia puncture finished, catheter can be placed in the epidural space, local anesthetic drugs are continuously added to the epidural space according to the surgical needs and anesthesia response to ensure an orderly procedure. Combined spinal and epidural anesthesia is widely used in clinical practice due to the advantages above. With the promotion of comfort medicine, patient-controlled analgesia is widely used clinically, PCEA and PCA are the most popular one. Related studies show that patient-controlled epidural analgesia has a definite effect, less dosage using without any systemic impact as well [24, 25]. After epidural injection of local anesthetic drugs, the liquid spreads along the epidural space, for this reason, the dosage of local anesthetic drugs play a key role in blocking area, while the concentration determined the degree of epidural anesthesia. The regulation of dosage and concentration were commonly used to reach the ideal degree of blocking and the level of blocking [26, 27]. In this study, PCEA electronic pumps with different flow rates ensure that the same dosage of ropivacaine is pumped into a unit of time. The effects of different concentrations of ropivacaine on epidural anesthesia and analgesia during cesarean section are compared. In Xu's study, 60 patients were grouped by concentrations of 0.3% ropivacaine and 0.4% ropivacaine, the effect of lumbar plexus sciatic nerve block was evaluated. Results indicated that both of them had stable blocking effect after 30 minutes of drug administration. However, the proportion of VAS score over 2 was above average in low concentration high capacity group [28], which implied this group owned a better anesthetic blocking effect. It has the same results with this study, which the VAS score and frequency of pressing PCEA pump in Group LC is less than that in Group HC and Group MC.

Compared with general anesthesia, the equipment required for intraspinal anesthesia is relatively simple, the price of anesthetic drugs is lower, and the maternal maintains a sober state during the entire operation, which can reduce intraoperative aspiration and is more humane. The continuous pumping of the local anesthetic through the epidural catheter can not only meet the need of intraoperative anesthesia, but also have good anesthetic effect

Table 7. Comparisons of puerpera perioperative adverse effects incidence in three groups [N (%), n=30]

Group	Intraoperative			Postoperative					
	Nausea and vomit	Stretch reflex	hypotension	Nausea and vomit	Headache	Osphyalgia	Lower limb paresthesia	Respiratory depression	Urinary retention
HC	4 (13.33)	4 (13.33)	4 (13.33)	2 (6.67)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	3 (10.0)
MC	4 (13.33)	4 (13.33)	3 (10.00)	3 (10.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	2 (6.67)
LC	7 (23.33)	6 (20.00)	8 (26.67)	4 (13.33)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	4 (13.33)
χ^2	1.440	0.698	3.360	0.797	0.000	0.000	0.000	0.000	0.797
P	0.487	0.479	0.186	0.392	1.000	1.000	1.000	1.000	0.669

Table 8. Apgar scores of newborns in three groups ($\overline{x}$ ± s, n=30)

Time after birth	Group HC	Group MC	Group LC	*F*	*P*
1 min	9.77±0.57	10.00±0.00	9.93±0.37	2.849	0.063
5 min	9.90±0.31	10.00±0.00	9.97±0.18	1.845	0.164
10 min	9.97±0.18	10.00±0.00	10.00±0.00	1.000	0.372

and can also meet the need for postoperative analgesia. It should be noted that epidural anesthesia reduces the resistance of the systemic circulation by reducing the resistance of the systemic circulation, dampening the spinal nerves and the sympathetic nerves in the dominance range with reducing the elastic resistance of blood vessels, and expanding the arterial and venous blood vessels throughout the body. Decreased cardiac output and heart rate, which in turn causes a decrease in arterial blood pressure [29]. The enlarged uterus in late pregnancy oppresses the mother's inferior vena cava to reduce the amount of returning blood, and it also easily leads to hypotension after epidural anesthesia. Therefore, we need to pay extra attention to the change of blood pressure in our clinical work. Hypotension after epidural anesthesia can easily cause nausea, vomiting and other adverse effects. Dyspnea could occur in severe cases. Hypotension caused by cerebral hypoperfusion can cause changes in maternal consciousness, which would easily trigger stomach contents reflux aspiration or related cardiovascular complications. Postpartum pregnant woman undergoes physiological changes in compression of the spine, which may lead to an increase in the level of blocking after epidural anesthesia. Puerperae, as a special group of people, the blood flow throughout the body will redistribute, the maternal uterine blood flow can reach 500-700 ml/min, and the blood flow in the gap between the 350-550 ml/min is used for fetal metabolic exchange. Maternal arterial blood pressure largely determines the blood perfusion of pregnant uterus, hypotension often leads to the decrease of uterine blood flow, reducing the interstitial space blood flow, resulting in inadequate placental perfusion which might lead to fetal distress, acidosis. Study showed when maternal hypotension occurred, the number of cases with Apgar score less than 8 points was significantly increased at 1 minute after delivery. Neonatal asphyxia often impairs the development of the nervous system and has a higher risk of neonatal death [30]. Therefore, the extent of epidural anesthesia affecting the fetus or the newborn depends on the occurrence of maternal hypotension and the large dosage of local anesthetic drugs. The key to obstetric anesthesia management is to guarantee the safety and comfort of maternal women during childbirth and the health of newborns. Anesthesiologists should minimize the use of local anesthetic drugs and reduce adverse effects, such as maternal hypotension, nausea and vomiting. This experiment compared three different concentrations of ropivacaine for epidural anesthesia and analgesia in caesarean section. The same dosage of sufentanil was combined to produce analgesic effect by combining with spinal opioid receptors and enhanced the analgesic effect of local anesthetics, reducing the use of large dosage of local anesthetic drugs. In this study, intraoperative hemodynamics is one of the most important indicators, results demonstrated there is no significant difference in SBP, DBP, MAP, HR and SpO_2 among groups at T1 to T6, the reasons of the stability of hemodynamics are probably as follows, 1) The median level of the highest sensory blocking in three groups was distributed around T6, and there was no case that the blocking level was too high, 2)

