ISSN: 2690-9189

Research Article

International Journal of Orthopaedics Research

The Influence Of Sufentanil On Epidural Anesthetic Effect of Ropivacaine In Lower Limb Surgery

Mukesh Kumar[1*], Radheshyam Gupta[2], Binay Kumar Shah[3], Satish Gupta[4], Suman Gupta[5] and Essa Ceesay[6]

[1]Department of Anesthesiology, Everest Hospital , Kathmandu , Nepal, Paropakar Maternity & Women's Hospital , thapathali , Nepal, Department of Anesthesiology, shanghai tongji hospital, Shanghai 200065, China

[2]Department of Urology, Nepal Korea Friendship Municipality Hospital, Madhyapur Thimi, Nepal, Department of Urology, Harbin Medical University Cancer Hospital, Harbin, 150081, China

[3]Department of Medicine, Narayani Hospital, Birgunj, Nepal

[4]Nepalese Army Institute of Health Sciences, Shree Birendra Hospital, Chhauni,Kathmandu, Nepal

[5]Department of Dental Surgery, National Medical College, Birgunj, Parsa, Nepal

[6]Department of Oncology Physician. Lamin Health Center, Gambia. West Africa

[*]Corresponding Author

Mukesh Kumar, Department of Anesthesiology, Everest Hospital , Kathmandu , Nepal, Paropakar Maternity & Women's Hospital , thapathali , Nepal, Department of Anesthesiology, shanghai tongji hospital, Shanghai 200065, China.

Submitted: 2024, Aug 19; **Accepted**: 2024, Sep 25; **Published**: 2024, Sep 30

Citation: Kumar, M., Gupta, R., Shah, B. K., Gupta, S., Gupta, S., et al. (2024). The Influence of Sufentanil On Epidural Anesthetic Effect Of Ropivacaine In Lower Limb Surgery. *Int J Ortho Res, 7*(3), 01-08.

Abstract

Background: *The Effective dose of ropivacaine, alone for lower limb surgery is higher and can increase the risk of adverse effects. Sufentanil, a more lipophilic and higher analgesic opioid, has been found to reduce the dosage of ropivacaine. Therefore, in the present study, we compared the anesthetic effect, in terms of onset time to sensory block and duration of analgesia, of two different concentrations of ropivacaine, when administered alone or co-administered with sufentanil.*

Methods: *80 consecutive American Society of Anesthesiologist physical status (ASA) I-II patients who were scheduled for lower limb surgery under epidural anesthesia were enrolled and assigned to one of four different groups (20 patients in each): 0.3375% Ropivacaine alone (Group A1; GA1); 0.375%, Ropivacaine alone (Group A2; GA2); 0.3375% ropivacaine with 20 µg Sufentanil (Group B1; GB1); 0.375% Ropivacaine with 20 µg Sufentanil (Group B2; GB2), Anesthetic effects in terms of onset time to sensory block and analgesic duration as well as adverse effects were compared between groups, success rates with different groups were also assessed.*

Results: *The demographic parameters such as age, sex, body weight, etc., were not significantly different among groups. Although increasing concentrations of ropivacaine decrease onset time to sensory block and increase analgesic duration, the effects were not statistically significant (P> 0.05). However, addition of Sufentanil to each concentration of ropivacaine increases analgesic duration and decreases onset time to sensory block significantly, (GA1 vs GB1: P=0.012); (GA2 vs GB2: P=0.001). In addition, the success rate for each concentration of ropivacaine was also accentuated significantly by the addition of sufentanil. Except for GB2, none of the groups achieved 100% successful anaesthesia, which was significantly higher compared to other groups. There were no significant differences in hemodynamics and postoperative adverse reactions among any groups.*

Conclusion: *The minimum concentration of ropivacaine required to induce 100% satisfactory anesthesia was achieved with the concentration of 0.375%. Addition of Sufentanil to Ropivacaine significantly decreases onset time of epidural block and increases analgesic duration, irrespective of concentration of administered Ropivacaine. Moreover, addition of Sufentanil did not have any significant hemodynamic changes or any adverse effects in both groups.*

