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Original Research Article

Comparative Study of Intrathecal Hyperbaric Ropivacaine with Fentanyi Versus Hyperbaric Bupivacaine with Fentanyl for Orthopedic Surgeries

Uma Mandal[1], Keya Chakraborty[2], Dhrubajyoti Sarkar[3]

[1]Assistant Professor, Department of Anaesthesiology, College of Medicine and JNM Hospital (WBUHS), Kalyani, Nadia, West Bengal, India

[2]Professor, Department of Anaesthesiology, Ramkrishna Mission Seva Pratishthan & Vivekananda Institute of Medical Sciences (RKMSP & VIMS), Kolkata, West Bengal, India

[3]Professor & Head of the Department, Department of Anaesthesiology, College of Medicine and JNM Hospital (WBUHS), Kalyani, Nadia, West Bengal, India

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Corresponding Author: Dr. Keya Chakraborty

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Abstract

Introduction: Spinal anesthesia is widely used for lower limb orthopedic surgeries due to its rapid onset, reliable sensory and motor blockade, and minimal systemic effects. Hyperbaric bupivacaine is the conventional choice; however, ropivacaine, a newer long-acting amide local anesthetic, is associated with reduced motor blockade and cardiotoxicity. The addition of intrathecal fentanyl can enhance analgesia and improve block characteristics.

Aims: This study aimed to compare the efficacy and safety of intrathecal hyperbaric ropivacaine with fentanyl versus hyperbaric bupivacaine with fentanyl in patients undergoing orthopedic surgeries.

Materials and Methods: This was a comparative interventional analytical study conducted over 1 year in the operation theatres of College of Medicine and JNM Hospital, Kalyani, and Ramkrishna Mission Seva Pratisthan& Vivekananda Institute of Medical Sciences, Kolkata. The study population comprised patients undergoing elective lower extremity orthopedic surgeries under spinal anesthesia, with a total sample size of 202 patients. Group A patient had received intrathecal 0.75% Hyperbaric Ropivacaine 2.5ml along with 25 mcg Fentanyl. Group B patients had received intrathecal 0.5% hyperbaric bupivacaine 2.5ml along with 25 mcg Fentanyl.

Results: In this study, baseline characteristics including age, weight, height, ASA physical status, and duration of surgery were comparable between Group A (Ropivacaine with Fentanyl) and Group B (Bupivacaine with Fentanyl), showing no significant differences. Mean time of Onset of sensory and motor block as well as time to reach peak sensory level were similar. Whereas recovery time from sensory block [9.27 ± 1.48 minutes in Group A compared to 9.29 ± 0.69 minutes in Group B ($p = 0.903$] and motor block [158.77 ± 18.94 minutes in Group A versus 211.21 ± 11.78 minutes in Group B ($p < 0.0001$)] were significantly longer in Group B ($p < 0.0001$). Sedation scores were comparable, but micturition occurred earlier in Group A (220.10 ± 30.12 min vs. 289.60 ± 39.09 min; $p < 0.0001$). Complications were minimal, with hypotension observed only in 6.93% of Group B patients, indicating that both regimens were safe and well tolerated, with faster recovery in the Ropivacaine group.

Conclusion: Intrathecal hyperbaric ropivacaine with fentanyl provides effective sensory block comparable to hyperbaric bupivacaine with fentanyl but with reduced motor blockade, allowing earlier postoperative mobilization. Both agents are safe and provide satisfactory anesthesia and analgesia for orthopedic procedures. Ropivacaine may be preferred when early motor recovery is desirable.

Keywords: Spinal Anesthesia, Hyperbaric Ropivacaine, Hyperbaric Bupivacaine, Fentanyl, Orthopedic Surgery, Motor Blockade, Postoperative Analgesia.

Introduction

Spinal anesthesia (subarachnoid block) remains a cornerstone technique for lower limb and lower abdominal surgeries due to its rapid onset of sensory and motor blockade, dense and reliable anesthesia, minimal systemic effects, and the ability to provide postoperative analgesia with low morbidity compared to general anesthesia [1]. Hyperbaric 0.5% bupivacaine has long been considered the standard local anesthetic for major orthopedic procedures, given its potent anesthetic properties and prolonged duration of both sensory and motor block [2,3].

