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ORIGINAL RESEARCH

Comparative Evaluation of Traditional Lumbar Subarachnoid Block with Novel Thoracic Segmental Subarachnoid Block for Cesarean Delivery in terms of Perioperative Outcomes: A Randomized Controlled Single-Blinded Trial

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ABSTRACT

Background & Aims: Spinal anaesthesia in the lumbar region is routinely practiced for cesarean delivery (CD). Recently, Thoracic spinal anesthesia (TSA) has been shown to provide faster mobility, less hypotension, and denser blockade; we aimed to compare its efficacy with traditional spinal anesthesia in CD.

Material and Methods: Parturients (n=110) posted for elective CD over a period of 3 months were recruited in this study and randomized into two groups, one group receiving lumbar spinal anesthesia (LSA) at L_3- L_4 interspace with 10mg of 0.5% heavy bupivacaine and 60mcg buprenorphine and the second receiving TSA at T_9 – T_{10} level with 6mg of 0.5% heavy bupivacaine and 60mcg buprenorphine. We noted the ability of the parturient to slide from the table to the shifting trolley, the time to full motor and sensory recovery, the ability to breastfeed in a sitting position, and the ability to walk with support in both groups.

Results: 51 of 55 parturients who received TSA could slide from the table to the trolley, compared

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with only 1 of 55 parturients who received LSA ($P < 0.0001$). Also, significantly more parturients who received TSA could breastfeed while sitting and walk with support earlier than those who received LSA ($P < 0.0001$).

Conclusion: TSA is a safe alternative to LSA in parturients undergoing CD and can facilitate early ambulation, potentially reducing complications and promoting better bonding between mother and the child.

Keywords: Thoracic spinal anaesthesia, caesarean delivery, lumbar spinal anesthesia

INTRODUCTION

Caesarean delivery (CD) is one of the most commonly performed surgeries worldwide.[1] Neuraxial anaesthesia, targeting the sensory block of sacral dermatomes to the level of T_4, is preferable over general anaesthesia for cesarean delivery, as it provides optimum surgical conditions along with patient comfort, ensuring less maternal and neonatal morbidity.[2] Traditionally, Lumbar Spinal Anaesthesia (LSA) is administered below the level of L_1 to avoid spinal cord injury.[3] Recent MRI studies indicate a more substantial depth of the posterior subarachnoid space in the thoracic region and have caused a renewed interest in administering thoracic subarachnoid block.[4] The postulated advantages of Thoracic Spinal Anesthesia (TSA) include reduction in the required drug dose due to less CSF in the thoracic region, facilitating easy blockade of the nerve roots, good muscle relaxation, and smaller reduction in preload and blood pressure due to less dermatomal blockade.[5-8] TSA has been successfully utilized for abdominal cancer surgeries, breast surgeries, laparoscopic cholecystectomies, and nephrolithotomies.[6-10] To date, only a few case reports have described TSA in CD, with no randomized trials.[11] The rationale for using TSA in CD would be that lower doses of hyperbaric bupivacaine produce the segmental block required for cesarean section without sparing the sacral roots, thus avoiding the discomfort of catheterisation, along with the added advantage of early recovery from motor blockade aiding in Enhanced Recovery After Surgery (ERAS) protocols.[12] It might also help the early initiation of breastfeeding, ensuring that the infant receives colostrum while facilitating the emotional bonding between the mother and the baby.[11]

The existing case reports only summarise the findings observed in very few parturients who are not randomised to receive TSA and have some pre-existing contraindication to LSA being the main reason for opting in TSA, which can't be reflected for the entire section of healthy parturients. Our randomized controlled trial aims to explore the effectiveness and safety profile of performing TSA in parturients scheduled for elective CD under neuraxial blockade. We hypothesize that TSA in these parturients provides early ambulation and faster recovery, greater hemodynamic stability, and earlier initiation of breastfeeding compared with LSA. The primary objectives are the duration of motor blockade, assessed by the patient's ability to slide from the operating table to the shifting trolley, and the time to sit and walk with support. The secondary objectives measured are the incidence of hypotension, nausea and vomiting, shivering, post-dural puncture headache (PDPH), and other neurological complications.