Keywords: Epidural Anesthesia, Lower Limb Surgery, Ropivacaine, Sufentanil

1. Introduction

Epidural anesthesia has a short onset and longer duration of action. Intense motor block in patients, so lumbar epidural anesthesia is the most commonly used anesthetic regimen for lower limb surgery [1-2]. Ropivacaine, associated with decreased potential for central nervous system toxicity and cardiotoxicity is a local amino amide anesthetic drug that which exerts reversible inhibition of sodium ion influx in nerve fibers with reduced lipophilicity [3]. Recent studies show that ropivacaine with intrathecal addition of sufentanil, a synthetic opioid with higher affinity to local anesthetics drastically raises the anesthetic quality, lengthens the analgesic duration while simultaneously reducing the local anesthetic dosage and onset time of sensory block [5-10].

Sufentanil has a cephalad spread and is more potent than fentanyl or morphine [11-13]. Practical implementation has shown that the use of an opioid, especially sufentanil, enables to lower the concentrations of dosage. This has been advocated for labour analgesia [14-16]. However, there are no studies on the optimal concentration of ropivacaine in addition to sufentanil in patients undergoing lower limb surgery.

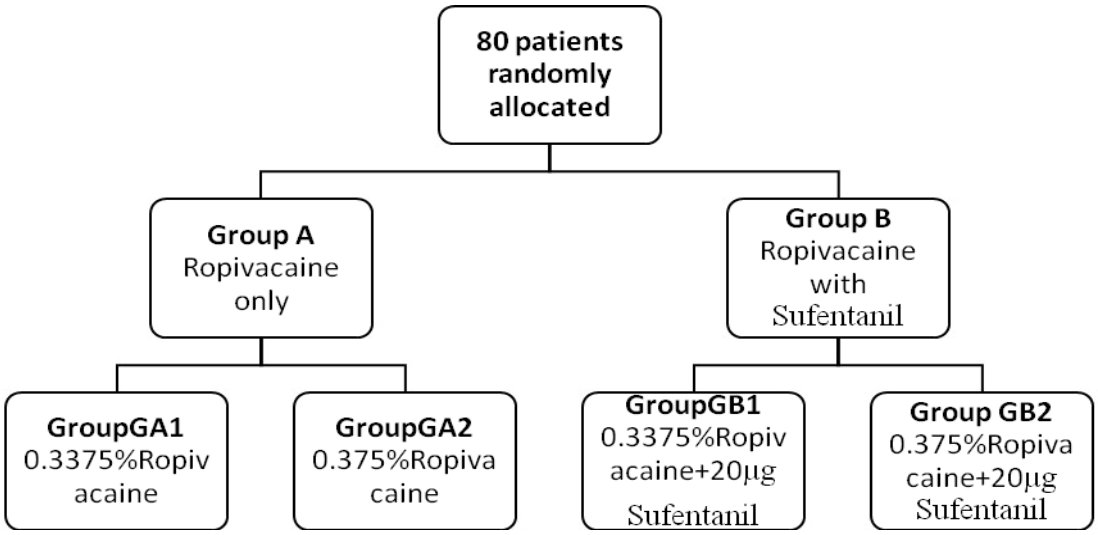
The purpose of our study is to investigate the minimum concentration of epidural ropivacaine combined with a fixed dose of sufentanil using two different concentrations of ropivacaine as well as to compare the anesthetic effect of epidural ropivacaine at two different concentrations co-administered with sufentanil with those administered alone.

2. Materials And Methods

2.1. Patients selection

In our study dating from February 2016 to March 2017, we selected 80 patients from the American Society of Anesthesiologists physical status I-II. Pateints ranged from 18 to 65 years old. The protocol was approved by the ethics committee of Everest Hospital, Kathmandu, Nepal. Signed informed consent was acquired from each participant. The exclusion criteria were: (1) history of hypersensitivity to local epidural anesthetics or opioids, especially sufentanil; (2) patients showing absolute contraindication to epidural anesthesia, and (3) patients with a history of any sedative drugs or opioids within the past 12 hours.