Despite its advantages, bupivacaine carries a risk of dose-dependent adverse effects, including prolonged motor blockade, hypotension, bradycardia, and potential cardiotoxicity or central nervous system toxicity. These concerns are particularly relevant in patients with comorbidities or in settings where early postoperative mobilization is desirable [4]. Consequently, there has been increasing interest in alternative local anesthetics with a better safety profile and more favorable motor-sensory differentiation.

Ropivacaine, a long-acting amino-amide local anesthetic, is a pure S-enantiomer. It is characterized by lower lipid solubility and reduced penetration into large, myelinated motor fibers, leading to preferential sensory blockade while preserving motor function [5]. Clinical studies have demonstrated that intrathecalropivacaine provides effective sensory anesthesia with a shorter duration of motor blockade compared to bupivacaine, facilitating earlier postoperative ambulation and rehabilitation [6,7]. This characteristic is particularly advantageous in orthopedic surgeries, where early mobilization reduces complications and supports functional recovery.

The addition of intrathecal adjuvants, such as fentanyl, is a well-established strategy to enhance the quality of spinal anesthesia. Fentanyl, a lipophilic opioid, potentiates sensory analgesia, improves block density, shortens onset time, and prolongs postoperative analgesia without significantly increasing motor blockade or systemic side effects [8]. When combined with ropivacaine, fentanyl may compensate for any marginal reduction in anesthetic potency relative to bupivacaine, ensuring adequate anesthesia while maintaining the advantage of earlier motor recovery [9]. Several studies have compared intrathecal ropivacaine and bupivacaine in orthopedic surgery. Jain et al. demonstrated that 0.5% hyperbaric ropivacaine with 25 μg fentanyl provided comparable sensory block to hyperbaric bupivacaine with fentanyl but allowed faster motor recovery (mean 242.8 ± 47.06 min vs 268 ± 49.9 min; P = 0.023). Sharma et al. reported that ropivacaine-fentanyl yielded slightly shorter sensory block duration but maintained adequate anesthesia, with hemodynamic stability comparable to bupivacaine-fentanyl. Meta-analyses confirm that ropivacaine consistently results in shorter motor block duration by an average of 30–40 minutes without significant compromise in sensory anesthesia or increased adverse events [10]. The study aims to compare intrathecal hyperbaric ropivacaine with fentanyl versus hyperbaric bupivacaine with fentanyl in lower limb orthopedic surgeries by evaluating the level of sensory and motor block, perioperative analgesia, hemodynamic stability, and the need for intraoperative and postoperative rescue analgesics. This will help determine which regimen provides effective anesthesia and analgesia with optimal safety and recovery.

Materials and Methods

Study Type: Prospective Comparative Interventional study.

Study Duration: 1 year

Study Place: Operation Theatre, College of medicine and JNM Hospital, Kalyani and Ramkrishna Mission Seva Pratisthan & Vivekananda Institute of Medical Sciences, Kolkata.

Study Population: Patients undergoing elective lower extremity orthopedic surgery under spinal anaesthesia.

Sample Size: Sample was collected for a period of 1 year on getting clearance from Institutional Ethics Committee. 202 patients undergoing elective orthopedic surgeries under spinal anesthesia.

Study Variables

- Demographic and Surgical Characteristics
- ASA PS
- Sensory block [onset, total duration]
- Motor block [onset, total duration]
- Total duration of perioperative analgesia
- Sedation Score and Micturition Onset
- Perioperative Complications

Inclusion Criteria

- Adult patients aged 18–55 years undergoing elective lower limb orthopedic surgeries.
- American Society of Anesthesiologists (ASA) physical status I or II.
- Patients providing written informed consent.
- Patients suitable for spinal anesthesia.

Exclusion Criteria

- Known allergy or hypersensitivity to study drugs
- Patient who does not give or not in a mental state to consent due to any reason.
- Any contraindication to SAB
- Patient requiring intraoperative any general anaesthetic aid
- Pregnant or lactating women.

Statistical Analysis: Data from the study were analyzed using SPSS software, with continuous variables expressed as mean ± SD and compared using t-tests or Mann–Whitney U tests. Categorical variables were presented as frequencies and percentages and compared using Chi-square or Fisher's exact tests. Kaplan-Meier analysis may be

used for time-to-intervention comparisons. A p-value < 0.05 was considered significant.

