Original Research Article

A comparative study of 0.75% ropivacaine and 0.5% bupivacaine for epidural anesthesia in patients undergoing lower abdominal and lower extremity surgeries

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Abstract

Background: Regional anaesthesia has come to occupy an important part in clinical anaesthesiology today. As with other fields, regional anaesthesia too has undergone major developments both in techniques and drug availability.

Aim: To study and compare the effect of 0.75% Ropivacaine with 0.5% Bupivacaine for epidural anaesthesia in patients undergoing lower abdominal and lower extremity surgeries with respect to the following factors, Onset and Duration of Sensory Block and Onset and Duration of Motor Block.

Materials and Methods: To conduct this study, it was decided to consider a random sample of at least sixty (60) patients of either sex between the age of 20-65 years belonging to the American Society of Anaesthesiologists (ASA) physical status I or II scheduled to undergo elective surgery. The study was conducted to compare 0.75% Ropivacaine and 0.5% Bupivacaine for epidural anaesthesia in lower abdominal and lower extremity surgeries across the following parameters; Time taken for the onset of sensory block T_{12}, Time taken for maximum height of sensory block T_6, Time

taken for two dermatome segment regression, Time taken for regression up to T_{12}, Time taken for the onset of maximum motor block and Duration of motor block.

Results: The onset time for sensory block up to T_{12} and up to the maximum height of T_6 were found to be statistically insignificant; there was no difference in the effect of both the drugs. The two dermatome segment regression and regression up to T_{12} were statistically significant; it was prolonged in the case of Ropivacaine compared to Bupivacaine. The onset of motor block was statistically significant and was found to be faster in the case of Bupivacaine. The duration of the motor block was also statistically insignificant and it was the same for both the drugs.

Conclusion: From these results, this study provides a reasonable ground to conclude that Ropivacaine and Bupivacaine differ in terms of their onset and duration of both sensory and motor block in epidural anaesthesia. Thus Ropivacaine with its higher efficacy, prolonged sensory blockade, lower propensity for motor blockade, proven reduced potential for CNS toxicity and cardiotoxicity, appears to be an important option for regional anaesthesia, management of post-operative pain, labour pain making it the current local anaesthetic drug of choice.

Key words

Ropivacaine, Bupivacaine, Epidural anesthesia, Abdominal, Lower extremity, Surgery.

Introduction

Regional anaesthesia has come to occupy an important part in clinical anaesthesiology today. As with other fields, regional anaesthesia too has undergone major developments both in techniques and drug availability. Historically Bupivacaine was used clinically as it had a long duration of action. Subsequently it was found that propyl derivatives of pipecoloxylidide were less toxic than butyl derivatives (Bupivacaine). Ropivacaine was thus developed after Bupivacaine was noted to be associated with significant number of cardiac arrests [1]. Ropivacaine is a long acting local anaesthetic that is structurally related to Bupivacaine. It is a pure S (-) enantiomer unlike Bupivacaine which is a racemate developed for the purpose of reducing potential toxicity and improving relative sensory and motor profiles. Cardiotoxicity of Ropivacaine is less than Bupivacaine as it causes lesser depression of cardiac contractility [2]. The current study is aimed at comparing the sensory and motor blockade properties of 0.75% Ropivacaine and 0.5% Bupivacaine which was administered for epidural anaesthesia in patients undergoing lower abdominal and lower extremity surgeries. Various parameters referring to sensory and motor blockade were observed and studied. The results obtained from this study have been reviewed along with the other comparative studies conducted earlier to arrive at the conclusions.

Materials and methods

The study was conducted to compare 0.75% Ropivacaine and 0.5% Bupivacaine for epidural anaesthesia in lower abdominal and lower extremity surgeries across the following parameters; Time taken for the onset of sensory block T_{12}, Time taken for maximum height of sensory block T_6, Time taken for two dermatome segment regression, Time taken for regression up to T_{12}, Time taken for the onset of maximum motor block and Duration of motor block. To conduct this study, it was decided to consider a random sample of at least sixty (60) patients of either sex between the age of 20-65 years belonging to the American Society of Anaesthesiologists (ASA) physical status I or II scheduled to undergo elective surgery. The study was commenced after obtaining approval from the Institutional Ethical Committee of MNR Medical College and Hospital, Sangareddy and by also obtaining written informed consent from each of the patients selected randomly. These