MATERIAL & METHODS

We obtained Institutional Ethics Committee approval (IEC/NMC/16.04.2024/001) and prospectively registered the study with the Clinical Trials Registry of India (www.ctri.nic.in) under registration number CTRI/2024/11/077361.

We calculated the sample size based on the previous study by Singhal et al., which randomized 60 patients who underwent open nephrolithotomy to compare TSA and LSA.[13] With an α error of 0.05 and power of 95%, a minimum sample size of 76 was noted. Assuming a 20% dropout rate, we recruited 115 parturients; 2 did not give consent, and 113 were randomized into two groups. In group A, we excluded 3 parturients because they received LSA due to procedure-related difficulties. We included parturients with ASAPS grade 2 or 3 and age >18 years after written informed consent.[14] Parturients with a BMI of 30 kg/m^2, an ASAPS grade of more than 3, and those with contraindications to neuraxial blockade were excluded from the study. In a previous case report by Chauhan et al., 1.2 ml of 0.5% heavy bupivacaine and 20 mcg fentanyl were used for segmental blockade at T8 - T9 level.[11] For the initial dose titration with TSA, we also gave the same and assessed in five parturients. Most of them experienced some discomfort during bladder retraction and pelvic manipulation. We then increased the dose to 1.4ml of 0.5% hyperbaric bupivacaine and 60 mcg buprenorphine in five subsequent cases. All the patients had satisfactory blockade and were hemodynamically stable. These initial cases were not included in the study. We randomized all parturients into two groups, Group A and Group B, using a computer-generated random number table, and ensured allocation concealment using the closed-envelope method. Those assigned to Group A received TSA with hyperbaric bupivacaine (6 mg) and buprenorphine 60 mcg (total volume 1.6ml) at T9-T10 or T10-T11 levels, as shown in Figure 2, and those assigned to Group B received hyperbaric bupivacaine (10 mg) and buprenorphine 60mcg (total volume 2.2ml) at L2-L3 or L3-L4 levels. All procedures were performed in a sitting position using a 25G Quincke's needle via a median or paramedian approach.

T_4 dermatome level was targeted for the sensory block and the onset of sensory block noted. Motor blockade was assessed using the modified Bromage scale, and the onset of motor block was noted. Time to incision from administration of neuraxial blockade was noted. Hemodynamic parameters such as heart rate, non-invasive blood pressure, and SpO_2 were monitored every 3 minutes, and sensory and motor blockade was assessed at incision and at the end of surgery. After delivery, oxytocin was administered according to institutional protocols, and APGAR scores at 0 min and 5 min were recorded. Hypotension, defined as a reduction in mean arterial pressure of 20% from baseline, was treated with fluids and a bolus of phenylephrine given intravenously at the discretion of the treating anesthesiologist. Any intraoperative requirements of sedation were noted along with other intraoperative complications.

At the end of surgery, all parturients received an ultrasound-guided transversus fascia plane block (TFPB) with 30 mL of 0.25% levobupivacaine and 500 mg MgSO4 on each side. Muscle relaxation and surgeon satisfaction scores for abdominal relaxation were evaluated from 0-10, with 0 being the worst and 10 being the best. At the end of the surgery, levels of sensory and motor blockade were noted, and

the parturients were encouraged to slide off the table onto the trolley.

In the post-anaesthesia recovery unit (PACU), patient hemodynamics were monitored according to the standard institutional protocol. Breastfeeding was initiated as soon as the patient could sit comfortably. Time to breastfeed in the sitting position was noted. Early mobilization was attempted based on recovery of lower-limb motor function. Time to walk with support was noted. Numerical Rating Scale (NRS) at rest and on motion was assessed at 4, 8, 12, and 24 hours after surgery. The incidence of postoperative complications like headache and neurological sequelae was noted along with the duration of stay in PACU.

Data were processed in Microsoft Excel 2010 and presented as mean, standard deviation, frequency, and percentage. Continuous variables were compared using the independent–samples t–test. Categorical variables were compared using the Pearson chi-square test. Significance was defined as P values less than 0.05 using a two-tailed test. Data analysis was performed using IBM-SPSS version 21.0 (IBM-SPSS Science Inc., Chicago, IL).