Methodology

On obtaining approval from Institutional ethical committee from respective college and after getting prospectively registered on Clinical trial Registry of India with CTRI number CTRI/2023/05/052583, a prospective comparative study was conducted in operation theater of COM & JNMH, Kalyani and RKMSP & VIMS, Kolkata respectively.

Written informed consent for examination, participation in the study and undergoing surgery under spinal anaesthesia was taken from 202 patients with ASA Physical status I or II, aged 18 to 55 years who was scheduled for lower limb orthopaedic surgery. All investigations were done according to the institutional protocol prior to surgery. Visual Analogue Scale for pain was explained in details to patients.

Grouping: all the participants was alternatetly divided into two equal group. One anaesthesiologist had done the grouping of the patients into two group and accordingly prepared the drug combinations.

Another anaesthesiologist (principal investigator) who were unaware of the drug combination and grouping of the patient would administered the drug and would made a record of various data.

All the patients was kept fasting as per the fasting guideline and premedicated with tab Alprazolam 0.5mg, tab Ranitidine 150mg 12hrs prior to surgery. On arrival to the Operation Room, all participants had an intravenous access using 18G intravenous cannula established. Preloading was done with 8-10ml/kg of Ringer Lactate over 10-15 mins. Standard monitors of electrocardiography, pulse oximetry, and noninvasive blood pressure was applied for recording baseline pulse rate, SBP, DBP, MAP, SpO2, RR. Subarachnoid block was performed following strict aseptic precautions, antiseptic dressing and draping, after anaesthetising the point of puncture by infiltrating the skin and subcutaneous tissue with Inj. Lignocaine 2% with Adrenaline 1:200000 by midline approach with patient in sitting position, using 25G Quincke spinal needle.

Group A: had received intrathecal Inj. of hyperbaric Ropivacaine (0.75%) 2.5ml along with inj fentanyl 25mcg.

Group B: had received intrathecal Inj. of hyperbaric Bupivacaine (0.5%) 2.5ml along with inj. Fentanyl 25mcg.

After giving spinal anaesthesia patient was positioned into supine position.

The sensory level was assessed by pin-prick sensation using a blunt 25-gauge needle along the mid clavicular line bilaterally at 2min, 5mins, 10mins of spinal anesthesia and thereafter at 15 mins interval.

Onset of sensory block: time required to achieve sensory block at T10 level.

Time taken to reach peak sensory level was also noted.

Motor block was assessed by modified bromage scale [MBS] at 2mins, 5 mins, 10mins and 15mins
Grade 0: no motor loss
Grade 1: inability to flex the hip
Grade 2: inability flex the knee
Grade 3: inability to flex the ankle

Onset of motor block; time taken to achieve MBS 3 was also noted.

Intraoperative haemodynamic monitoring was done just before the subarachnoid block given [taken as baseline value] then at 3mins interval for first 15mins, then 5mins interval for next 30mins thereafter at 1hr interval. Hypotension (decrease of SBP>25%) was recorded and treated with vesopressor (Inj Mephentermine) and bolus i.v fluid. Bradycardia (HR<50) will be treated with inj Atropine 0.6mg. Postoperatively in PACU sensory block and motor block regression was checked at 30 mins interval. Motor blockade was assessed till complete regression of motor block of lower limb. VAS for pain was evaluated postoperatively at 1 hrinterval. When VAS ≥4 Inj Paracetamol 1gm was given intravenously as rescue analgesic. Total duration of perioperative analgesia: taken as duration from intrathecal injection upto recue analgesia given.

Result

Table 1: Comparison of Demographic and Surgical Characteristics Between Group A and Group B

Parameter	Group A (Mean ± SD)	Group B (Mean ± SD)	t-statistic	p-value
Age (years)	43.06 ± 12.93	45.00 ± 12.69	-1.08	0.283
Weight (kg)	61.43 ± 6.32	63.03 ± 5.75	-1.89	0.061
Height (inches)	64.23 ± 2.47	63.64 ± 2.45	1.69	0.093
ASA Physical Status	1.44 ± 0.50	1.51 ± 0.50	-1.13	0.262
Duration of Surgery (hrs)	1.83 ± 0.26	1.78 ± 0.30	1.27	0.206