Summary of procedures



2.2. Study Design

This was a prospective, randomized study. A total of 80 cases that underwent lower limb surgical procedures were selected. The patients were selected and assigned to one of four groups (20 patients in each): 0.375% ropivacaine alone (Group A1; GA1); 0.3375% ropivacaine alone (Group A2; GA2); 0.375% ropivacaine + 20µg sufentanil (Group B1; GB1); 0.3375% Ropivacaine + 20µg sufentanil (Group B2; GB2. The dose of sufentanil in Group B was kept constant while different doses of ropivacaine were used, which were determined for each patient on the basis of designated sub groups. Cases were considered independent of the operative diagnosis. The surgical procedures were, including but not limited to, endovenous laser ablation surgery for great saphenous varicose vein, pelvic, or perineal regions, Pelvic Floor Reconstruction Ureteral Stenting or Ureteral Access Surgery, ACL reconstruction, Hip replacement, Achilles tendon repair, Hemiarthroplasty, Plating or intra medullary fixation, Tension Band Wiring or K-wire fixation.

2.3. Procedure

Once the patient entered the operating room, an intravenous catheter was inserted into a large peripheral arm vein and 500 ml Lactated Ringer's solution was given. The Patient was placed in a left lateral position with flexed forward. Under all aseptic condtions, by using an 18-gauge tuohy needle in the midline approach, L2-L3 or L3-L4 space was identified with loss of resistance to the air syringe

technique. Continuous pulse oximetry (SpO2), electrocardiogram (ECG) and Non-invasive arterial pressure (NIBP) were monitored.

2.4. Evaluation Criteria

Table 1 shows the level of sensory block was assessed bilaterally along the mid clavicular line by the loss of pinprick sensation with the help of a sharp needle. Sensory level to pinprick was estimated with the help of the Hollmen scale [17].

After injecting epidural analgesia, motor block in both lower extremities was examined by using the Modified Bromage scale at the end of thirty minutes [18]. Motor block in the lower limbs was determined by the Modified Bromage Scale in Table 2.

Grade	Definition
0	Ability to appreciate a pinprick as sharp
1	Ability to appreciate a pinprick as less sharp
2	Inability to appreciate a pinprick as sharp (analgesia)
3	Inability to appreciate a pin touching (anesthesia)

Note: The level of sensory block was assessed bilaterally along the mid clavicular line by the loss of pinprick sensation with the help of a 18G needle.

Table 1.

grade	Definition
0	Lack of Movement
1	Discrete movements (Trembling) of muscle groups
2	Ability to move against gravity, but not against resistance
3	Reduced strength, but able to move against resistance
4	Full muscle strength in relevant muscle groups

Table 2: Motor block in the lower limbs was determined by the Modified Bromage Scale

The total amount of drug needed to achieve adequate analgesia, duration of anesthetic effect post-surgery, the level of sensory block, severity of pain and recovery time were assessed. Moreover, side effects such as hypotension, bradycardia, respiratory depression, nausea, vomiting, shivering, and pruritus during surgery were also recorded.The severity of pain at rest and movement, the amount of opioid analgesics administered, and patients' satisfaction with their postoperative pain management were all assessed. Anesthesia was determined to be a failure if affective anesthesia was not achieved after 20 minutes of administration of the complete 20ml of the combination.

2.5. Statistical Analysis

All analyses were performed using the GraphPad Prism version 5.0 (GraphPad Software Inc., San Deigo, CA, USA) software. Continuous variables were recorded as mean ± standard deviations, and categorical variables were shown as percentages. Continuous variables were compared using an unpaired t test. Categorical variables were compared using a Fisher's exact test a p value <0.05 was considered statistically significant.

