

Intrathecal Hyperbaric Ropivacaine for Day Case Pelvic, Perineal and Lower Limb Surgeries – A Prospective Study

Ankur Khandelwal^{1,*}, Abhijit Tarat², Rupankar Nath³, Shrikant Subhash Kote⁴

¹Senior Resident, Department of Anaesthesia, Vardhman Mahavir Medical College and Safdarjung Hospital, New Delhi

²Associate Professor, ³Registrar, ⁴Post Graduate Trainee, Department of Anaesthesia, Silchar Medical College, Silchar

***Corresponding Author:**

Email: ankurchintus@gmail.com

ABSTRACT

Background: The rationale of this study was to evaluate the efficacy of intrathecal hyperbaric ropivacaine for day case pelvic, perineal and lower limb surgeries.

Methods: Seventy ASA physical status I-II patients undergoing the above mentioned surgeries were enrolled for the study. Hyperbaric ropivacaine in a dose of 15 mg was injected intrathecally in each of the patients. The primary outcome variables of the study were- duration of sensory and motor block. Secondary outcome variables were- time for onset of sensory block to T10 dermatomal level and motor block to Bromage Score 3, maximum spread of sensory block, time to reach maximum sensory level, quality of intraoperative analgesia and muscle relaxation, time to mobilize, time to spontaneous voiding and side effects.

Results: The mean time for onset of sensory block to T10 dermatome level and motor block to Bromage Score 3 were 3.25 + 0.84 mins and 5.12 + 0.76 mins respectively. The median value of HSL was T5 (T4 - T6) and mean time to reach HSL was 9.08 + 1.05 mins. The total duration of sensory and motor block (mean) were 132.22 + 8.44 mins and 104 + 8.56 mins respectively. The time needed to mobilize the patients and spontaneous voiding (mean) were 206 + 9.26 and 230 + 10.33 mins respectively. Based on Modified Postanesthesia Discharge Scoring System (PADS) in addition to spontaneous micturition, 61 (87.14%) patients were discharged on the same day of operation.

Conclusion: Results have demonstrated that 15 mg of hyperbaric ropivacaine when injected intrathecally is sufficient to produce anesthesia for day case pelvic, perineal and lower limb surgeries.

Keywords: intrathecal, ropivacaine, day case surgery, Modified Postanesthesia Discharge Scoring System (PADS)

Access this article online	
Quick Response Code:	Website: www.innovativepublication.com
	DOI: 10.5958/2394-4994.2015.00012.8

INTRODUCTION

Ambulatory surgery has evolved considerably over the past two decades, with more complex procedures being performed, and more ASA (American Society of Anaesthesiologists) physical status class III patients being eligible. Evolution of anesthetic pharmacology, including new drugs and better understanding of their complex interactions, as well as more targeted regional anesthetic techniques have had an enormous impact.⁽¹⁾

Though various techniques are available for carrying out day-case anesthesia, preference for a technique depends upon the type of procedure, patient profile, associated co-morbidities, available infrastructure and back-up facilities, monitoring devices and comfort of the attending anesthesiologist with the technique. Day-case spinal anesthesia for ambulatory surgery has gained a wider acceptance

and numerous drugs are available for use in loco-regional anesthesia.⁽²⁾

For subarachnoid block, lignocaine was widely used as a short acting local anesthetic but it fell into disrepute after reports of transient neurological syndrome following its use. These symptoms were probably due to neurotoxicity from high concentration used for spinal anesthesia.^(3,4) Others have tested the efficacy of low dosages of bupivacaine.

Spinal anesthesia using long-acting local anaesthetic (LA) agents is associated with delayed return of bladder function and urinary retention and inability to ambulate due to motor weakness. Intrathecal bupivacaine 10 mg was associated with prolonged return of detrusor function (462 ± 61 min) compared to intrathecal lidocaine 100 mg (235 ± 30 min).⁽⁵⁾ Little information is available in the literature regarding the use of hyperbaric ropivacaine to produce spinal block for ambulatory surgeries. In this study, spinal anesthesia was performed with 15 mg of hyperbaric ropivacaine in seventy ASA grade I- II patients undergoing pelvic, perineal and lower limb surgeries with the aim to study the safety and efficacy of intrathecal hyperbaric ropivacaine for day case surgeries.