Table 2: Comparison of Time-Related Parameters Between Group A and Group B

Variable	Group A (Mean ± SD)	Group B (Mean ± SD)	t-statistic	p-value
Onset of sensory block (T1)	5.94 ± 1.21	5.78 ± 0.90	1.06	0.292
Onset of motor block (T2 (Min)	8.89 ± 1.11	8.64 ± 1.21	1.54	0.124
T3 (Min) Time to reach peak sensory level	9.27 ± 1.48	9.29 ± 0.69	-0.12	0.903
Duration of motor block (T4) (Min)	158.77 ± 18.94	211.21 ± 11.78	-23.63	<0.0001
Duration of sensory block (T5) (Min)	187.33 ± 21.95	224.84 ± 29.35	-10.29	<0.0001
Total duration of perioperative analgesia (T6) (Min)	231.73 ± 25.59	302.56 ± 52.90	-12.11	<0.0001

Table 3: Comparison of Sedation Score and Micturition Onset Between Group A and Group B

Variable	Group A (Mean ± SD)	Group B (Mean ± SD)	t-statistic	p-value
Sedation Score	1.05 ± 0.22	1.06 ± 0.24	-0.31	0.758
Micturition Onset (min)	220.10 ± 30.12	289.60 ± 39.09	-14.16	<0.0001

Table 4: Incidence of Perioperative Complications in Group A and Group B

Variable	Group A Count (%)	Group B Count (%)	Overall Count (%)
Bradycardia	0 (0.0%)	0 (0.0%)	0 (0.0%)
Hypotension	0 (0.0%)	7 (6.93%)	7 (3.46%)
Respiratory Depression	0 (0.0%)	0 (0.0%)	0 (0.0%)
Nausea	0 (0.0%)	0 (0.0%)	0 (0.0%)
Vomiting	0 (0.0%)	0 (0.0%)	0 (0.0%)

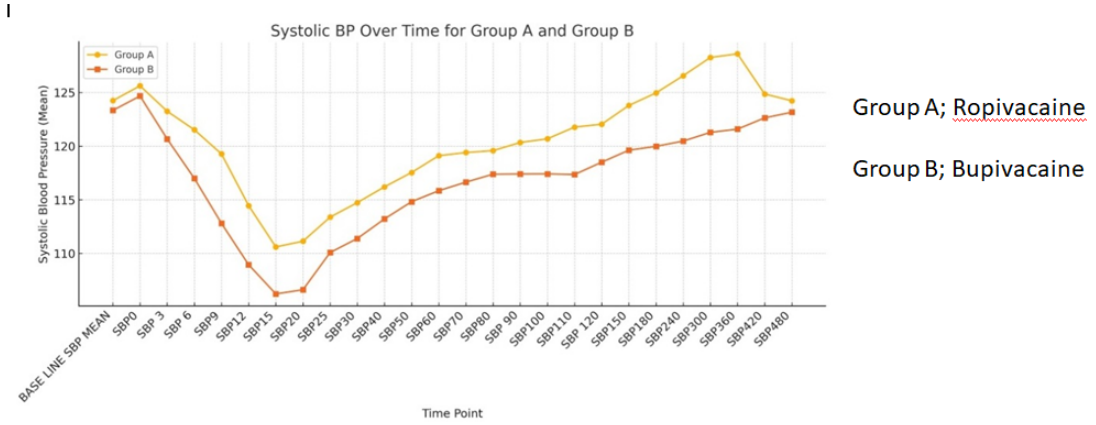

Figure 1: Comparison of systolic blood pressure (SBP) Between Group A and Group B