3. Results

3.1. Pre-operative demographic findings

All 80 patients finished the study. The demographic findings of all the patients are presented in table number 3. There was no significant difference for any of the measured data among the groups ($p > 0.05$).

3.2. Evaluation of anesthetic effects

Onset time to sensory block did not differ significantly between either concentration of ropivacaine ($p> 0.05$) in table 4. However, on addition of sufentanil onset time to sensory block significantly decreases for each concentration of ropivacaine (GA1 vs GB1: p=0.001); (GA2 vs GB2 p=0.012) (Figure. 1). Similarly, while the difference in duration of analgesia was also insignificant for either concentration of ropivacaine, the addition of sufentanil significantly increased analgesic duration for both concentration (GA1 vs GB1: p=0.001); (GA2 vs GB2: p=0.012) (Figure. 2). There was no significant difference between either group for mean highest and lowest level of block ($p> 0.05$). The Mean highest level of block was T9 while the lowest was S1 for each group. Total volume of ropivacaine used was significantly lower with the concentrations of 0.3375% as compared to 0.375% (p=0.015). The Addition of sufentanil not only further lowers the dose of 0.375% ropivacaine (p=0.029) but also the dose of 0.3375% ropivacaine (p=0.0001).

3.3. Anesthetic Success rate

Figure. 3 clearly demonstrate the addition of sufentanil to either concentration of ropivacaine accentuates its success rate. However, except GB2 (0.375% ropivacaine + sufentanil 20µg group) none of the groups achieved 100% successful anaesthesia which was significantly higher compared to other groups.

3.4. Hemodynamic Data and intra-operative complications

There was no significant differences in hypotension, bradycardia and respiratory depression observed among groups. No incidence of pruritus, nausea or vomiting were observed for any groups.

	M/F	Age	Height	Weight
GA1	12:7	41.3±8.6	165.6±4.5	62.2±7.8
GA2	12:9	44.8±7.2	170.2±2.5	64.2±8.3
GB1	19:5	51.3±10.5	169.1±6.9	65.0±8.7
GB2	10:6	45.1±8.6	165.3±5.1	65.8±4.2

Table 3: Perioperative demographics

Age in years; Height in centimeters; Weight in kilograms.

Table 3. shows the preoperative demographics of the patients in the both groups. The number of males and females in Group A as well as in Group B shows clearly that males outnumbered females in both the groups. The patients belonged to a varied age group. The mean height was 167.6 centimeters in Group A and 167.1 centimeters in Group B, and the mean weight was 63.2 kilograms in Group A and 65.4 kilograms in Group B.

Parameters	***Group A***		***Group B***	
	GA1 (0.3375%Ropivacainne)	**GA2 (0.375%Ropivacaine)**	**GB1 (0.3375%+20µg sufentanil)**	**GB2 (0.375%+20µg sufentanil)**
Duration of Surgery	165.4 ±19.2	169.9 ±19.3	153.4 ±8.5	165.7 ±11.2
Anesthesia Time	171.3 ±17.7	174.1 ±21.2	158.9 ±8.1	171.1 ±10.9
Time for onset	7.8 ±1.4	7.5±1.63	6.3 ±0.9*	5.7 ±1.2*
Mean Highest Level	$T_9(T_8\text{-}T_{12})$	$T_9(T_8\text{-}T_{12})$	$T_9(T_8\text{-}T_{12})$	$T_9(T_8\text{-}T_{12})$
Mean Lowest Level	$S_1(S_1\text{-}L_4)$	$S_1(S_1\text{-}L4)$	$S_1(S_1\text{-}L_4)$	$S_1(S_1\text{-}L_4)$
Duration of Analgesia	296.5 ±12.2	300.0±10.36	346.7 ±12.2**	372.3 ±12.7**
Total volume of ropivacaine used(ml)	16.4±1.95	14.25±1.16*	13.52±0.71*	11.8±1.26**