MATERIALS AND METHODS

This study was carried out in Silchar Medical College and hospital during the period between 01/09/2014- 31/03/2015. Initially, a pilot study was conducted on 15 patients receiving 15 mg of hyperbaric ropivacaine injected intrathecally as no large scale randomised controlled trial (RCT) has been done in India to test the efficacy of intrathecal hyperbaric ropivacaine for day case surgeries. This was done after approval of the institutional ethics committee and after obtaining informed written consent from the patients. Hyperbaric solution of Ropivacaine was prepared aseptically (by an anesthetist who was not one of the investigators), immediately before injection by adding 2 ml of 0.75% plain ropivacaine (commercially available) with 0.4 ml of autoclaved (to maintain sterility) 50% glucose ampoules which gave a volume equal to 2.4 ml containing 15 mg of the drug. Samples of 0.75% ropivacaine (containing dextrose 83 mg/ml) were sent to the laboratory to test the specific gravity and for culture sensitivity. In the pilot study, the mean specific gravity of the hyperbaric 0.75% ropivacaine solution at 37°C (by the addition of 83mg/ml glucose) was 1.0334 and the samples were negative for bacterial culture. In the pilot study 12 (80%) patients had excellent analgesia (no discomfort or pain during surgery). Considering the prevalence of 80% and type I error of 10%, the sample size was calculated to be 64. Thus a total of 70 ASA I-II patients undergoing day case pelvic, perineal and lower limb surgeries were selected with the aim to study the safety and efficacy of intrathecal hyperbaric ropivacaine for day case surgeries.

The primary outcome variables were:

1. Duration of sensory block
2. Duration of motor block

Secondary outcome variables were:

1. Time for onset of sensory block to T10 dermatomal level
2. Time for onset of motor block to Bromage Score 3
3. Maximum spread of sensory block
4. Time to reach maximum sensory level
5. Quality of intraoperative analgesia and muscle relaxation
6. Time to mobilize
7. Time to spontaneous voiding and
8. Side effects.

Inclusion Criteria's:

1. Patients belonging to ASA grade I and II.
2. Patients of both sexes between age 20 to 50 yrs.

3. Patients undergoing pelvic, perineal and lower limb surgeries with expected duration of surgery less than 90 mins.
4. Patient approval, willingness, understanding and ability to follow discharge instruction.
5. Presence of a responsible attendant at home to take care of the patient after surgery.

Exclusion Criteria's:

1. Patients with history of hypersensitivity to local anesthetics.
2. Emergency cases and cases belonging to ASA grade III and above.
3. Patients less than 20 years and more than 50 years.
4. Patients with history of hypertension, diabetes mellitus, psychiatric disorder or any other systemic disease.
5. Short stature, (height less than 152 cms).
6. Overweight patients (weight > 120 kg).
7. Patients with disorders of blood clotting, patients on anti-coagulants or anti-platelets.
8. Patients with skin sepsis in lumbar region, patients with pre-existing neurological disorders or spine deformity.
9. Surgeries involving major blood loss.

Preanesthetic evaluation and preparation of the patient:

Preoperatively detailed history from all the patients was taken. Age, height, weight, hospital registration number and baseline data i.e. pulse rate, blood pressure and general condition were noted. The back of the patient was examined to rule out any spinal deformity. Cardiovascular, respiratory and central nervous system were thoroughly examined. After history, clinical examination and reviewing laboratory findings patients were taken up for study.

Preoperatively patient's informed written consent was taken. Nil per oral status of the patient was confirmed.

Anaesthesia Method:

- The procedure of subarachnoid block was explained and the patient was informed to communicate about the perception of any pain or discomfort during surgery.
- Standard monitoring devices were connected before starting the procedure and an intravenous cannula 18 Gauge was inserted.
- No premedication was given the day of surgery.⁽⁶⁾
- All patients were preloaded with 500ml of Hartman's solution 15 minutes prior to spinal anesthesia.⁽⁷⁾

- Pulse rate, blood pressure, SpO₂, and respiratory rate were recorded immediately before spinal anesthesia.

Procedure:

- The patients were put in left lateral position and the L3- L4 interspace was identified with the help of Touffier's line.
- Under all aseptic precaution lumbar puncture was performed with 25 Gauge Quincke's needle in the above mentioned space.
- The position of the needle was confirmed by aspiration of CSF and the study drug was injected over 45 seconds and the patients were turned supine.
- Surgery was started after establishment of the surgical blockade.
- Oxygen at the rate of 5L per minute was administered by face mask until the end of surgery.⁽⁸⁾