sixty patients randomly selected were posted for various surgical procedures such as; Gynaecological procedures like Abdominal Hysterectomies, Vaginal Hysterectomies, General Surgery procedures like Inguinal, Umbilical, & Incisional Hernia repairs, Urological surgical procedures like TURP and Various Orthopaedic procedures like Open Reduction and Internal fixation of Femur & Tibia, DHS Fixation, external fixation of Tibia, Triple Arthrodesis of Ankle, Knee joint Arthroscopy. These patients were divided randomly into two (2) groups namely; Group I – Control group administered with 15 ml of 0.5% Bupivacaine epidurally and Group II – Study group administered with 15 ml of 0.75% Ropivacaine epidurally. Pre-anaesthetic check-up was conducted for all the patients to assess their clinical condition and investigated to rule out presence of any systemic disease. During these pre-anaesthetic check-ups, the patients were explained about the anaesthetic process, technique and effects. All patients deemed fit for the study were subjected to review once again on the day of surgery. The patients were investigated for Hemogram including Blood group and type, Bleeding time and Clotting time, Blood chemistry-Sugar, Urea, Creatinine, HIV, HBSAg, Urine Analysis, ECG and Chest X-Ray. Inclusion Criteria was that patients of either sex, ASA grades I and II, age between 20 years to 65 years, body weight between 45 kg to 80 kg, Patients planned for elective general surgeries, orthopaedic surgeries, gynaecological surgeries, and surgeries of the lower abdominal or lower extremities. Exclusion Criteria was patients who did not provide consent, ASA grades III, IV and V, bleeding and clotting disorders, patients with sepsis, both local and systemic, age below 20 years and above 65 years, spinal deformities such as kyphoscoliosis, neurological deficit, previous spinal injuries or surgeries, history of allergy to local anaesthetics, emergency procedures, height below 4’8”, weight more than 80 kg. All patients across both the groups were administered with anxiolytic drugs at bedtime, a day prior to surgery. Patients were kept nil per oral for at least 6 hours prior to surgery.

Venous Cannulation and Monitoring

In the operation theatre, an 18 gauge intravenous cannula was secured in a good peripheral vein and all the patients received intravenous pre-hydration with 10 ml/kg of crystalloid Ringer Lactate solution. Standard Monitors like Electrocardiogram, Pulse Oximeter, and Non-Invasive Blood Pressure monitor were connected to the patients. Pulse Rate, Blood Pressure, Respiratory Rate, SPO_2 and ECG recording was done before and after the conduct of anaesthesia which later continued throughout the surgical procedure.

Results

A total of sixty patients undergoing lower abdominal and lower extremity surgeries were studied.

Table - 1 shows both the control group and the study group were made up of thirty patients each of both sexes. The male to female sex ratio are nearly the same across both the groups. The ratio of ASA status I and II between the two groups is also the same. In the control group, the age varies between 23 years to 60 years and the weight from 40 to 78 kg, while in the study group, the age of the patients varies from 25 to 60 years and the weight from 52 to 76 kg.

Table – 1: Demographic details of control and study groups.

Variable	Control Group (n=30)	Study Group (n=30)
Mean age (years)	45.63	46.20
Avg. Weight (Kg)	62.93	61.93
Sex Ratio (M:F)	4:6	3:7
ASA status (I:II)	9:1	9:1

The control group and the study group were similar in terms of their age and weight distribution, with no significant differences.

Figure – 1: Time taken for the onset of sensory block T_{12}.

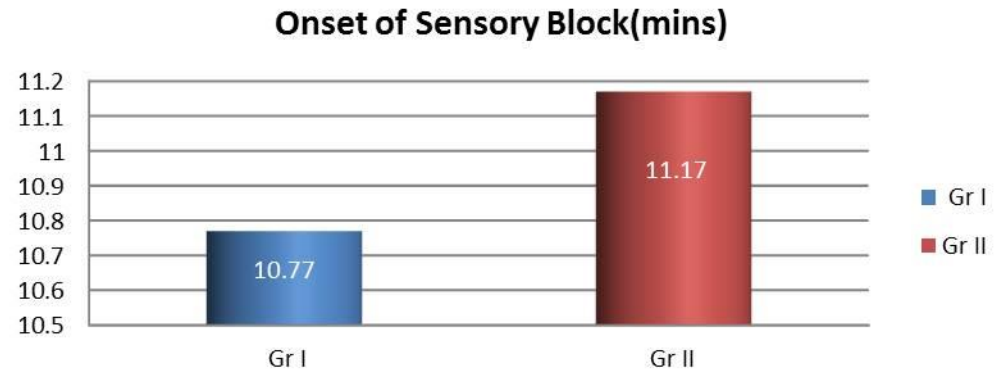


Figure – 2: Onset of motor block.