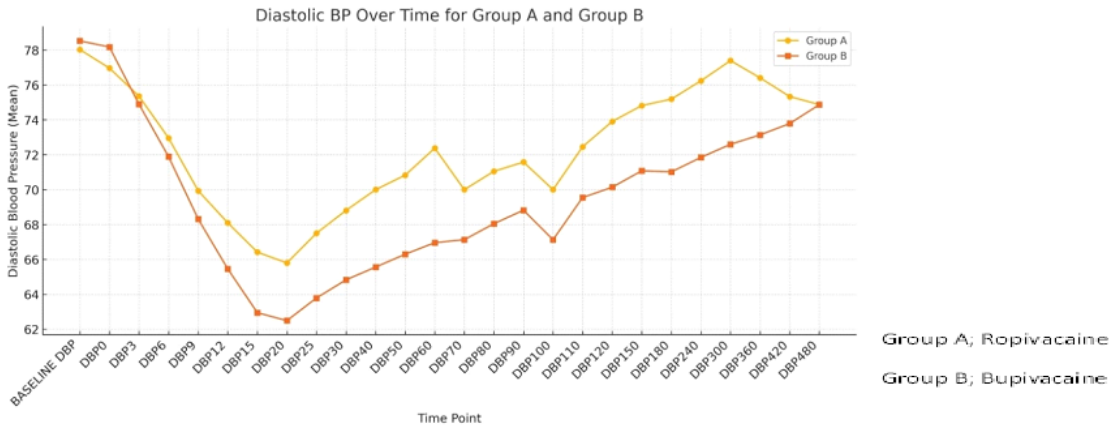

Figure 2: Comparison of Diastolic blood pressure (DBP) Between Group A and Group B

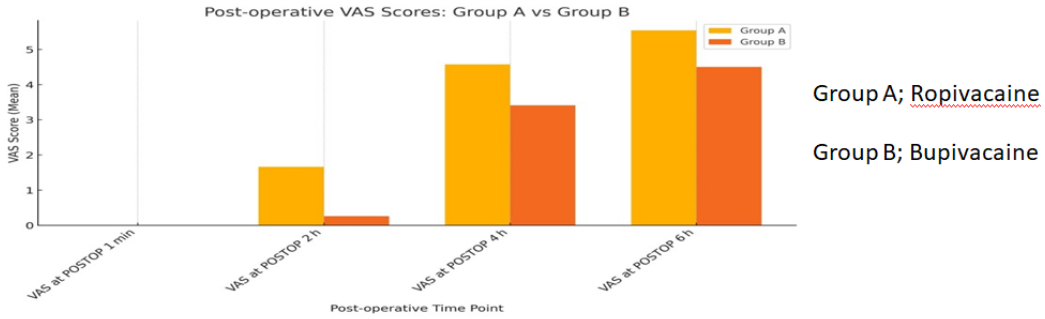

Figure 3: Comparison of VAS score between Group A and Group B

In our study, the demographic parameters (age, weight, height, ASA PS) of the study participants were comparable between Group A and Group B. The mean duration of surgery was 1.83 ± 0.26 hours in Group A versus 1.78 ± 0.30 hours in Group B ($p = 0.206$) showing no significant difference [Table 1]

In our study, the intraoperative and perioperative time-related variables were analyzed between Group A and Group B. The mean T1(Onset of sensory block) was 5.94 ± 1.21 in Group A and 5.78 ± 0.90 in Group B ($p = 0.292$), T2(onset of motor block)was 8.89 ± 1.11 minutes in Group A versus 8.64 ± 1.21 minutes in Group B ($p = 0.124$), and T3 (time to reach peak sensory level)was 9.27 ± 1.48 minutes in Group A compared to 9.29 ± 0.69 minutes in Group B ($p = 0.903$), showing no statistically significant differences. However, significant differences were observed in mean T4(duration of motor block) was 158.77 ± 18.94 minutes in Group A versus 211.21 ± 11.78 minutes in Group B ($p < 0.0001$), mean T5 (duration of sensory block)was 187.33 ± 21.95 minutes in Group A versus 224.84 ± 29.35 minutes in Group B ($p < 0.0001$), and mean T6 (total duration of analgesia)was 231.73 ± 25.59 minutes in Group A compared to 302.56 ± 52.90 minutes in Group B ($p < 0.0001$). [Table 2]

Postperative VAS score for pain showed Ropivacaine group have high VAS score in posptoperative first 2h, 4h than bupivacaine group that are statistically significant.

The perioperative haemodynamic parameters were comparable between twogroup except first 60 min the reduction of systolic blood pressure and diastolic blood pressure is more in Group B than Group A and that is statistically significant.