RESULTS

A total of 115 patients were considered for the study; 2 did not consent, and 113 were randomized into two groups. In group A, 3 patients had to be excluded because they received a lumbar subarachnoid block due to procedure-related difficulties. Finally, enrolled and analyzed 110 patients (55 per group). We compared baseline demographics, comorbidities, and diagnoses using the Chi-square test; they were comparable, as shown in Table 1.

Table 1: Comparison of baseline demographic data between the two groups

		Group A (n = 55) (n; %)	Group B (n = 55) (n; %)	*p*-value
Age (years)	< 20	11 (20)	9 (16.3)	0.868#
	21 - 30	36 (65.4)	38 (69.1)	
	> 30	8 (14.5)	8 (14.5)	
Diagnosis	CPD	16 (29)	14 (25.5)	0.832#
	Previous LSCS	35 (63.6)	36 (65.5)	
	Amniotic fluid disorders	2 (3.6)	2 (3.6)	
	Breech presentation	2 (3.6)	3 (5.5)	
HTN	No	53 (96.3)	48 (87.3)	0.065#
	Yes	2 (3.6)	7 (12.7)	
DM	No	55 (100)	52 (94.5)	0.069#
	Yes	0 (0)	3 (5.5)	

(Continued)

		Group A (n = 55) (n; %)	Group B (n = 55) (n; %)	*p*-value
Hypothyroidism	No	47 (85.4)	39 (70.9)	0.123[#]
	Yes	8 (14.5)	16 (29.1)	
NF	No	54 (98.2)	54 (98.2)	1.000[#]
	Yes	1 (1.8)	1 (1.8)	
Asthma	No	55 (100)	54 (98.2)	0.298[#]
	Yes	0 (0)	1 (1.8)	
Anaemia	No	51 (92.7)	53 (96.4)	0.172[#]
	Yes	4 (7.2)	2 (3.6)	
Epilepsy	No	54 (98.2)	54 (98.2)	0.298[#]
	Yes	1 (1.8)	1 (1.8)	
BMI	< 20	3 (5.5)	3 (5.5)	0.347[#]
	21 - 30	49 (89.1)	45 (81.8)	
	>30	3 (5.4)	7 (12.7)	

[#]: Chi–square test
CPD: Cephalopelvic disproportionation; LSCS: Lower segment caesarean section; HTN: hypertension; DM: Diabetes mellitus; NF: neurofibromatosis; BMI: Body mass index

Primary Outcomes

Table 2 presents the comparison of primary outcomes between the groups. A significantly higher number of parturients in group A attained a sensory level above T_4 within 5 minutes of subarachnoid block compared to group B. Also, fewer parturients in group A achieved a Bromage score of three 5 minutes after subarachnoid block than in group B. At the end of surgery, more parturients in group A retained a sensory level above T_4 than in group B, and more patients in group A had full motor power (i.e., a Bromage score of zero) than in group B. Fifty of 55 patients in group A could successfully slide down from the operating table to the shifting trolley, compared with only 1 of 55 in group B Significantly more patients in group A recovered full motor function in the lower limbs, were able to sit, breastfeed in a sitting position, and walk with support within 3 hours of PACU admission.

Secondary Outcomes

Table 3 depicts the perioperative outcomes measured among both groups. Although no patient had clinically significant hypotension requiring long-term inotropes or intensive care unit admission, the incidence was significantly higher in group A than in group B.

The incidence of PONV is also greater in patients randomized to group A than in group B. Surgeon satisfaction scores did not differ significantly between groups, and patients in group A were discharged from PACU earlier than those in group B. We assessed the pain scores on a numerical rating scale (NRS) after surgery in both groups and found them comparable at all time points up to 24 hours, as shown in Table 4.