Methods of assessment:-

- ★ Time for onset of sensory block : It is defined as time interval between the completion of injection of the study drug to the onset of complete loss of sensation to pinprick at the level of thoracic dermatome 10.⁽⁸⁾
- ★ Time for onset of motor block : It is defined as the time taken for inability of the patient to move legs or feet (Bromage score 3) from the time of completion of intrathecal injection.⁽⁸⁾
- ★ Highest level of sensory block and time to obtain this: It is defined as the highest dermatomal level of sensory blockade as assessed by complete loss of sensation to pinprick.
- ★ Duration of sensory blockade : It is defined as time interval from injection of the study drug to regression of sensory block to the level of L1.⁽⁹⁾
- ★ Duration of maximum motor blockade : It is denoted by the time taken from the onset of complete motor blockade (Bromage score 3), to time when patient had free movement of legs and feet (Bromage score 0).⁽⁸⁾
- ★ Hypotension: defined as fall in SBP to <100 mm Hg or a fall in the mean arterial blood pressure more than 20% of the preoperative value. Treated with a rapid infusion of crystalloids and if persisting a bolus of intravenous ephedrine 6 mg was administered.⁽⁷⁾
- ★ Bradycardia defined as fall in heart rate below 60/min was treated with atropine sulphate 0.6 mg i.v bolus.⁽⁷⁾
- ★ Bradypnea: it was taken as a marker of respiratory depression and respiratory rate less than 10/ min was taken as the lower limit. If

occurred it was to be treated with oxygen supplementation and assisted ventilation.⁽¹⁰⁾

- ★ Duration of analgesia: It is defined as the time taken from the onset of analgesia to time when patient complained of pain or VAS score was ≥ 4 .⁽¹⁰⁾
- ★ Cardiovascular and respiratory changes: The readings of pulse rate (PR), blood pressure, SpO₂ and respiratory rate (RR) were observed every 2 mins for first 10 mins, then at 15 minutes interval for the remainder of the operation and thereafter at 30 minutes interval until patient complains of pain. Whenever the pain score of any patient was ≥ 4 the patients were given diclofenac 75mg was administered intramuscularly as a rescue analgesic.

Any side effect and complaints: Side effects like nausea, vomiting, headache, shivering, respiratory distress, pruritus etc. if found were recorded. Other than these, if any unexpected side effects occur, these are recorded.

The different scales used in the study were:

- (1) Visual analogue Scale for pain assessment⁽¹⁰⁾
- (2) Modified Bromage scale for assessment of motor block⁽⁷⁾
- (3) Quality of intraoperative analgesia⁽⁸⁾
- (4) Quality of intraoperative muscle relaxation⁽⁸⁾
- (5) Modified Post Anesthesia Discharge Scoring System (PADS)⁽¹¹⁾

Patients were discharged on the same day of operation based on PADS system. The reasons of not being able to discharge the patient on the same day were noted. Patients were followed on phone daily for first 15 postoperative days.

STATISTICAL ANALYSIS

Analysis of data was done by using SPSS version 20. Data was expressed as Mean \pm Standard deviation. Percentages and proportions with bar diagrams were used to interpret data. Considering the prevalence of 80% and type I error of 10%, the sample size from pilot group (15 patients) was calculated to be 64. Hence we included a total of 70 ASA I-II patients undergoing day case pelvic, perineal and lower limb surgeries were selected with the aim to study the safety and efficacy of intrathecal hyperbaric ropivacaine for day case surgeries.

RESULTS AND OBSERVATIONS

The mean + SD age of all the patients was 36.22 + 2.33 yrs. 41 patients (58.57 %) were males. The mean + SD weight and height were 61.96 + 4.18 kg and 168 + 3.34 cms respectively. (Table 1)

The mean + SD time for onset of sensory block to T10 dermatome level was 3.25 + 0.84 mins whereas mean + SD time for onset of motor block to Bromage Score 3 was 5.12 + 0.76 mins. The median value of HSL was T5 (T4 - T6) and mean + SD time to reach highest level of sensory block was 9.08 + 1.05 mins. The total duration of sensory block (mean + SD) was 132.22 + 8.44 mins whereas the total duration of motor block (mean + SD) was 104 + 8.56 mins. The time needed to mobilise the patients (mean + SD) was 206 + 9.26 mins. The mean + SD time for spontaneous voiding was 230 + 10.33 mins. (Table 2 and bar diagrams 1, 2) With regards to quality of intraoperative analgesia, 87.5 % of the patients had excellent analgesia (no discomfort or pain during surgery), 10% good (minimal discomfort, relieved by opioid), and 2.5 % fair (minimal pain, relieved by opioid). With regards to quality of intraoperative muscle relaxation, 93% had excellent muscle relaxation (no disturbing muscle strain) and 7% satisfactory (disturbing, but acceptable muscle strain). Overall, 55 % of the patients had intraoperative hypotension which was well within 20% of the baseline and 10% had bradycardia and shivering. 9 (12.8%) patients complained of nausea and 2 (2.85%) of them had vomiting. No other side effects were noticed (Table 3). Based on Modified Postanesthesia Discharge Scoring System (PADS) in addition to spontaneous micturition, 61 (87.14%) patients were discharged on the same day of operation. Due to persistent nausea, 3 (4.29%) patients could not be discharged on the same day, 5 (7.14%) patients due to unbearable pain and 1(1.43%) patient due to lack of responsibility by the attendant. None of the patients discharged complained of headache or any symptoms suggestive of Transient Neurological Symptoms (TNS) when reviewed over telephone for next 15 days (Table 3).