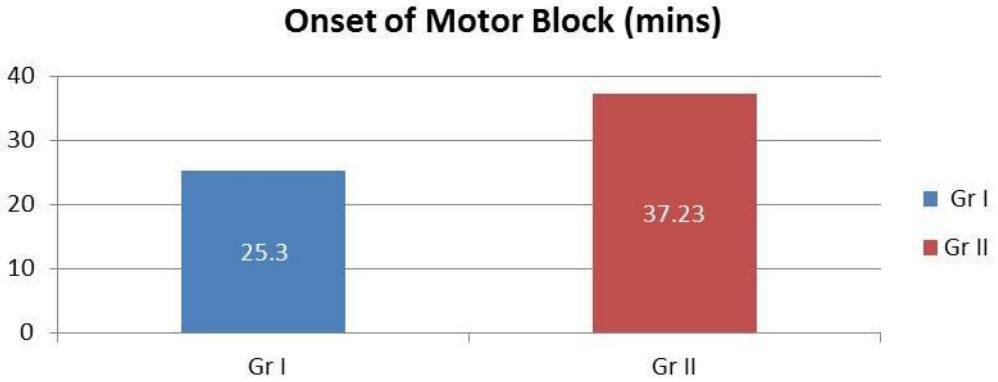
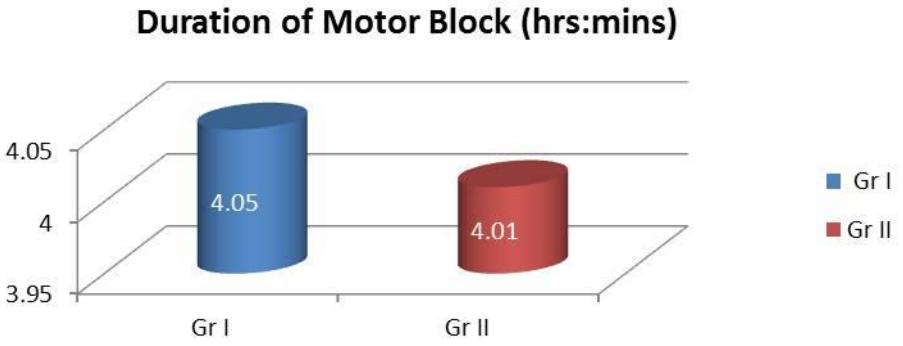


Figure – 3: Duration of motor block.



The observations were made at intervals of every two (2) minutes for the first 30 minutes, five (5) minutes for the next 30 minutes and thereafter the assessment was made at intervals of every fifteen (15) minutes till the end of the surgery. The time taken for the onset of sensory block T12 was 10.77 with SD of 1.14 in group I and in group II it was 11.17 with SD of 1.15. The time taken for maximum height of sensory block T6 was 24.37 with SD of 2.28 and in group II, it was 25.1 with SD of 2.11. Time taken for two dermatome segment regression was 1.50 with SD of 0.15 in group I and in group II, it was 2.12 with SD of 0.14. Time taken for regression up to T12 was 2.46 with SD of 0.18 in group I and in group II, it was 3.05 with SD of 0.22. The time taken for the onset of maximum motor block was 25.3 with SD of 4.06 in group I and in group II it was 37.23 with SD of 4.45. The duration of motor block was 4.05 with SD of 0.16 in group I and in group II it was 4.01 with SD of 0.21 (**Figure – 1, 2, 3**).

Table - 2: Parameters in control group and study group.

