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Comparative Evaluation of 0.5% Levobupivacaine with Dexamethasone Versus Fentanyl in Bilateral Ultrasound-Guided Transversus Abdominis Plane Block for Total Abdominal Hysterectomy

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ABSTRACT

Background: Effective postoperative pain control after total abdominal hysterectomy (TAH) is essential for early mobilization and reduced opioid use. This study compared dexamethasone and fentanyl as adjuvants to 0.5% levobupivacaine in bilateral ultrasound-guided transversus abdominis plane (TAP) block.

Methods: In this prospective, randomized, double-blind study, 100 ASA I-II patients undergoing elective TAH were allocated into two groups (n=50 each). Group D received 15 mL 0.5% levobupivacaine with dexamethasone 8 mg per side, while Group F received 15 mL 0.5% levobupivacaine with fentanyl 1 µg/kg per side. Primary outcome was duration of analgesia. Secondary outcomes included Visual Analogue Scale (VAS) scores, rescue tramadol consumption, hemodynamic parameters, and adverse effects over 24 hours.

Results: Duration of analgesia was significantly longer in Group D (9.70 ± 1.07 h) compared to Group F (5.10 ± 0.63 h) ($p<0.001$). VAS scores were significantly lower in Group D at 4, 6, and 12 hours ($p<0.001$). Total tramadol consumption was reduced in Group D (52.0 ± 15.8 mg) versus Group F (74.4 ± 18.2 mg) ($p<0.001$). Hemodynamic parameters were more stable in Group D. No significant adverse effects were observed.

Conclusion: Dexamethasone is a superior adjuvant to fentanyl in TAP block for TAH, providing prolonged analgesia and reduced opioid requirements without added complications.

Key words: Transversus abdominis plane block, Levobupivacaine, Dexamethasone, Fentanyl, Total abdominal hysterectomy, Postoperative analgesia

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INTRODUCTION

Effective postoperative pain management is a key determinant of recovery following major abdominal procedures such as total abdominal hysterectomy. Poorly controlled postoperative pain is associated with delayed mobilization, increased opioid consumption, prolonged hospital stays, and impaired functional recovery.[1-4] Consequently, contemporary perioperative care increasingly emphasizes multimodal and opioid-sparing analgesic strategies to improve functional recovery and patient satisfaction. These associations are well recognized within enhanced recovery after surgery (ERAS) pathways, where effective multimodal analgesia is central to facilitating early mobilization, shortening hospital stay, and improving overall postoperative recovery.[5]

Regional anesthesia techniques play an essential role in multimodal analgesia. Among these, the ultrasound-guided transversus abdominis plane block has gained widespread acceptance for providing effective somatic analgesia of the anterior abdominal wall. The block involves deposition of local anesthetic within the fascial plane between the internal oblique and transversus abdominis muscles, resulting in blockade of thoracolumbar nerves supplying the abdominal wall.[6,7] Several studies have demonstrated that ultrasound-guided transversus abdominis plane block significantly reduces postoperative pain scores and opioid requirements following abdominal and gynecologic surgeries, including hysterectomy.[2,8,9]

Levobupivacaine is frequently used for transversus abdominis plane block because of its long duration of sensory blockade and improved cardiovascular safety profile compared with racemic bupivacaine.[10,11] Despite these advantages, the analgesic duration of a single-shot transversus abdominis plane block may be insufficient to cover the entire postoperative pain period after major abdominal surgery, particularly beyond the first 12-24 hours.[2,3,8,12] This limitation has driven interest in the use of adjuvant agents to prolong block duration and enhance analgesic quality.

Dexamethasone has emerged as a highly effective non-opioid adjuvant in regional anesthesia. Its analgesic-prolonging effects are attributed to anti-inflammatory properties, suppression of nociceptive transmission, and reduction of perineural inflammation. Randomized trials and meta-analyses have consistently shown that adding dexamethasone to local anesthetics in transversus abdominis plane block significantly prolongs postoperative analgesia and reduces rescue opioid consumption across abdominal procedures.[1,13-15]

Opioids such as fentanyl have been evaluated as adjuvants in regional anesthesia because of their potent analgesic effects and rapid onset of action; however, evidence supporting their ability to prolong analgesia in transversus abdominis plane block is limited and inconsistent with benefits largely confined to the early postoperative period.[16] Systematic reviews have further confirmed the effectiveness of transversus abdominis plane block in reducing postoperative pain and opioid consumption following abdominal surgery, while also highlighting variability in the duration of analgesia achieved with single-shot techniques.[17]

Although both dexamethasone and fentanyl have been individually studied as adjuvants in transversus abdominis plane block, direct comparative evidence evaluating their efficacy when combined with levobupivacaine in bilateral ultrasound-guided transversus abdominis plane block for total abdominal hysterectomy is limited. Identifying the more effective and safer adjuvant has important implications for optimizing postoperative analgesia and minimizing opioid exposure.