Table 1: Demographic Data

Age (Mean + SD)in years	36.22 + 2.33
Gender(M/F)	41/29
Weight (Mean + SD)in Kg	61.96 + 4.18
Height (Mean + SD)in cms	168 + 3.34
Pelvic surgeries (No.)	22
Perineal surgeries (No.)	25
Lower Limb surgeries (No.)	23

*SD – Standard deviation

Table 2: Spinal Block Characteristics

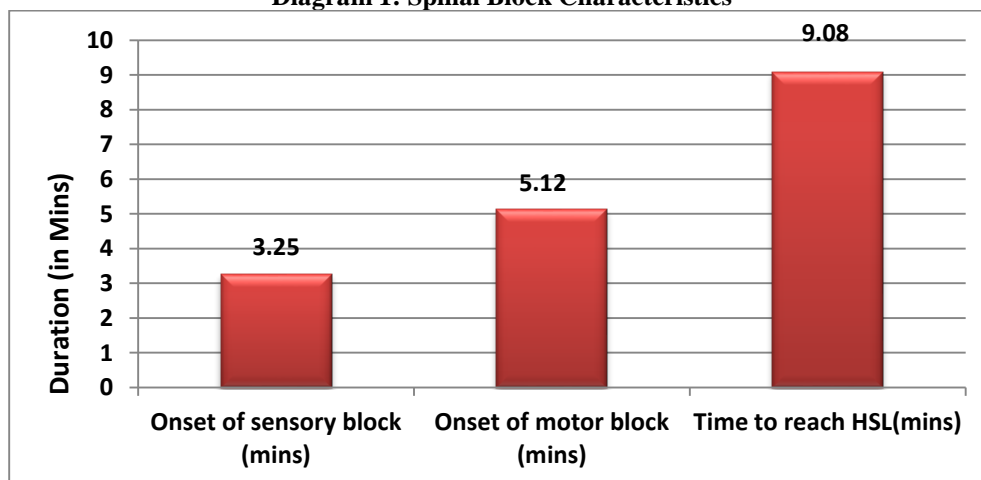
Time for onset of sensory block to T10 dermatome level (Mean + SD)	3.25 + 0.84 mins
Time for onset of motor block to Bromage Score 3 (Mean + SD)	5.12 + 0.76 mins
Median value of HSL (Highest Sensory Level)	T5 (T4 - T6)
Time to reach HSL (Mean + SD)	9.08 + 1.05 mins
Duration of sensory block (Mean + SD)	132.22 + 8.44 mins
Duration of motor block (Mean + SD)	104 + 8.56 mins
Time to mobilise (Mean + SD)	206 + 9.26 mins
Time to micturition (Mean + SD)	230 + 10.33 mins