S.No	Parameter	Control Group		Study Group	
		Mean	SD	Mean	SD
1	Time taken for Onset of Sensory Block T_{12} (mins)	10.77	1.14	11.17	1.15
2	Time taken for maximum height of Sensory Block T_6 (mins)	24.37	2.28	25.10	2.11
3	Time taken for 2 dermatome segment regression (hrs:mins)	1.50	0.15	2.12	0.14
4	Time taken for regression upto T_{12} (hrs:mins)	2.46	0.18	3.05	0.22
5	Time taken for onset of maximum Motor Block (mins)	25.30	4.06	37.23	4.45
6	Duration of Motor Block (hr:min)	4.05	0.16	4.01	0.21

Threshhold "p_{alpha}" value = 0.05

S.No	Parameter	Control Group (Bupivacaine)		Study Group (Ropivacaine)		p Value	"p" less than "p_{alpha}"
		Mean	SD	Mean	SD		
1	Time taken for Onset of Sensory Block T_{12}(mins)	10.77	1.14	11.17	1.15	0.18130	FALSE
2	Time taken for maximum height of Sensory Block T_6 (mins)	24.37	2.28	25.10	2.11	0.13110	FALSE
3	Time taken for 2 dermatome segment regression (hrs:mins)	1.50	0.15	2.12	0.14	0.00000	TRUE
4	Time taken for regression upto T_{12} (hrs:mins)	2.46	0.18	3.05	0.22	0.00000	TRUE
5	Time taken for onset of maximum Motor Block (mins)	25.30	4.06	37.23	4.45	0.00000	TRUE
6	Duration of Motor Block (hr:min)	4.05	0.16	4.01	0.21	0.41100	FALSE

Table - 2 shows that for the study parameters 1, 2 and 6 the difference between the means was statistically insignificant since $p > 0.05(p_\alpha)$. This implies that there was no significant difference between 0.75% Ropivacaine and 0.5% Bupivacaine in terms of time taken for the onset of sensory block T_{12}, time taken for maximum height of sensory block T_6, duration of motor block. While on the other hand, we observe that the study parameters 3, 4 and 5 are statistically significant as $p < 0.05(p_\alpha)$ implying that 0.75% Ropivacaine and 0.5% Bupivacaine significantly differ in terms of time taken for two dermatome segment regression, time taken for regression up to T_{12}, the time taken for onset of maximum motor block.

Discussion

Epidural analgesia and anaesthesia were primarily introduced to provide anaesthesia for various surgical procedures and for post-operative and obstetric analgesia. Various local anaesthetic drugs belonging to ester and amide groups are used for this purpose. This includes Bupivacaine and Ropivacaine which belong to the amide group. Bupivacaine Hydrochloride is a long acting, amide local anaesthetic which has a potent sensory and motor blockade when used in higher concentrations. However, when used in lower concentrations, it has lower sensory and motor blockade. Ropivacaine is a newly introduced long acting, local anaesthetic belonging to the amide group. It is a monohydrate of the hydrochloride salt of 1-propyl-2,6-pipecoloxylidide and is prepared as pure S (-) enantiomer. The current study compares 0.75% Ropivacaine with 0.5% Bupivacaine used as an anesthetic and administered epidurally for lower abdominal and lower extremity surgeries. For the purpose of this study, the sixty randomly selected patients were divided into two equal groups; Group 1 comprising the control group was administered with 0.5% Bupivacaine while those in Group II,

the study group were administered with 0.75% Ropivacaine. The study was undertaken to compare the effect of Bupivacaine and Ropivacaine in terms of their sensory and motor blockade properties by observing the following parameters, Time taken for the onset of sensory block $T_{12,}$ Time taken for maximum height of sensory block $T_{6,}$ Time taken for two dermatome segment regression, Time taken for regression up to $T_{12,}$ Time taken for the onset of maximum motor block and Duration of motor block.

Time taken for the onset of sensory block T12: Time taken for maximum height of sensory block T6

