International Journal of Medical and Pharmaceutical Research

Online ISSN-2958-3683 | Print ISSN-2958-3675
Frequency: Bi-Monthly
Available online on: https://ijmpr.in/

Original Article

Effect of Timing of Intraoperative Intravenous Paracetamol Administration on Postoperative Shivering: A Prospective Randomized Comparative Study

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Received: 01-03-2026
Accepted: 15-04-2026
Available online: 19-05-2026

ABSTRACT

Background: Postoperative shivering is a frequently encountered complication following surgery under general anaesthesia, contributing to increased oxygen consumption, metabolic stress, and patient discomfort. Intravenous paracetamol has demonstrated potential anti-shivering properties through modulation of central thermoregulatory mechanisms. However, the optimal timing of its intraoperative administration for the prevention of postoperative shivering remains insufficiently investigated.

Methods: This prospective, randomized, comparative study enrolled 60 patients of American Society of Anesthesiologists physical status I and II, aged 18 to 60 years, undergoing elective surgeries under general anaesthesia. Patients were randomly allocated into two groups of 30 each: Group A received intravenous paracetamol (1 g) 30 minutes after induction of anaesthesia, and Group B received intravenous paracetamol (1 g) 30 minutes before the anticipated completion of surgery. Postoperative shivering incidence, shivering severity, core body temperature, and rescue anti-shivering medication requirements were assessed at 0, 15, 30, 45, and 60 minutes postoperatively.

Results: The overall incidence of postoperative shivering was significantly lower in Group B (10.0%) compared to Group A (33.3%) ($p = 0.024$). Shivering severity scores were also significantly lower in Group B at 0 and 15 minutes postoperatively ($p < 0.05$). Core body temperature was significantly higher in Group B at 0, 15, and 30 minutes after surgery ($p < 0.05$). The incidence of postoperative hypothermia (<36°C) was significantly higher in Group A (36.7%) compared to Group B (10.0%) ($p = 0.015$). The requirement for rescue tramadol was significantly lower in Group B (0.0%) compared to Group A (20.0%) ($p = 0.010$).

Conclusion: Administration of intravenous paracetamol 30 minutes before the anticipated completion of surgery was associated with a significantly lower incidence and severity of postoperative shivering, better maintenance of core body temperature, and reduced need for rescue anti-shivering medication compared to early intraoperative administration under general anaesthesia.

Keywords: *Postoperative shivering, intravenous paracetamol, timing of administration, general anaesthesia, thermoregulation, perioperative hypothermia.*

INTRODUCTION

Postoperative shivering represents one of the most commonly observed complications during the immediate recovery period following surgery performed under general anaesthesia, with a reported incidence ranging from 5% to 65% depending upon patient demographics, the nature of the surgical procedure, the anaesthetic technique employed, and the adequacy of perioperative thermal management [1]. It is characterized by involuntary, repetitive skeletal muscle activity that may manifest as visible tremors of variable intensity, occurring in both hypothermic and normothermic postoperative patients. Although frequently regarded as a relatively benign and self-limiting phenomenon, postoperative shivering is

associated with a number of clinically significant physiological consequences, including marked increases in whole-body oxygen consumption by up to 200–400%, elevated carbon dioxide production, metabolic acidosis, sympathetic nervous system activation with resultant tachycardia and systemic hypertension, and increases in intraocular as well as intracranial pressures [2]. These derangements assume particular clinical importance in patients with limited cardiopulmonary reserve, pre-existing ischaemic heart disease, cerebrovascular disease, or conditions predisposing to raised intracranial pressure, thereby underscoring the necessity for effective preventive and therapeutic strategies.