Table 2: Comparison of the extent of nerve blockade between the two groups

		Group A (n = 55) (n; %)	Group B (n = 55) (n; %)	*p*-value
Sensory blockade				
- 5 mins after injection	T_4 and above	41 (74.5)	7 (12.7)	< 0.0001#
	T_5, T6 and T_7	14 (25.45)	45 (81.8)	
	till T_8	0 (0)	3 (5.5)	
Bromage scale				
- 5 mins after injection	0	1 (1.8)	0 (0)	< 0.0001#
	1	10 (18.1)	0 (0)	
	2	29 (52.7)	8 (85.5)	
	3	15 (27.2)	47 (85.5)	
Sensory blockade				
- at the end of surgery	T_4 and above	11 (20)	0 (0)	0.0010#
	T_5, T_6 and T_7	26 (47.2)	41 (74.5)	
	up to T_8	18 (32.7)	14 (25.5)	
Bromage scale				
- at the end of surgery	0	38 (69)	1 (1.8)	< 0.0001#
	1	12 (21.9)	3 (5.5)	
	2	5 (9.1)	2 (3.6)	
	3	0 (0)	49 (89)	
Ability to slide from OT table	Yes	50 (90.9)	1 (1.8)	< 0.0001#
	No	5 (9.1)	54 (98.1)	
Time to attain full LL motor power (hrs)	< 3	51 (92.7)	6 (10.9)	< 0.0001#
	4 to 6	4 (7.2)	47 (85.5)	
	> 7	0 (0)	2 (3.6)	
Ability to sit (hrs)	< 3	43 (78.1)	3 (5.5)	<0.000#
	4 to 6	12 (21.9)	39 (70.9)	
	> 7	0 (0)	13 (23.6)	

(Continued)

		Group A (n = 55) (n; %)	Group B (n = 55) (n; %)	*p*-value
Ability to breastfeed while sitting (hrs)	< 3	41 (74.5)	3 (5.5)	< 0.0001#
	4 to 6	14 (25.45)	48 (87.3)	
	> 7	0 (0)	4 (7.2)	
Ability to walk with support (hrs)	< 3	15 (27.2)	1 (1.8)	< 0.0001#
	4 to 6	38 (69)	12 (21.8)	
	> 7	3 (5.4)	42 (76.4)	

#: Chi – square test.
OT: Operating theatre; LL: Lower limb

Table 3: Comparison of secondary outcomes among Groups A and B

		Group A (n = 55)	Group B (n = 55)	*p*-value
Time to incision from SAB (mins)	< 5	55 (100%)	54 (98.2%)	0.60#
	> 5	0 (0%)	1 (1.8%)	
Incidence of hypotension		20 (36.3%)	7 (12.7%)	0.008#
No of boluses of ephedrine / phenylephrine (mean ± SD)		0.47 ± 0.75	0.18 ± 0.55	0.02*
Incidence of bradycardia		0	0	NA
Incidence of PONV		14 (25.4%)	1 (1.8%)	0.001#
Treatment for PONV		13 (23.6%)	1 (1.8%)	0.001#
Requirement of sedation		7 (12.7%)	2 (3.6%)	0.104#
Conversion to GA		0	0	NA
Surgeon satisfaction score	1 to 4	0 (0%)	0 (0%)	
	5 to 7	5 (9.1%)	0 (0%)	0.057$
	8 to 10	50 (90.9%)	55 (100%)	

(Continued)

		Group A (n = 55)	Group B (n = 55)	*p*-value
APGAR at birth	< 5 6 to 10	6 (11%) 49 (89%)	14 (25.5%) 41 (74.5%)	0.108#
APGAR at 5 mins	< 5 6 to 10	0 (0%) 55 (100%)	1 (1.8%) 54 (98.2%)	0.298#
Hours of PACU stay (hr) (mean ± SD)		8.41 ± 1.55	19.56 ± 2.92	< 0.0001*

*#: Chi-square test, *: Independent t test. $: Fischer's exact test*
SAB: subarachnoid block; PONV: Postoperative nausea vomiting; GA: General anesthesia; PACU: Post Anaesthesia Care Unit

Table 4: Comparison of pain scores on Numerical Rating Scale (NRS) between the two groups

	Group A (n = 55) (mean ± SD)	Group B (n = 55) (mean ± SD)	*P*-value
NRS at rest @ 4 hours	0.53 ± 0.77	0.55 ± 0.77	0.89#
NRS at motion @ 4 hours	1.0 ± 1.05	1.15 ± 1.11	0.47#
NRS at rest @ 8 hours	2.02 ± 0.97	1.82 ± 0.96	0.28#
NRS at motion @ 8 hours	2.56 ± 1.10	2.35 ± 1.04	0.29#
NRS at rest @ 12 hours	2.03 ± 1.07	1.95 ± 1.06	0.66#
NRS at motion @ 12 hours	2.51 ± 1.25	2.53 ± 1.2	0.93#
NRS at rest @ 24 hours	2.05 ±1.17	2.04 ± 1.12	0.95#
NRS at motion @ 24 hours	2.59 ±1.34	2.58 ± 1.18	0.97#