The study indicates that 0.75% Ropivacaine and 0.5% Bupivacaine do not differ in the time taken for the onset of the sensory block. This is because as "p" (0.1813) > 0.05 (p_α) and statistically insignificant, implying that the effect of both the drugs are similar. The time taken for maximum height of sensory block up to T_6 is also found to be statistically insignificant, "p" (0.1311) > 0.05 (p_α). Ropivacaine does not differ from Bupivacaine in terms of the time to attain the maximum height of sensory block. The Pk_a and pH values of the anaesthetic solution determine the degree of ionization of specific agents. This degree of ionization influences the rate of diffusion of local anaesthetic across the nerve sheath and membrane. Given that the Pk_a values of both Bupivacaine and Ropivacaine are the same (8.1), it is understandable that there is no significant difference for the time taken for the onset of sensory block and the time taken for maximum height of the sensory block between these two drugs. In a study by Katz JA, Knarr D, Bridenbaugh PO [2] they compared 0.75% Ropivacaine 20 ml with 0.5% Bupivacaine 20 ml and no major differences were noted between these two drugs except that the time for two dermatome segment regression was of longer duration with Ropivacaine in comparison to Bupivacaine. Brockway MS, Bannister J, McClure JH, McKeown D, Wild Smith JAW [3] in their study compared 0.5%, 0.75% and 1.0% Ropivacaine 15 ml with 0.5% and 0.75% Bupivacaine 15 ml in 110 patients and found no significant difference in the onset, spread and duration of sensory block. However, Ropivacaine produced a slower onset, shorter duration and less intense motor block. In the study of clinical efficacy and kinetics of the lumbar extradural administration of 10 ml of 1.0%, 20 ml of 0.5% Ropivacaine and 20 ml of 0.5% Bupivacaine, Morrison LMM, Emanuelsson BM, McClure JH, Pollok AJ, McKeown D, Brockway MS, Jozwiak H, Wild Smith JAW [4] observed no difference between the two drugs in terms of onset, duration and spread of sensory block. The motor block produced by Ropivacaine was less intense and of shorter duration than Bupivacaine. Brown DL, Carpenter RL, Thompson GE [5] in their comparative study of Ropivacaine and Bupivacaine showed that Bupivacaine had a slightly longer duration of sensory and motor block but the spread was similar.

Time taken for two dermatome segment regression: Time taken for regression up to T12

These two parameters are indicative of duration of the sensory block. The time taken for two dermatome segment regression is found to be statistically significant. The study indicates that 0.75% Ropivacaine and 0.5% Bupivacaine differ in the time taken for two dermatome segment regression and the time taken for regression up to T_{12} is "p" (0.0000) < 0.05 (p_α) in both the parameters and statistically significant indicating that Ropivacaine differs from Bupivacaine. It is observed that Ropivacaine has taken a longer time to regress by two dermatome segments when compared to Bupivacaine. The prolonged duration of sensory block with Ropivacaine could be due to the variation of anaesthetic potency of the drug and the degree of protein binding. The anaesthetic potency of the drug depends primarily upon the lipid solubility. Though the lipid solubility and protein binding of Bupivacaine is more than that of Ropivacaine, the duration of sensory block with Ropivacaine was longer. This could be on account of the increased concentration of Ropivacaine (0.75%)

vs Bupivacaine (0.5%) and also due to vasoconstrictive property which decreases the absorption of the drug from the site of administration and thus prolong the duration of the block. This also could be on account of the differences between in-vitro and in-vivo potency which may be related to the differences in charge, hydrophobicity and vasoactive properties. In a study by Katz JA, Knarr D, Bridenbaugh PO [2] they compared 0.75% Ropivacaine 20 ml with 0.5% Bupivacaine 20 ml and found that the time for two dermatome segment regression was of longer duration with Ropivacaine in comparison to Bupivacaine. The time taken for regression up to T_{12} is statistically significant and observed that for Ropivacaine the regression time is significantly much longer than that of Bupivacaine. Two independent studies comparing 1.0% Ropivacaine and 0.75% Bupivacaine found no difference in terms of onset, extent or duration of motor block [6, 7]. But the duration of sensory block was longer and clinical efficacy was better with Ropivacaine. In the study of Osawa Masami, Suzuki Hajime, Hanakoa Kazuo, Yoshiya Ikuto, Komemushi Sadao, Mori Kenjiro [8], they found that the duration of sensory block in Ropivacaine group was same or longer than that of the Bupivacaine group. No significant differences after identical lapses of the time were found between the two groups but the decay time (duration of sensory block) was significantly longer in the Ropivacaine group than that of Bupivacaine group. In elective hip surgery, 1.0% Ropivacaine provided satisfactory anaesthesia more frequently than 0.5% Bupivacaine and the duration of sensory and motor block was also significantly longer in Ropivacaine [9]. Ropivacaine provided a similar anaesthetic profile to that of Levobupivacaine in patients undergoing lower epidural anaesthesia for lower limb surgeries [10]. In patients undergoing lumbar epidural anaesthesia for lower limb surgery, a 20 ml dose of Ropivacaine 0.5% or Bupivacaine 0.5% resulted in a median duration of T_{10} sensory block of 3.5 hours for Ropivacaine and 3.4 hours for Bupivacaine [11].