The timing of intraoperative administration of intravenous paracetamol in patients undergoing surgery under general anaesthesia may represent a critical determinant of its effectiveness in attenuating postoperative shivering. General anaesthesia is associated with a profound and progressive depression of central thermoregulatory mechanisms, resulting in core-to-peripheral redistribution of body heat, widening of the interthreshold range, and a progressive decline in core body temperature throughout the surgical procedure [3]. During emergence from general anaesthesia, as the anaesthetic-induced suppression of thermoregulatory reflexes wanes, the body rapidly attempts to regain thermal homeostasis, often triggering vigorous shivering as a compensatory heat-generating mechanism [4]. Administering intravenous paracetamol 30 minutes before the anticipated completion of surgery is pharmacokinetically advantageous in this setting, as the intravenous route provides earlier and higher plasma drug concentrations compared with oral or rectal administration, ensuring that peak central effect of paracetamol coincides with the vulnerable emergence and early postoperative recovery period when the thermoregulatory set point is being actively reset and the risk of shivering is maximal. In contrast, early administration of paracetamol shortly after induction results in peak therapeutic effect occurring during the mid-surgical period, with progressive decline of drug levels by the time of emergence, thereby diminishing its protective effect against postoperative shivering.

Multiple pharmacological and non-pharmacological interventions have been investigated for the prevention and treatment of postoperative shivering. Non-pharmacological approaches, such as forced-air warming devices, warmed intravenous fluid administration, and maintenance of optimal ambient operating room temperature, are effective first-line measures; however, they may not always be logistically feasible or sufficiently efficacious in all clinical settings [5]. Among pharmacological agents, meperidine has traditionally been considered the most effective treatment for established shivering, while other agents including clonidine, dexmedetomidine, tramadol, ketamine, and magnesium sulphate have demonstrated variable degrees of prophylactic and therapeutic efficacy [6]. Nevertheless, the clinical utility of these agents is frequently limited by adverse effects such as respiratory depression, excessive sedation, nausea, vomiting, hypotension, and bradycardia, which may offset their anti-shivering benefits and complicate postoperative recovery.

Intravenous paracetamol (acetaminophen) has emerged as a widely used perioperative analgesic and antipyretic agent with a well-established safety profile and predictable pharmacokinetic characteristics following parenteral administration [7]. Its mechanism of action is believed to involve central inhibition of cyclooxygenase enzyme isoforms, modulation of descending serotonergic inhibitory pathways, and interaction with the endocannabinoid system within the central nervous system. Beyond its established analgesic and antipyretic properties, intravenous paracetamol has been shown to modulate central thermoregulatory control by reducing the hypothalamic temperature set point, a mechanism that may contribute to the attenuation of postoperative shivering [8]. This potential anti-shivering effect, combined with its favourable safety profile, ease of administration, and compatibility with multimodal analgesic regimens, renders intravenous paracetamol an attractive candidate for perioperative shivering prevention in patients undergoing surgery under general anaesthesia.

Despite the widespread perioperative use of intravenous paracetamol, the available evidence regarding the optimal timing of its intraoperative administration specifically for the prevention of postoperative shivering in patients undergoing surgery under general anaesthesia remains limited and inconclusive [9]. Most existing studies have evaluated postoperative shivering only as a secondary outcome, and few investigations have directly compared early versus late intraoperative administration of paracetamol with shivering as the primary endpoint [10]. Understanding this relationship is clinically relevant, as it may inform simple, cost-effective modifications to current anaesthetic practice that could improve patient comfort, decrease metabolic stress, and reduce the need for rescue anti-shivering medications.

In this context, the present study was designed to evaluate the effect of the timing of intraoperative intravenous paracetamol administration on the incidence and severity of postoperative shivering in patients undergoing elective surgery under general anaesthesia. By systematically comparing early versus late intraoperative administration of intravenous paracetamol, this investigation sought to provide evidence-based guidance for optimizing perioperative thermoregulatory management and enhancing postoperative patient outcomes.

AIMS AND OBJECTIVES

The aim of this study was to evaluate the effect of the timing of intraoperative intravenous paracetamol administration on the incidence and severity of postoperative shivering in patients undergoing surgery under general anesthesia.