**p< 0.05, **p< 0.01. Anesthesia Parameters in the two subgroups of Group A and B are listed in the table above.*

Table 4: Anesthesia Parameters

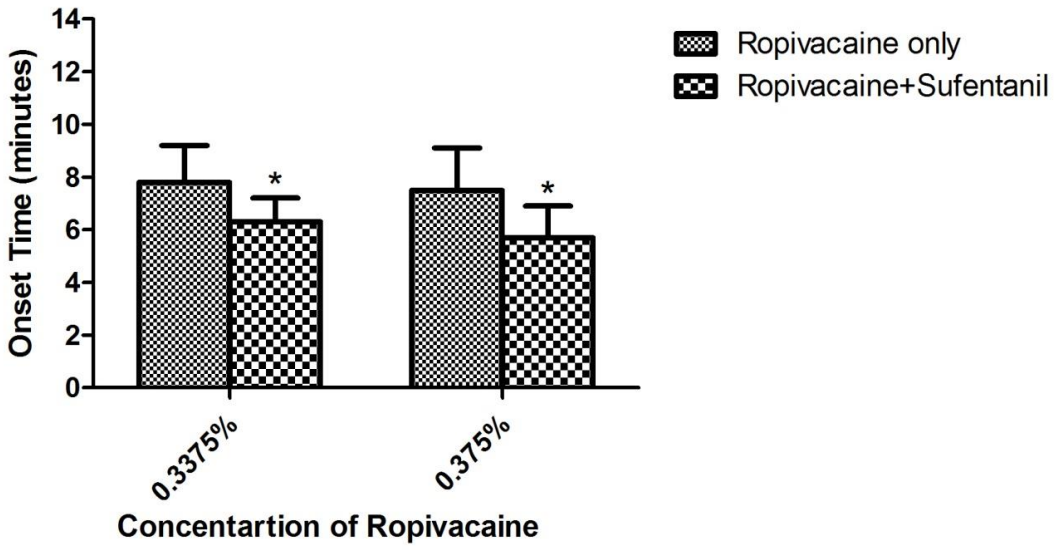


Figure 1: Anesthetic outcome with different concentration of ropivacaine: Onset time of sensory block with different concentration of ropivacaine. *P < 0.05.

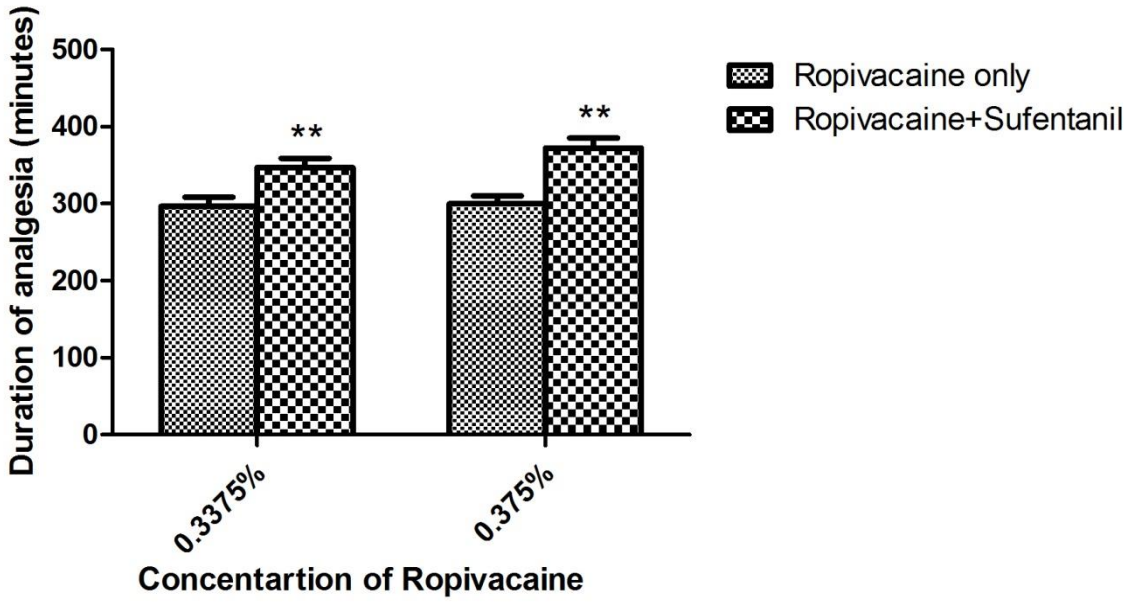


Figure 2: Anesthetic outcome with different concentration of ropivacaine: Duration of analgesia with different concentration of ropivacaine. **P < 0.01.