*SD – Standard deviation

Table 3: Complications during intraoperative and early postoperative period

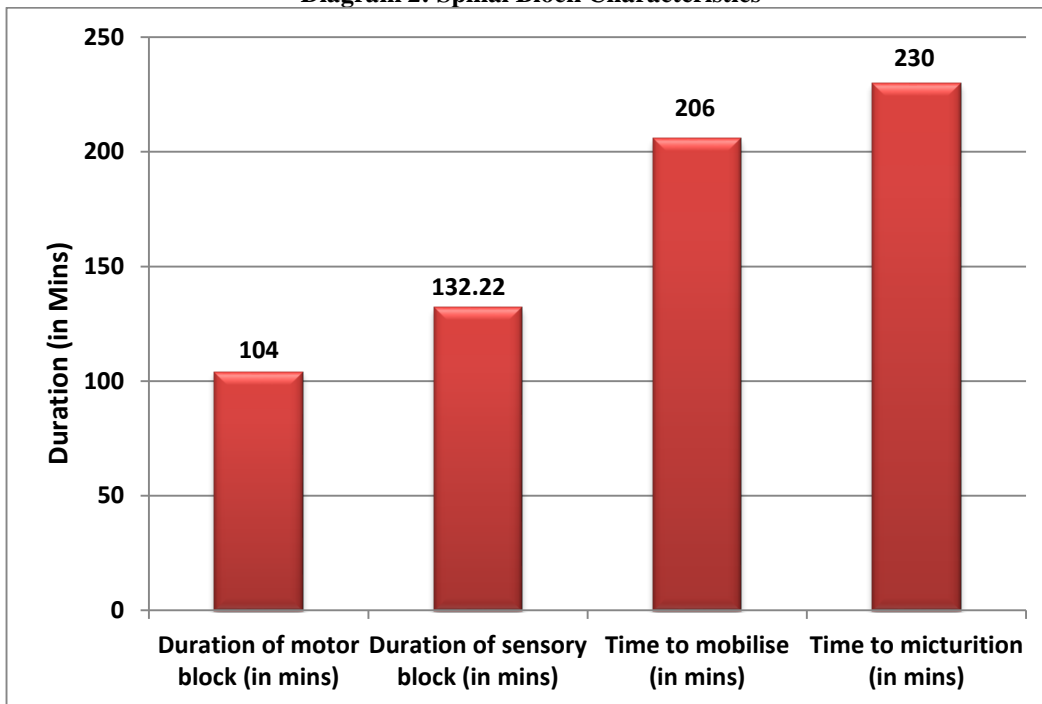
Type	Number of patients with percentage
Hypotension	38 (54.28%)
Bradycardia	7 (10%)
Bradypnoea	00
Nausea	9 (12.8 %)
Vomiting	2 (2.85%)
Shivering	7 (10%)
Pruritus	00
PDPH*	00

*PDPH- Post Dural Puncture Headache

Diagram 1: Spinal Block Characteristics

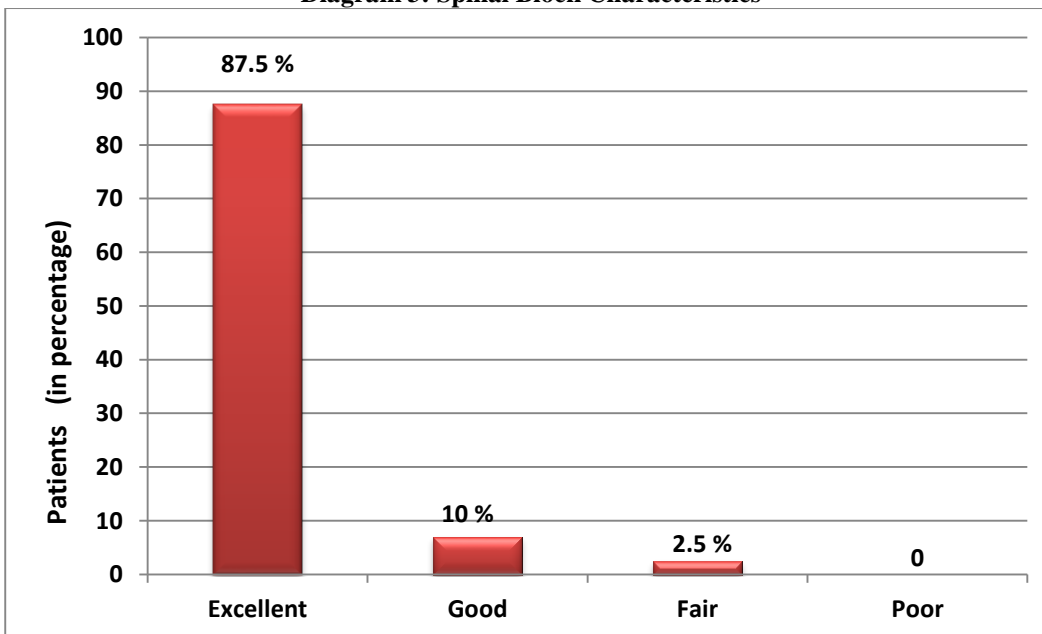
Bar Diagram showing the mean time for onset of sensory block, motor block and mean time to reach highest sensory level.