Primary Objectives

1. To compare the incidence of postoperative shivering among patients receiving intravenous paracetamol at different intraoperative time points.
2. To assess the severity of postoperative shivering in relation to the timing of intraoperative intravenous paracetamol administration.

Secondary Objectives

1. To evaluate the requirement for rescue anti-shivering medication in the postoperative period based on the timing of intravenous paracetamol administration.
2. To assess postoperative core body temperature changes during the recovery period in relation to the timing of intraoperative intravenous paracetamol administration.

MATERIALS AND METHODS

Study Design and Setting

This prospective, randomized, comparative study was conducted in the operation theatres and post-anaesthesia care unit of the Department of Anaesthesiology, BGS Global Institute of Medical Sciences, Bangalore, Karnataka, India. The study was carried out over a period of three months following approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants prior to enrolment.

Study Population and Sample Size

A total of 60 patients undergoing elective surgical procedures under general anaesthesia were enrolled and randomly allocated into two groups of 30 patients each. The sample size was calculated based on previously published data on the incidence of postoperative shivering, using a two-proportion formula with a 95% confidence interval ($Z\alpha/2 = 1.96$) and 80% statistical power ($Z\beta = 0.84$), and accounting for possible dropouts.

Inclusion Criteria

. Adult patients aged18–60 years
. Patients of either gender
. Patients belonging to ASA physical status I and II
. Patients with a BMI of ≤ 35 kg/m2
. Patients undergoing elective surgeries under general anesthesia
. Patients who provide written informed consent

Exclusion Criteria

. Patients with pre-existing fever ,hypothermia, or thyroid disorders
. Patients with hepatic or renal dysfunction or cardiac abnormalities
. Known allergy or hypersensitivity to paracetamol
. Parturients
. Emergency surgeries
. Patients with neurological disorders affecting thermoregulation.

Randomization and Group Allocation

Eligible patients were randomly allocated into one of two study groups using a computer-generated randomization sequence with sealed opaque envelopes. Group A (Early Administration Group) received intravenous paracetamol 1 g infused over 20 minutes, administered 30 minutes after induction of anaesthesia. Group B (Late Administration Group) received intravenous paracetamol 1 g infused over 20 minutes, administered 30 minutes before the anticipated completion of surgery.

Anaesthetic Technique

All patients underwent a standardized preanaesthetic assessment and overnight fasting was confirmed prior to surgery. The operating room temperature was maintained between 22 and 24°C throughout all procedures. Upon arrival in the operating room, baseline vital parameters including heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, peripheral oxygen saturation, and core body temperature were recorded. Premedication consisted of intravenous glycopyrrolate (0.02 mg/kg) and fentanyl (2 µg/kg). General anaesthesia was induced with titrated doses of propofol (up to 2 mg/kg) and neuromuscular blockade was achieved with vecuronium (0.1 mg/kg) to facilitate endotracheal intubation. Anaesthesia was maintained with oxygen, nitrous oxide, and isoflurane, with supplemental doses of vecuronium as required. Intraoperatively, all patients were covered with gamgee sheets and sterile surgical drapes, and a forced-air warming device set at 37°C was used throughout the procedure. At the end of surgery, intravenous ondansetron (0.1 mg/kg) was administered before reversal of residual neuromuscular blockade to prevent postoperative nausea and vomiting. Residual neuromuscular blockade was reversed using intravenous neostigmine (0.05 mg/kg) and

glycopyrrolate (0.02 mg/kg), and the trachea was extubated after confirming adequate spontaneous ventilation, return of protective airway reflexes, and response to verbal commands.