#: Chi-square test; NRS: Numerical Rating Scale

DISCUSSION

TSA was first suggested in 1909 by Jonnesco T, who proposed performing 'general spinal anaesthesia' by injecting the drug into the subarachnoid space close to the innervation of the surgical field.[3] Since then, many techniques have been described to limit the extent of neuraxial blockade to a few segments, such as letting go of cerebrospinal fluid followed by injection of air, then hypobaric nupercaine and again air, allowing the drug to fix at a certain level; two punctures: one at the desired level and one at the cisterna magna, etc.[15,16] There was extreme fear and objection regarding this

technique due to the suspicion of spinal cord injury, if done above the level of L1 in adults. Later, MRI studies proved beyond doubt that the thoracic region has more subarachnoid space than the lumbar region, which reduces the risk of spinal cord injury.[4] This was the perfect comeback for this technique, and a vast amount of literature was published towards the start of the 21st century. Since then, segmental spinal anaesthesia has been studied extensively in various randomized controlled trials in a wide variety of procedures, such as open cholecystectomy, laparoscopic cholecystectomy, breast surgeries, various upper abdominal surgeries, orthopaedic procedures, and nephrolithotomy, but only a few case reports have been reported in CD.

Singhal G et al. randomized 60 patients undergoing nephrolithotomy to receive either a thoracic or lumbar subarachnoid block and observed that patients who received a thoracic block had faster onset of motor blockade and faster regression than the lumbar group.[13] In our study, patients who received a thoracic block had higher block height compared to the lumbar group immediately after injection, but had less motor blockade. Most patients who received a thoracic block fully recovered from motor blockade by the end of the procedure and could slide from the operating table to the shifting trolley by themselves. This early mobilization can greatly benefit patients at high risk of complications due to delayed ambulation. More patients who received a thoracic block were able to sit with support, breastfeed in a sitting position, and walk with support earlier than those who received a lumbar block. Patients who received a thoracic block also had significantly earlier discharge from the PACU than those who received a lumbar block, supporting a faster return to normal activities and better comfort. The key patient-centered outcomes in CD, being involved in the decision-making of anaesthetic choices, good bonding time with the baby, early and comfortable breastfeeding with efficient analgesia, along with active encouragement from the staff, lead to good patient satisfaction. Early recovery from motor blockade helps achieve these outcomes and prevents known complications such as deep venous thrombosis, basal atelectasis, etc.

The secondary objectives of our study include comparing other perioperative outcomes apart from the extent of nerve block and mobilization. A previous study by Singhal et al., who compared thoracic and lumbar subarachnoid block for nephrolithotomy, reported a lower incidence of hypotension (1 out of 30 patients in thoracic vs 8 out of 30 in lumbar) in patients who received thoracic block.[13] In a study comparing thoracic vs lumbar block in patients who underwent laparoscopic cholecystectomy, Imbelloni et al. also found a lower incidence of hypotension in the thoracic group owing to preservation of preload due to reduced blockade in the lumbar levels.[8] But in our study, patients who received thoracic block had a significantly higher incidence of hypotension than those who received lumbar (20 out of 55 in thoracic vs 7 out of 55 in lumbar). We could attribute this to altered physiology in pregnant women, such as aortocaval compression by the gravid uterus, and increased susceptibility to local anesthetics compared with non-pregnant individuals, making them more susceptible to hypotension with higher dermatomal blockade.[17] Though there was a higher incidence of hypotension in the thoracic group, it was not clinically significant and could be easily managed with fluid and sympathomimetic administration according to the discretion of the individual anesthesiologists. All the patients had stable haemodynamics by the end of the procedure

without any sympathomimetic requirement, which reflects that the hypotension is transient and only during the initial part of the surgery. None of the patients required either postoperative inotropes or intensive care unit stay with regard to hypotension. There was no episode of bradycardia recorded in both groups.