Diagram 2: Spinal Block Characteristics



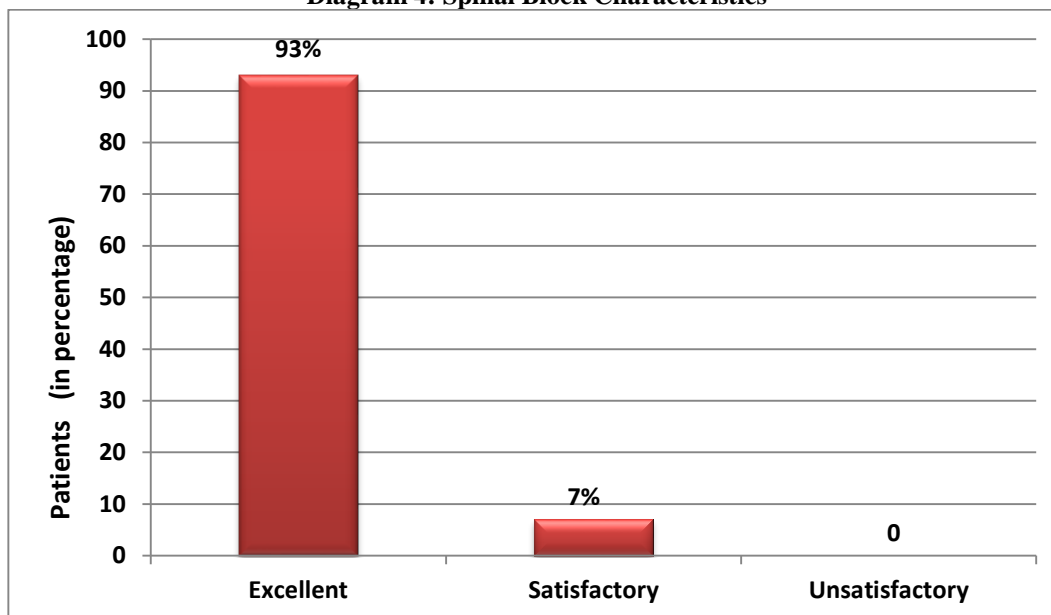
Bar Diagram showing the mean duration of motor block, sensory block, time for mobilisation and micturition.

Diagram 3: Spinal Block Characteristics



Bar Diagram showing quality of intraoperative analgesia where **Excellent**= no discomfort or pain, **Good**= mild pain or discomfort, no need for additional analgesics, **Fair**= Pain that required additional analgesics, **Poor**= moderate or severe pain that needed more than 100 mcg fentanyl or General anaesthesia

Diagram 4: Spinal Block Characteristics



Bar Diagram showing quality of intraoperative muscle relaxation where **Excellent**= No disturbing muscle strain, **Satisfactory**= disturbing but acceptable muscle strain and **Unsatisfactory**= Unacceptable muscle strain.

DISCUSSION

Years after years, the search for a better intrathecal agent for day care surgery is still under process. Hyperbaric 5% lidocaine has recently been reported to be associated with transient radicular irritation following single-dose spinal anesthesia⁽¹²⁻¹⁶⁾ and thus avoided now a days. Several investigators have re-examined the use of older short-acting local anesthetics such as prilocaine or mepivacaine.⁽¹⁴⁻¹⁹⁾ Other RCTs have tested the efficacy of low dosages of bupivacaine.⁽²⁰⁻²³⁾

In the present study, ropivacaine was used so as to evaluate its efficacy for ambulatory surgery. Ropivacaine is a long-acting local anesthetic that is structurally related to bupivacaine. Evidence from some studies suggest that addition of dextrose to ropivacaine increases the density and provides a predictable and consistently high sensory block.^(9,24,25) In a study conducted by Chung *et al*⁽⁸⁾ comparing hyperbaric spinal ropivacaine to hyperbaric bupivacaine for caesarean delivery, the authors concluded that as compared to 12 mg of 0.5% hyperbaric bupivacaine, 0.5% hyperbaric ropivacaine 18 mg provided effective spinal anesthesia with shorter duration of sensory (188.5 ± 28.2 min vs 162.5 ± 20.2 min; $P < 0.05$) and motor block (113.7 ± 18.6 min vs 158.7 ± 31.2 min; $P < 0.000$). The intraoperative quality of anesthesia was excellent and similar in both groups. A study conducted by Luck *et al*⁽²⁶⁾ in which 60 ASA grade I–II patients undergoing elective surgery under spinal anesthesia were randomized to receive 3 ml of bupivacaine, levobupivacaine, or ropivacaine, each at 5 mg ml⁻¹ and made hyperbaric by the addition of glucose