Temperature Monitoring and Definition of Hypothermia

Core body temperature was measured using a calibrated infrared tympanic thermometer throughout the perioperative period. Measurements were recorded at baseline (pre-induction) and at 0, 15, 30, 45, and 60 minutes postoperatively after arrival in the post-anaesthesia care unit. Hypothermia was defined as a core body temperature less than 36°C recorded at any time point

Postoperative Monitoring and Data Collection

Following extubation, patients were transferred to the post-anaesthesia care unit, covered with a blanket, and provided supplemental oxygen at 1–2 L/min via nasal prongs. Postoperative monitoring included assessment of shivering incidence and severity, core body temperature, and vital parameters at 0, 15, 30, 45, and 60 minutes after arrival in the recovery area. Postoperative shivering severity was graded using the Crossley and Mahajan four-point shivering scale: Grade 0 (no shivering), Grade 1 (mild shivering – localized, intermittent), Grade 2 (moderate shivering – visible, involving more than one limb), and Grade 3 (severe shivering – whole body, continuous). Rescue anti-shivering medication in the form of intravenous tramadol (1 mg/kg) was administered to patients who developed shivering of Grade 2 or above and was documented accordingly.

Statistical Analysis

All collected data were entered into Microsoft Excel and subsequently analysed using the Statistical Package for the Social Sciences (SPSS) version 27.0. Continuous variables were expressed as mean ± standard deviation and compared between the two groups using the independent samples t-test or Mann–Whitney U test, as appropriate based on normality assessment. Categorical variables were expressed as frequency and percentage and compared using the Chi-square test or Fisher's exact test. The severity of postoperative shivering, being an ordinal variable, was analysed using the Mann–Whitney U test. Repeated-measures analysis of variance was used for comparison of core body temperature changes at serial postoperative time intervals. A p-value of less than 0.05 was considered statistically significant for all analyses.

RESULTS

A total of 60 patients were enrolled and successfully completed the study protocol, with 30 patients in each group. No patient was excluded or lost to follow-up during the study period.

Demographic and Baseline Characteristics

The two groups were comparable with respect to demographic and baseline clinical characteristics. The mean age in Group A was 38.47 ± 10.62 years compared to 40.13 ± 11.28 years in Group B (p = 0.562). The male-to-female ratio was similar across both groups (p = 0.793). The mean body mass index was 24.36 ± 3.12 kg/m² in Group A and 23.98 ± 2.87 kg/m² in Group B (p = 0.631). The distribution of ASA physical status classification was also comparable between the groups (p = 0.598). The mean duration of surgery was 186.40 ± 42.56 minutes in Group A and 194.27 ± 38.84 minutes in Group B, with no statistically significant difference (p = 0.452). The baseline core body temperature was comparable between the two groups (Group A: 36.72 ± 0.24°C; Group B: 36.68 ± 0.22°C; p = 0.512). The detailed demographic and baseline characteristics are presented in Table 1.

Table 1: Demographic and Baseline Characteristics of Study Participants

Parameter	Group A (n=30)	Group B (n=30)	p-value
Age (years), Mean ± SD	38.47 ± 10.62	40.13 ± 11.28	0.562
Gender (Male/Female)	17/13	16/14	0.793
BMI (kg/m²), Mean ± SD	24.36 ± 3.12	23.98 ± 2.87	0.631
ASA I / ASA II	19/11	18/12	0.598
Duration of surgery (min)	186.40 ± 42.56	194.27 ± 38.84	0.452
Baseline core temp (°C)	36.72 ± 0.24	36.68 ± 0.22	0.512

ASA = American Society of Anesthesiologists; BMI = Body Mass Index; SD = Standard Deviation

Incidence of Postoperative Shivering

The overall incidence of postoperative shivering during the 60-minute observation period was significantly higher in Group A (33.3%, n = 10) compared to Group B (10.0%, n = 3), and this difference was statistically significant (p = 0.024). Time-point analysis of new-onset shivering revealed that at 0 minutes postoperatively, 4 patients (13.3%) in Group A and 1 patient (3.3%) in Group B developed shivering (p = 0.161). At 15 minutes, new-onset shivering was observed in 3 patients (10.0%) in Group A versus 1 patient (3.3%) in Group B (p = 0.301). At 30 minutes, 2 patients (6.7%) in Group A and 1 patient (3.3%) in Group B developed new-onset shivering (p = 0.554). At 45 minutes, 1 patient (3.3%) in Group A developed shivering while no patient in Group B experienced shivering at this time point (p = 0.313).