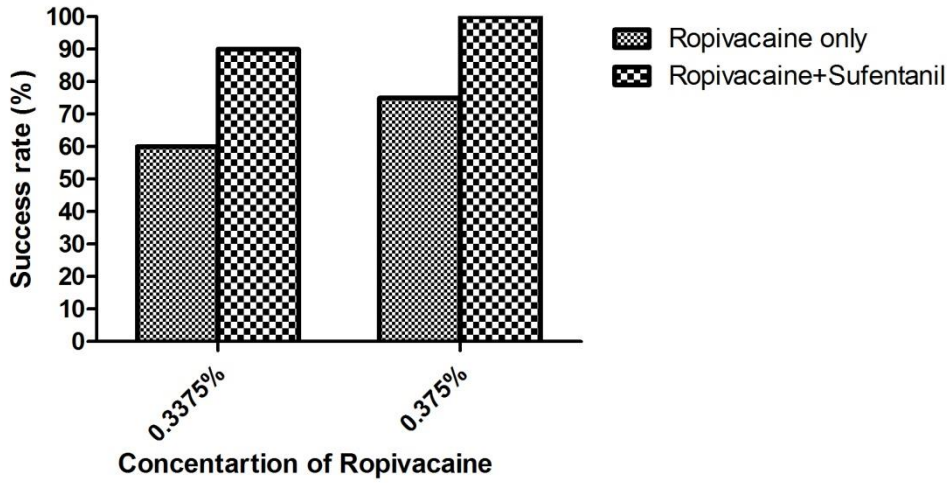


Figure 3: Comparative Success Rates of different doses of Ropivacaine, with and without Sufentanil.

4. Discussion

The present study aimed to evaluate the optimal concentration of ropivacaine that could achieve successful anesthesia in lower limb surgery in patients with the lowest possible volume administered. Furthermore, as previous studied have demonstrated the benefit of sufentanil in reducing ropivacaine concentration, we were tented to observe if addition of sufentanil would further decrease the concentration and dose of ropivacaine [19-20]. Several studies using intrathecal Sufentanil with local anesthetics have been reported [21-24]. Of which the dose of sufentanil ranged from 2.5 µg to 20 µg. Based on these studies, in the present study, we choose the highest reported dose. Initially 5ml volume of ropivacaine was used in each group to induce the block and subsequent volume were added upon any pain complaints by the patients. Finally, if no relief in pain was noticed with the epidural anesthesia then it was concluded failed and converted to general anesthesia. We noted the lowest possible volume used to complete the successful anesthesia for each concentration of ropivacaine.

Ropivacaine can still cause obvious cardiotoxicity when used in high concentration.. Though a decrease in concentration might reduce the possibility of hemodynamic side effects, it might compromise the motor and sensory block effects. Thus, an optimal concentration of ropivacaine would be beneficial for patients. The addition of opioids to local anesthetics has been demonstrated to be an alternative method to establish sufficient sensory and motor block, while reducing hemodynamic side effects. Several previous studies have shown that addition of sufentanil to ropivacaine, bupivacaine, or levobupivacaine for labor anesthesia or analgesia reduced minimum local analgesic concentrations of epidural local

anesthetics and minimized motor block [25-33]. However, no study has been carried out to find out the optimal concentration of ropivacaine and the effect of adding of sufentanil to it in patients undergoing lower limb surgery.