30 mg ml⁻¹. They found no significant differences between the groups with regard to the mean time to onset of sensory block at T10, the extent of spread, or mean time to maximum spread. Regression of sensory block in the ropivacaine group was more rapid as demonstrated by duration at T10 ($P < 0.0167$) and total duration of sensory block ($P < 0.0167$). Patients in the ropivacaine group had more rapid recovery from motor block ($P < 0.0167$) and shorter times to independent mobilization ($P < 0.0167$). Whiteside *et al*⁽²⁷⁾ in their study selected 40 ASA grade I–II patients undergoing lower-abdominal, perineal or lower-limb surgery under spinal anesthesia and randomized to receive 15 mg of hyperbaric ropivacaine or 15 mg of hyperbaric bupivacaine. They found that patients receiving ropivacaine was mobilized sooner (ropivacaine mean 253.5 mins; bupivacaine 331 mins; $P = 0.002$) and passed urine sooner (ropivacaine mean 276 min; bupivacaine 340.5 min; $P = 0.01$) than those receiving bupivacaine. More patients in the bupivacaine group required treatment for hypotension (>30% decrease in systolic pressure; $P = 0.001$). Similar observations were consistent with other studies.^(28,29,30)

CONCLUSION

Rapid onset of both sensory and motor blockade, adequate surgical anaesthesia and analgesia, better hemodynamic stability, and lesser incidence of PONV with early patient mobilization suggests that 15 mg of hyperbaric ropivacaine when injected intrathecally is sufficient to produce anesthesia for day case pelvic, perineal and lower limb surgeries.