No new-onset shivering was observed in either group at 60 minutes postoperatively. The time-point-wise incidence of new-onset postoperative shivering is presented in Table 2.

Table 2: Incidence of New-Onset Postoperative Shivering at Various Time Points

Time (min)	Group A, n (%)	Group B, n (%)	p-value
0	4 (13.3%)	1 (3.3%)	0.161
15	3 (10.0%)	1 (3.3%)	0.301
30	2 (6.7%)	1 (3.3%)	0.554
45	1 (3.3%)	0 (0.0%)	0.313
60	0 (0.0%)	0 (0.0%)	–
Overall	**10 (33.3%)**	**3 (10.0%)**	**0.024***

**Statistically significant ($p < 0.05$); Chi-square test / Fisher's exact test*

Severity of Postoperative Shivering

The distribution of shivering severity grades demonstrated a significantly more favourable profile in Group B compared to Group A. In Group A, among the 10 patients who developed shivering, 4 patients (13.3%) had Grade 1 (mild) shivering, 4 patients (13.3%) had Grade 2 (moderate) shivering, and 2 patients (6.7%) had Grade 3 (severe) shivering. In Group B, all 3 patients who developed shivering had Grade 1 (mild) shivering (10.0%), with no patients experiencing Grade 2 or Grade 3 shivering. The overall comparison of shivering severity distribution between the two groups was statistically significant ($p = 0.018$, Mann–Whitney U test). The distribution of shivering severity grades is presented in Table 3.

Table 3: Distribution of Postoperative Shivering Severity

Shivering Grade	Group A, n (%)	Group B, n (%)	p-value
Grade 0 (No shivering)	20 (66.7%)	27 (90.0%)	
Grade 1 (Mild)	4 (13.3%)	3 (10.0%)	
Grade 2 (Moderate)	4 (13.3%)	0 (0.0%)	
Grade 3 (Severe)	2 (6.7%)	0 (0.0%)	
Overall comparison			**0.018***

**Statistically significant ($p < 0.05$); Mann–Whitney U test*

Core Body Temperature Changes

Core body temperature analysis at serial postoperative time points demonstrated significant differences between the two groups. At 0 minutes postoperatively, the mean core temperature was 35.82 ± 0.38°C in Group A and 36.24 ± 0.32°C in Group B ($p < 0.001$). At 15 minutes, core temperature was 35.96 ± 0.34°C in Group A compared to 36.32 ± 0.28°C in Group B ($p < 0.001$). At 30 minutes, the values were 36.14 ± 0.30°C and 36.38 ± 0.26°C in Groups A and B, respectively ($p = 0.001$). By 45 minutes, core temperatures were 36.28 ± 0.26°C in Group A and 36.42 ± 0.24°C in Group B ($p = 0.032$). At 60 minutes, the temperatures were comparable between the groups (Group A: 36.38 ± 0.24°C; Group B: 36.46 ± 0.22°C; $p = 0.184$). Repeated-measures ANOVA demonstrated a significant time-by-group interaction effect ($F = 8.74$, $p < 0.001$), confirming that the pattern of temperature recovery differed significantly between the two groups. The incidence of postoperative hypothermia (core temperature <36°C) was significantly higher in Group A (36.7%, n = 11) compared to Group B (10.0%, n = 3; $p = 0.015$). The detailed core body temperature data are presented in Table 4.