In our study, the comparison of sedation and micturition parameters between the two groups showed that the mean sedation score was 1.05 ± 0.22 in Group A and 1.06 ± 0.24 in Group B ($p = 0.758$), indicating no significant difference. However, the mean time to micturition onset was significantly shorter in Group A at 220.10 ± 30.12 minutes compared to 289.60 ± 39.09 minutes in Group B ($p < 0.0001$).

In our study, the incidence of intraoperative and postoperative complications was generally low in both groups. Bradycardia, respiratory depression, nausea, and vomiting were not observed in either group. Hypotension occurred in 7 patients (6.93%) in Group B, while no cases were reported in Group A. Overall, these findings suggest that both interventions were well tolerated, with only a small proportion of patients in Group B experiencing hypotension.

Discussion

The purpose of the study was to compare the level of block, perioperapertive analgesic effect as well as perioperative haemodynamic stability in patients receiving either hyberbaric bupivacaine or hyperbaric ropivacaine for spinal anaesthesia for orthopedic surgeries. In our study, baseline characteristics including age, weight, height, ASA physical status, and duration of surgery were comparable between Group A (ropivacaine with fentanyl) and Group B (bupivacaine with fentanyl), indicating proper randomization and matching. Similar observations were reported by Crawford et al. [11], Gour and Joshi [12], and Vampugalla et al. [13], who also found no significant demographic differences between ropivacaine and bupivacaine groups. In our study onset of sensory block (T1) and motor block (T2) and time to reach peak sensory block height (T3) were similar in both groups.

However, significant differences were observed in mean T4(duration of motor block)that was 158.77 ± 18.94 minutes in Group A versus 211.21 ± 11.78 minutes in Group B ($p < 0.0001$).U Srivastava et al [14] had similar observation using bromage score to compare 15mg of 0.5% hyperbaric ropivacaine and 11mg of 0.5% Hyperbaric Bupivacaine for caesarean section.Further Ramesh Koppal et al.[15] noted significant difference in time required for regression of motor block between 2.5ml

Ropivacaine with Fentanyl (154.5+/-20.1 min) and 2.5ml Bupivacaine with Fentanyl (196.0+/-24.2 min) for perineal surgeries. Whereas mean T5 (duration of sensory block) was 187.33 ± 21.95 minutes in Group A versus 224.84 ± 29.35 minutes in Group B ($p < 0.0001$), and mean T6 (total duration of analgesia) was 231.73 ± 25.59 minutes in Group A compared to 302.56 ± 52.90 minutes in Group B ($p < 0.0001$)were significantly longer in the bupivacaine group, consistent with studies showing that bupivacaine produces longer sensory and motor block durations compared to ropivacaine. Sedation scores were comparable between the groups, while time to micturition onset was significantly shorter in Group A (220.10 ± 30.12 min vs. 289.60 ± 39.09 min; $p < 0.0001$), reflecting faster motor recovery. Similar results were reported by Rathi et al. [16], Prajwal et al. [17], and Saran A et.al.[18], who noted earlier ambulation and voiding in patients receiving ropivacaine with fentanyl.The incidence of complications was low overall. Bradycardia, respiratory depression, nausea, and vomiting were absent in both groups, whereas hypotension occurred only in 7 patients (6.93%) in the bupivacaine group, supporting previous findings that ropivacaine is associated with a lower incidence of hypotension compared to bupivacaine .Sorout Det.al.[19] and Roshan NK et. al.[20] further confirmed in their studies the superior hemodynamic stability of ropivacaine. Other studies by Gupta, Hemathe [21] and Rathod Set. al. [22] also corroborate our findings of adequate anesthesia, faster motor recovery, and good tolerability with ropivacaine-fentanyl for lower-limb orthopedic surgeries.

Conclusion

In conclusion, both intrathecal hyperbaric ropivacaine with fentanyl and hyperbaric bupivacaine with fentanyl provided effective anesthesia for lower limb orthopedic surgeries. The baseline characteristics and sedation levels were comparable between the groups. Ropivacaine was associated with faster recovery, as evidenced by earlier return of motor function and micturition.

Both interventions were well tolerated, with a low incidence of intraoperative and postoperative complications, although hypotension was observed more frequently with bupivacaine. Overall, ropivacaine with fentanyl appears to offer a favorable balance of efficacy, recovery profile, and hemodynamic stability in this patient population.

Conflict of interest: The authors declare there are no conflicts of interest.

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