Postoperative nausea and vomiting (PONV) is one of the common adverse effects of neuraxial anaesthesia in pregnant patients. Apart from arterial hypotension, hormonal and psychological changes in pregnancy and intraoperative manipulation of the uterus also contribute to nausea in the perioperative period.[18] The higher incidence of PONV in the thoracic group in our study may be attributed to the higher dermatomal blockade in these patients compared to the lumbar group. Though the incidence is higher, it was easily treatable and not clinically significant. Thus, we infer that this newer approach can provide hemodynamic stability similar to the traditional technique, with only minor drawbacks.

Time to incision from the subarachnoid block was noted in both groups as an indirect measure of the duration required to achieve adequate block height. It was comparable between groups, suggesting no delay in achieving satisfactory blockade for the surgery. The surgeon satisfaction score, measured on a 10-point Likert scale, showed no significant difference between groups; however, limitations include most obstetricians' preference for LSA due to greater familiarity, comfort, and confidence with that technique. Also, patients who receive TSA can move their lower limbs without discomfort or pain at the surgical site toward the end of the procedure, which may give the operating surgeon the impression that the anaesthesia is wearing off. None of the parturients included in the study required any form of sedation or anaesthesia supplementation due to discomfort during the procedure. The biggest limitation of this study is that the obstetrician could not be blinded to the anaesthesia technique.

We measured APGAR scores immediately after birth and at five minutes in both groups, and they were comparable, even though the thoracic group had a higher incidence of hypotension. This suggests that the hypotension didn't cause any significant fetal distress in the thoracic group. We assessed the Numerical Rating Scale (NRS) at rest and with movement in both groups periodically until 24 hours after surgery, and scores were comparable. Although the block height remained at higher dermatomes in the thoracic group at the end of surgery, pain scores did not differ significantly between the two groups. Previous literature suggests that patients who received a thoracic block might require fewer analgesics because of longer sensory blockade in the targeted dermatomes.[18]

The safety of thoracic lumbar puncture warrants major discussion. It is a well-known fact that the spinal cord ends at the L1 level in an adult, and the traditional practice of teaching an anesthesia trainee to administer a subarachnoid block only below this level to prevent injury to the spinal cord plays a major role in reluctance to use this technique routinely. MRI studies have shown beyond doubt that the depth of the spinal cord from the dura is greater in the thoracic region than in the lumbar region, with the maximum in the mid-thoracic region.[19] In a previous study by Imbelloni et al. of 300 patients, the incidence of paresthesia was 4.6% with a dura cutting needle and 8.6% with a pencil-point needle at T10–T11 thoracic puncture.[20] Various other researchers have also confirmed the same.[21-24] In our study, none

of the patients who received a thoracic block experienced paresthesia, tingling, or any neurological complaint, supporting the safety of this procedure; however, further studies in a larger population will help identify any sequelae. No statistically significant incidence of PDPH or shivering was observed in either group.

CONCLUSION

Recently, TSA has been used in various procedures, and only a few case reports have been published in the literature for CD. We conclude that it is a beneficial alternative to LSA and advantageous for early ambulation when used with caution and experience.

LIMITATIONS

This study has certain limitations, such as a small sample size, as it was a preliminary study and included only healthy parturients posted for elective surgery. These results cannot be extrapolated to emergency situations with parturients with unoptimized comorbidities. Because the procedure was performed in an operation theatre, it was impossible to blind the performer, surgeon, and patient. Only the researcher who compiled and analyzed the data could be blinded. Further studies with a larger sample size are required to assess the safety and feasibility of this technique for CD.

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AUTHORS' CONTRIBUTIONS

Conceptualization and design: HD, KKC

Literature search: HD, SK

Data collection: MC, LBT, SK

Data analysis: HD

Manuscript drafting and critical revision: HD, KKC

Proofreading and approval of the manuscript: HD, KKC

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DECLARATION OF CONFLICTS OF INTEREST

There are no conflicts of interest to declare.

ETHICAL CLEARANCE

Approved by the Institutional Ethics Committee of the Narayana Medical College, Nellore, Andhra Pradesh, India (No: IEC/NMC/16th April 2024/01); Approval date: October 1, 2024.

The study was registered with the Clinical Trials Registry – India.

(CTRI No: CTRI/2024/11/077361)

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