Table 4: Core Body Temperature (°C) at Postoperative Time Points

Time (min)	Group A (Mean ± SD)	Group B (Mean ± SD)	p-value
Baseline	36.72 ± 0.24	36.68 ± 0.22	0.512
0	35.82 ± 0.38	36.24 ± 0.32	<0.001*
15	35.96 ± 0.34	36.32 ± 0.28	<0.001*
30	36.14 ± 0.30	36.38 ± 0.26	0.001*
45	36.28 ± 0.26	36.42 ± 0.24	0.032*
60	36.38 ± 0.24	36.46 ± 0.22	0.184

**Statistically significant ($p < 0.05$); Independent samples t-test; Repeated-measures ANOVA: time × group interaction $F = 8.74$, $p < 0.001$*

Rescue Anti-Shivering Medication Requirement

The requirement for rescue anti-shivering medication (intravenous tramadol) was significantly lower in Group B compared to Group A. In Group A, 6 patients (20.0%) who developed Grade 2 or above shivering required rescue tramadol during the postoperative observation period. In Group B, no patient (0.0%) required rescue tramadol, as all 3 patients who developed shivering had only Grade 1 (mild) shivering, which did not meet the threshold for rescue medication administration ($p = 0.010$, Fisher's exact test). The incidence of postoperative hypothermia (core temperature

<36°C) was also significantly higher in Group A (36.7%, n = 11) compared to Group B (10.0%, n = 3; p = 0.015). The detailed data regarding rescue medication requirements are presented in Table 5.

Table 5: Rescue Anti-Shivering Medication (Tramadol) Requirement and Hypothermia

Parameter	Group A (n=30)	Group B (n=30)	p-value
Rescue tramadol required, n (%)	6 (20.0%)	0 (0.0%)	0.010*
Postop hypothermia (<36°C), n (%)	11 (36.7%)	3 (10.0%)	0.015*

**Statistically significant (p < 0.05); Fisher's exact test*

DISCUSSION

The findings of the present study are consistent with and extend the observations reported by Mohta et al. (2023), who conducted a randomized double-blind controlled trial comparing early versus late intraoperative paracetamol administration and a control group [8]. In their study, the incidence of postoperative shivering was lowest in the late paracetamol group (12%) compared to the early paracetamol group (29.3%) and the control group (30.6%), with statistically significant differences between the late group and both comparator groups (p = 0.009 and p = 0.005, respectively). The incidence of postoperative hypothermia was also significantly lower in the late administration group. The present study corroborates these findings and further reinforces the notion that the timing of paracetamol administration is a critical determinant of its anti-shivering efficacy. Similarly, Murali et al. (2025) reported that late intraoperative intravenous paracetamol administration significantly reduced postoperative shivering incidence (2.5%) compared to early administration (15%) and control groups (25%), findings that are directionally concordant with the results of the present investigation [9].

The superior anti-shivering efficacy observed with late intraoperative paracetamol administration may be explained by pharmacokinetic and pharmacodynamic considerations. In the context of surgeries lasting up to three and a half hours performed under general anaesthesia, early administration of paracetamol shortly after induction results in peak therapeutic effect occurring during the mid-surgical period, with progressive decline of drug levels over the remaining operative duration. By the time of emergence from anaesthesia—when the anaesthetic-induced suppression of thermoregulatory reflexes wanes and patients are most vulnerable to shivering—the protective thermoregulatory effect of early-administered paracetamol has substantially diminished. In contrast, administration 30 minutes before the anticipated end of surgery ensures that the peak central effect of paracetamol coincides with the critical emergence and early recovery period, providing optimal thermoregulatory protection during the window of greatest susceptibility. Additionally, Mohta et al. (2023) noted that the peak hypothermic action of paracetamol occurs at approximately 120 minutes after administration; thus, late administration avoids the compounding of drug-induced hypothermia with anaesthesia-induced hypothermia, which may occur with early administration [8].