Before operation, the right hip of puerperae was padded 30 degree, which reducing the pressure of the uterus on the inferior vena cava. There were 4 cases, 3 cases and 8 cases of transient hypotension in three groups respectively, indicating that low concentration with high volume groups might easily lead to hypotension, the reason probably is high-capacity local anesthetic fluid spreads more extensively in the epidural space, which lead to sympathetic blocking furtherly. Meanwhile, the Apgar score of Group HC at 1 minute, 5 minute and 10 minute after delivery was 9.77±0.57, 9.90±0.31 and 9.97±0.18; The Apgar score of Group MC at 1 minute, 5 minute and 10 minute after delivery was 10.00±0.00, 10.00±0.00 and 10.00±0.00; The Apgar score of Group LC at 1 minute, 5 minute and 10 minute after delivery was 9.93±0.37, 9.97±0.18 and 10.00±0.00, no significant difference among groups has been found, the scores were in the normal range of 8 to 10, which demonstrated that three concentrations of epidural ropivacaine have barely adverse effects on newborns.

The recommended cesarean section blocking level in foreign obstetric anesthesia guidelines is generally T2 to T6, it varies in individuals. The domestic related research shows that the sensory block level of spinal anesthesia in cesarean section reaches T8, which can meet the surgical needs [31]. The Cesarean section requires more than just not in pain, but also a good muscle relaxation, eliminating the traction response as much as possible, thus, the maximum sensory block level of spinal anesthesia for cesarean section need to reach T6 or T4 [32, 33]. In this study, the median level of highest sensory blocking level reached to T6 among three concentration groups, and the VAS score was 0 in all groups, the occurrence of traction reaction in three concentration groups was 4 cases, 4 cases and 6 cases. The hypothesis may be that the use of low concentrations of ropivacaine for epidural anesthesia for cesarean section results in a higher sensory block than the motor block, leading to tractions in lower concentration group. Evaluation of three concentrations of ropivacaine after epidural anesthesia by modified Bromage score, resulting shows that 0.075% ropivacaine basically returned to level 0 after 6 hours motor blocking, no lower limb motor blocking (28/30), while 0.05% ropivacaine group has 21 cases returning to level 0 of motor blocking (21/30), differences between groups were statistically significant. It might imply that the motor block was recovered faster than the low concentration group when 0.075% ropivacaine was used for epidural anesthesia, and the postoperative motor impact was lighter and maternal comfort was better. Group of maternal perioperative adverse effects results showed that the cases of intraoperative vomiting, nausea, traction reaction and hypotension in Group LC were higher than those in others, meanwhile, the cases of postoperative vomiting, nausea and retention of urine were higher, however, the rates of hypotension and postoperative retention of urine in Group MC were the lowest among groups.

In summary, at the same dosage, 0.1%, 0.075%, and 0.05% of three concentrations of ropivacaine epidural pump can meet the cesarean section anesthesia and analgesic requirements, intraoperative hemodynamics indicators of maternal are stable, and have little effect on the Apgar score of newborns. 0.075% epidural pumping with ropivacaine is effective for anesthesia and analgesia for caesarean section, better postoperative recovery of lower extremity block, lighter movement effects and less perioperative adverse effects, it is recommended as the most appropriate concentration.

Disclosure of conflict of interest

None.

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