Time taken for the onset of maximum motor block

The time taken for the onset of maximum motor block is statistically significant. In the study 0.75% Ropivacaine and 0.5% Bupivacaine differ in the time taken for the onset of maximum block, "p" (0.0000) < 0.05 (p_α). Ropivacaine produced slower onset and less intense motor block compared to Bupivacaine. The speed of onset of motor blockade or paralysis depends upon the lipid solubility. The Pk_a and pH values of the anaesthetic solution determine the degree of ionization of specific agents. The unionized form is the active form. The rate of onset of motor blockade is associated with the aqueous diffusion rate which is inversely related to molecular weight. The rate of onset of motor blockade with Bupivacaine is faster when compared with Ropivacaine which could be on account of its increased lipid solubility, aqueous diffusion rate and hydrophobicity. Brockway MS, Bannister J, McClure JH, McKeown D, Wild Smith JAW [3] in their study compared 0.5%, 0.75% and 1.0% Ropivacaine 15 ml with 0.5% and 0.75% Bupivacaine 15 ml in 110 patients and found that Ropivacaine produced a slower onset, shorter duration and less intense motor block. Morrison LMM, Emanuelsson BM, McClure JH, Pollok AJ, McKeown D, Brockway MS, Jozwiak H, Wild Smith JAW [4] in their study of clinical efficacy and kinetics of the lumbar extradural administration of 10 ml of 1.0%, 20 ml of 0.5% Ropivacaine and 20 ml of 0.5% Bupivacaine observed that the motor block produced by Ropivacaine was less intense and of shorter duration than Bupivacaine. The motor block produced by Ropivacaine is slower in onset, less intense and shorter in duration than that of an equivalent dose of Bupivacaine. Motor block intensifies as the dose of Ropivacaine is increased in extradural anaesthesia [12].

Duration of motor block

It is observed that the duration of the motor block is statistically insignificant and there is no difference in the duration of the motor block between the two drugs, "p" (0.4110) > 0.05 (p_α).

The duration of motor block is dependent on lipid solubility and the degree of protein binding of the drug. Though the lipid solubility and degree of protein binding of Ropivacaine is less than that of Bupivacaine, it has been found in the current study that the duration of the motor block produced by both the drugs has been the same. Previous studies have indicated that the duration of motor blockade is less with Ropivacaine when compared to Bupivacaine. The current study indicates that the duration of motor block for both the drugs is the same. This could be probably be attributed to the increased concentration of Ropivacaine when compared to Bupivacaine. In a study by JH McClure [12] with 0.5% Ropivacaine and 0.5% Bupivacaine, it was observed that the motor block produced by Ropivacaine is shorter in duration than that of Bupivacaine. However, motor block intensifies as the dose of Ropivacaine is increased in extradural anaesthesia. In a study comparing 1.0% Ropivacaine and 0.75% Bupivacaine Niesel HC, Eilingsfeld T, Hornung M, Kaiser H [6] found no difference in terms of onset, extent or duration of motor block. Wood MB, Rubin AP [7] in a study of 1.0% Ropivacaine and 0.75% Bupivacaine found no difference in the duration of motor block. Zaric D, Axelsson K, Nydahl PA, Philipson L, Larsson P, Jansson JR [13] conducted a double-blind study and compared sensory and motor blockade during epidural analgesia with 1.0%, 0.75% and 0.5% Ropivacaine. They administered 20 ml of these concentrations to 30 volunteers, 10 in each group in a bolus dose. Motor block was assessed by quantitative mechanical measurement of isometric muscle force (IMF) and qualitative (modified Bromage scale) methods. Onset of motor blockade as assessed by quantitative method was significantly slower with 0.5% Ropivacaine. The intensity and duration of motor block increased with increase in dose. Scott DB, McClure JH, Giasi RM, Seo J, Covino BG [14] studied the effect of concentration of local anaesthetic drugs in extradural blockade. They found increase in concentration of the drug decreased the onset time and increased motor block as occurs with other local anaesthetic agents.

Conclusion

From these results, this study provides a reasonable ground to conclude that Ropivacaine and Bupivacaine differ in terms of their onset and duration of both sensory and motor block in epidural anaesthesia. Thus Ropivacaine with its higher efficacy, prolonged sensory blockade, lower propensity for motor blockade, proven reduced potential for CNS toxicity and cardiotoxicity, appears to be an important option for regional anaesthesia, management of post-operative pain, labour pain making it the current local anaesthetic drug of choice.

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