REFERENCES

1. Awad T I, Chung F. Factors affecting recovery and discharge following ambulatory surgery. *Canadian Journal of Anesthesia*: September 2006, volume 53, issue 9, page- 858-872.
2. Bajwa SJS, Jindal R. Use of Articaine in loco- regional anesthesia for day care surgical procedures: *Clinical Pharmacology*: year-2012, volume-28, Issue-4, page: 444-450.
3. Salazar F, Bogdanovich A, Adalia R. Transient neurologic symptoms after spinal anesthesia using isobaric 2% mepivacaine and isobaric 2% lidocaine. *Acta Anaesthesiol Scand* 2001;45:240-5.
4. deWeert K, Traksel M, Gielen M. The incidence of transient neurological symptoms after spinal anesthesia with lidocaine compared to prilocaine. *Anesthesia* 2000;55:1020-4.
5. Rosseland LA, Stubhaug A, Breivik H. Detecting postoperative urinary retention with an ultrasound scanner. *Acta Anaesthesiol Scand* 2002; 46: 279–82.
6. Ph. E. Gautier, M. De Kock, A. Van Steenberge, N. Poth, Lahaye-Goffart, L.Fanard, J. L. Hody. A comparison between intrathecal bupivacaine and ropivacaine for knee surgery. *Anaesthesiology* 1999; 91:1239.
7. Srivastava U, Joshi K, Gupta A, Dwivedi Y, Anand H, Kannaujia A, Pilendram S. Comparison of intrathecal hyperbaric ropivacaine and bupivacaine for caesarean delivery. *The Internet Journal of Anesthesiology*. Year-2012, vol-30, no.4.
8. Chung CJ, Choi SR, Yeo KH, Park HS, Lee SI, Chin YJ. Hyperbaric spinal ropivacaine for caesarean delivery: a comparison to hyperbaric bupivacaine. *Anesth Analg* 2001;93:157-61.
9. Khaw KS, Ngan Kee WD, Wong M, Ng F, Lee A. Spinal ropivacaine for caesarean delivery. A comparison of hyperbaric and plain solutions. *Anesth Analg* 2002; 94:680-685.
10. Hunt, Catherine O; Naulty, J.Stephen; Bader,Angela M; Hauch, Martha A; Vartikar, Jasmine V; Datta,Sanjay; Hertwig, Linda; Ostheimer, Gerard W : Perioperative analgesia with subarachnoid bupivacaine- fentanyl for Caesarean delivery: *The Journal of the American society of Anesthesiologists*: October 1989, vol-71, Issue 4.
11. Paul F. White, Matthew R. Eng. *Miller's Anesthesia*, 7th Edition, Chapter no. 78, Ambulatory (Outpatient) Anesthesia, 2010, page 2447.
12. Hampl KL, Schneider MC, Ummenhoffer W, Drewe J: Transient neurologic symptoms after spinal anesthesia. *Anesth Analg* 1995; 81:1148-53.
13. Schneider M, Ettlin T, Kaufmann M, Schumacher P, Urwyler A, Hampl K, von Hochstetter A: Transient neurologic toxicity after hyperbaric subarachnoid anesthesia with 5% lidocaine. *Anesth Analg* 1993; 76: 1154 -7.
14. Koenig W, Rucizic D: Absence of transient radicular irritation after 5000 spinal anesthetics with prilocaine (letter). *Anesthesia* 1997;52: 182-3.
15. Hampl KF, Heinzmann-Wieder S, Luginbuehl I, Harms C, Seeberger M, Schneider MC, Drasner K: Transient neurologic symptoms after spinal anesthesia: A lower incidence with prilocaine and bupivacaine than with lidocaine. *ANESTHESIOLOGY* 1998; 88:629- 33.
16. Liguori GA, Zayas VM, Chisholm MF: Transient neurologic symptoms after spinal anesthesia with mepivacaine and lidocaine. *ANESTHESIOLOGY* 1998; 88:619 -23.
17. Martinez-Bouriou R, Arzuaga M, Quintana JM, Aguilera L, Aguire J, Saez-Eguilaz JL, Arizaga A: Incidence of transient neurologic symptoms after hyperbaric subarachnoid anesthesia with 5% lidocaine and 5% prilocaine. *ANESTHESIOLOGY* 1998; 88:624 – 8.
18. Hiller A, Rosenberg PH: Transient neurological symptoms after spinal anesthesia with 4% mepivacaine and 0.5% bupivacaine. *Br J Anaesth* 1997; 79:301-5.
19. Lynch J, zur Nieden M, Kasper S-M, Radbrush L: Transient radicular irritation after spinal anesthesia with hyperbaric 4% mepivacaine. *Anesth Analg* 1997; 85:872-3.
20. Ben David B, Levin H, Solomon E, Admoni H, Vaida S: Spinal bupivacaine in ambulatory surgery: The effects of saline dilution. *Anesth Analg* 1996; 83:716-20.
21. Liu S, Ware PD, Allen HW, Neal JM, Pollock JE: Dose-Response characteristic of spinal bupivacaine in volunteers: Clinical implications for ambulatory anesthesia. *ANESTHESIOLOGY* 1996; 85:729- 36.
22. Gentili M, Senlis H, Houssel P, Monnier B, Bonnet F: Single-shot spinal anaesthesia with small doses of bupivacaine. *Reg Anesth* 1997; 22:511-14.
23. Kuusniemi K, Pihlajamaki K, Pitkanen M, Korkeila J: A low-dose hypobaric bupivacaine spinal anesthesia for knee arthroscopies. *Reg Anesth* 1997; 22:534-38.
24. Whiteside J, Burke D, Wildsmith JAW. A comparison of 0.5% ropivacaine (5% glucose) with 0.5% ropivacaine (1% glucose) when used to provide spinal anaesthesia for elective surgery. *Br J Anaesth* 2001; 86:241.
25. Fettes PDW, Hovking G, Peterson MK, Luck JF, Wildsmith JAW. Comparison of plain and hyperbaric solutions of ropivacaine for spinal anesthesia. *Br J Anesth*. 2004;94:107-111.
26. Luck JF, Fettes PDW, Wildsmith JAW: Spinal anaesthesia for elective surgery: a comparison of hyperbaric solutions of racemic bupivacaine, levobupivacaine, and ropivacaine. *British Journal of Anaesthesia* 101 (5): 705–10 (2008).
27. Whiteside JB, Burke D, Wildsmith JAW. Comparison of ropivacaine 0.5% (in glucose 5%) with bupivacaine 0.5% (in glucose 8%) for spinal anaesthesia for elective surgery. *Br. J. Anaesth*. (2003) 90 (3):304-308.
28. Markham A, Faulds D: Ropivacaine: A review of its pharmacology and therapeutic use in regional anesthesia. *Drugs* 1996; 52(4): 29 – 49.
29. Zaric D, Nydahl PA, Philipson L, Heierson A, Axelson K: The effect of continuous lumbar epidural infusion of ropivacaine(0. 1%,0.2% and 0.3%,) and 0.25% bupivacaine on sensory and motor blockade in volunteers: A double-blind study. *Reg Anesth* 1996: 21: 4 -25.
30. Scott DB, Chamley D, Mooney P, Deam RK, Mark AH, Haggloff B: Epidural ropivacaine infusion for postoperative analgesia after major abdominal surgery: A dose-finding study. *Anest Analg* 1995; 81(9):82-6.