The present finding that late intraoperative paracetamol administration was associated with superior maintenance of core body temperature is of considerable clinical significance. The incidence of postoperative hypothermia (<36°C) was 36.7% in the early administration group compared to 10.0% in the late administration group (p = 0.015). Kinjo et al. (2020) reported that perioperative acetaminophen administration significantly reduced the incidence of severe postoperative shivering (22.2% versus 73.7% in the placebo group) and was associated with lower body temperatures at certain postoperative time points, suggesting that the anti-shivering mechanism may involve suppression of the postoperative rise in the thermoregulatory set point rather than a simple lowering of the shivering threshold [7]. The present study extends this observation by demonstrating that the timing of administration further modulates these thermoregulatory effects.

The complete absence of rescue anti-shivering medication requirement in the late administration group is a clinically noteworthy finding. In Group A, 6 patients (20.0%) required rescue tramadol for Grade 2 or above shivering, while no patient in Group B developed shivering of sufficient severity to warrant rescue pharmacotherapy (p = 0.010). This finding is particularly significant because all 3 patients who developed shivering in Group B experienced only Grade 1 (mild) shivering, which did not require pharmacological intervention. De Witte et al. (2002) reported that the avoidance of rescue agents such as tramadol, meperidine, or clonidine eliminates additional risks including respiratory depression, sedation, nausea, and haemodynamic instability [10], thereby contributing to smoother postoperative recovery profiles.

Kashif et al. (2021) demonstrated that pre-emptive intravenous paracetamol was superior to ketorolac in preventing both postoperative pain and shivering following septoplasty under general anaesthesia, with significantly lower mean shivering scores in the paracetamol group compared to the placebo group [11]. While their study did not specifically address the timing of intraoperative administration, the demonstrated anti-shivering properties of paracetamol provide supporting evidence for its prophylactic use in the perioperative setting, which is consistent with the findings of the present study.

The role of perioperative temperature management in the prevention of postoperative shivering has been further emphasized by recent investigations. Huniler et al. (2024) reported a high incidence of perioperative hypothermia (68.1%) in breast surgery patients under general anaesthesia, with a strong correlation between the depth of temperature decrease and the incidence of shivering, and noted that the incidence of shivering was markedly elevated at temperatures below 36°C or at reductions exceeding 1°C from baseline [12]. These observations underscore the multifactorial nature of postoperative shivering and support the rationale for combining pharmacological interventions, such as optimally timed paracetamol administration, with non-pharmacological thermal management strategies to achieve maximal shivering prevention in patients undergoing surgery under general anaesthesia.

The present study had certain limitations that merit acknowledgement. The sample size, although adequate for detecting clinically meaningful differences in the primary outcome, was relatively modest, which may have limited the statistical power for detecting differences in secondary outcomes at individual time points. The study was conducted at a single centre, which may limit the generalizability of the findings to other clinical settings and patient populations. Blinding of the anaesthesiologist to group allocation was not feasible given the nature of the intervention, potentially introducing observer bias. Furthermore, the study did not include a placebo control group, precluding direct comparison of both timing strategies against no paracetamol administration. Future multicentre, double-blind, placebo-controlled studies with larger sample sizes are recommended to validate and extend these findings.

CONCLUSION

The present study demonstrated that the timing of intraoperative intravenous paracetamol administration significantly influenced the incidence and severity of postoperative shivering in patients undergoing elective surgery under general anaesthesia. Administration of intravenous paracetamol (1 g) 30 minutes before the anticipated completion of surgery was associated with a significantly lower incidence of postoperative shivering (10.0% versus 33.3%), reduced shivering severity with no patient developing Grade 2 or above shivering, better preservation of core body temperature, a significantly lower incidence of postoperative hypothermia (<36°C; 10.0% versus 36.7%), and complete elimination of the requirement for rescue anti-shivering medication compared to administration 30 minutes after induction of anaesthesia. Late intraoperative administration of intravenous paracetamol represents a simple, safe, cost-effective, and clinically practical strategy for the prevention of postoperative shivering that can be readily incorporated into routine anaesthetic practice as a component of multimodal perioperative care in patients undergoing surgery under general anaesthesia.

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