In the present study, a concentration of 0.375% ropivacaine achieved higher successful epidural anesthesia as compared to 0.3375% ropivacaine. Out of 20 patients 15 patients (75%) had successful anesthesia with 0.375% ropivacaine, while only 12 out of 20 (60%) with 0.3375% had successful anesthesia. This success rate, for each concentration of ropivacaine, was further increased with the addition of sufentanil. But again, with a higher success rate for 0.375% ropivacaine. 0.3375% ropivacaine in combination with sufentanil had 18 out of 20 (90%) successful anesthesia. On the other hand, administration of 0.375% ropivacaine in combination with sufentanil achieved a 100% success rate, i.e. all patients had 20 out of 20 (100%) successful anesthesia

Although one patient did complain of mild pain during surgery, infusion of dexmetotidine at the rate of 4µg achieved satisfactory effect and general anesthesia is not required, thus considered a successful epidural anesthesia. In addition, the total volume of ropivacaine used was significantly lower for concentration of 0.375% (14.25±1.16) as compared to 0.3375% (16.4±1.95) which further decreases for both a concentrations; 0.375% (11.8±1.26) and 0.3375% (13.52±0.71). 0.375% ropivacaine required the lowest possible volume of ropivacaine to complete successful anaesthesia; 11.8±1.26 ml. Regarding anesthetic effect, although not significant but 0.375% ropivacaine when co-administered with sufentanil required the least time to achieve sensory block (5.7 ±1.2 minutes). Moreover, duration of analgesia noted was longest in patient with 0.375% ropivacaine co-administered with sufentanil. A previous study by Li et al., reported the EC 50 of ropivacaine for motor blockade in patient with the TURP to be 0.383%, which is higher than our study, but the dose of sufentanil used in their study was lower (5mcg) than used in our study (20mcg) [34]. Furthermore, it is always difficult to compare EC50 values from different centers because the patient characteristics, anesthetic practice, and surgical practice may vary. From our study, we get the lowest concentration of ropivacaine but not the optimal concentration of ropivacaine. It is important to note that in the present study, none of the patients selected for the study had serious comorbidities that could potentially complicate the procedure. None had uncontrolled hypertension or significant peripheral neuropathy. We were prepared for the potential side effects of both the drugs in combination even though a lower dose of both drugs was used. Only one of the patients developed nausea and vomiting necessitating the use of antiemetic. Other expected side effects like hypotension and respiratory depression were not observed in any of the patients.

Some limitations of our study need to be acknowledged before drawing conclusion. we were able to demonstrate a significant effect of sufentanil on ropivacaine induced anesthetic effect, only one dose was investigated and this might not be the most effective dose. Finally, patients were not sub-analyzed according to age or weight.

5. Conclusion

In our study the concentration of ropivacaine alone yielded a satisfactory success rate. However, addition of sufentanil significantly increases the success rate of both concentrations of ropivacaine. In fact, addition of sufentanil to 0.375% ropivacaine achieved 100% successful anesthesia which was significantly higher compared to other concentrations of ropivacaine alone or even in combination with sufentanil. The Addition of sufentanil to both concentration of ropivacaine not only decreases the onset time to sensory block but also increases total analgesic duration. Moreover, sufentanil decreases the total dose of each concentration of ropivacaine to achieve the desired anesthetic effect. In addition, no major complications were noted. Thus, sufentanil is a suitable opioid to increase the anesthetic effect of ropivacaine at a low dose with no major side effects. Moreover, 0.375% concentration is the concentration of ropivacaine which when combined with sufentanil will achieve epidural anesthesia with a higher success rate.

Ethics approval and consent to participate

All procedures have been carried out in accordance with the applicable guidelines and regulations. A written consent was obtained from all patients and informed consent was obtained to participate from the parents/legal guardians of the patients. Ethical approval to conduct the study was obtained from the ethical Instructional review committee of EVPvt. Ltd, Kathmandu, Nepal.

Consent for publication

This study was conducted on human models. A written consent was obtained from all patients and their relatives to use their data and information in a research study for publication.

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