Current clinical practice guidelines strongly recommend multimodal and opioid-sparing analgesic strategies as a cornerstone of postoperative pain management to improve patient outcomes and reduce opioid-related adverse effects.[18] Therefore, this study was designed to compare dexamethasone and fentanyl as adjuvants to 0.5% levobupivacaine in bilateral ultrasound-guided transversus abdominis plane block for patients undergoing total abdominal hysterectomy. The study evaluated duration of postoperative analgesia, pain intensity, rescue analgesic requirements, hemodynamic parameters, and adverse effects.

MATERIALS AND METHODS

This prospective, randomized, double-blind, interventional study was conducted at the Gadag Institute of Medical Sciences (GIMS) Teaching Hospital, Gadag, Karnataka, over a period of 18 months, from June 2023 to November 2024. Ethical clearance was obtained from the Institutional Ethics Committee (IEC/GIMS/ANA/TAH-TAP/2023), and written informed consent was obtained from all participants prior to enrolment.

Sample Size and Randomization

Sample size was calculated using the formula for comparison of two means, based on pilot data from our institution. The pilot observations revealed a mean ± standard deviation duration of analgesia of 11.2 ± 2.86 hours in the levobupivacaine–fentanyl group and 10.24 ± 1.5 hours in the levobupivacaine–dexamethasone group. With a power of 80% and a two-sided α error of 0.05, the minimum required sample size was calculated as 88 patients. After accounting for an anticipated 10% dropout rate, 100 participants were enrolled and randomized equally into two groups of 50 each. These pilot observations were used solely for the purpose of sample size estimation and were not incorporated into the final analysis.

Randomization was performed using a computer-generated random number sequence. Group allocation was concealed using sequentially numbered, opaque, sealed envelopes, which were opened only at the time of block administration. Study drugs were prepared by an anesthesiologist who was not involved in patient man-

agement or postoperative assessment. The prepared solutions were placed in identical syringes labeled with the participant code only, ensuring that both patients and postoperative outcome assessors remained blinded to group allocation throughout the study.

Study Groups and Drug Doses

Participants were allocated to one of two groups. Group D received 15 mL of 0.5% levobupivacaine supplemented with 8 mg dexamethasone per side, while Group F received 15 mL of 0.5% levobupivacaine supplemented with fentanyl at a dose of 1 µg/kg per side. The dose of dexamethasone (8 mg) was selected on the basis of prior randomized trials and meta-analyses demonstrating significant prolongation of analgesia in transversus abdominis plane (TAP) block without increased adverse effects or neurotoxicity [1,13,14]. Perineural dexamethasone in this dose range has been consistently shown to extend block duration meaningfully and to reduce postoperative opioid consumption. Fentanyl was administered at 1 µg/kg, consistent with doses employed in previous TAP block studies evaluating opioid adjuvants for enhancement of early postoperative analgesia while minimizing opioid-related adverse effects [16].

Inclusion and Exclusion Criteria

Female patients aged 35–60 years, classified as American Society of Anesthesiologists (ASA) physical status I or II, scheduled for elective total abdominal hysterectomy (TAH), with a body mass index (BMI) below 30 kg/m² and normal hepatic, renal, and coagulation profiles were included in the study. Patients were excluded if they had a known hypersensitivity to levobupivacaine, dexamethasone, or fentanyl; a local infection at the proposed injection site; a history of chronic opioid use or chronic pain disorders; major cardiovascular, hepatic, renal, or respiratory illness; coagulopathy; or psychiatric disorders that could impair reliable pain assessment.

Anaesthetic Technique and TAP Block Administration

All patients underwent standardized spinal anaesthesia with 3 mL of 0.5% hyperbaric bupivacaine administered at the L3–L4 interspace using a 25-gauge Quincke needle under strict aseptic precautions. Following completion of surgery and prior to reversal of anaesthesia, a bilateral ultrasound-guided TAP block was administered by an experienced anaesthesiologist who was not involved in postoperative assessment.

Using a high-frequency linear ultrasound probe (6–13 MHz), the transversus abdominis plane was identified between the internal oblique and transversus abdominis muscles at the mid-axillary line, between the costal margin and the iliac crest. Following confirmation of negative aspiration, the study drug was injected into the fascial plane on each side. Real-time visualization of injectate spread within the plane was confirmed to ensure accurate drug deposition, as recommended by Hebbard et al. [7].

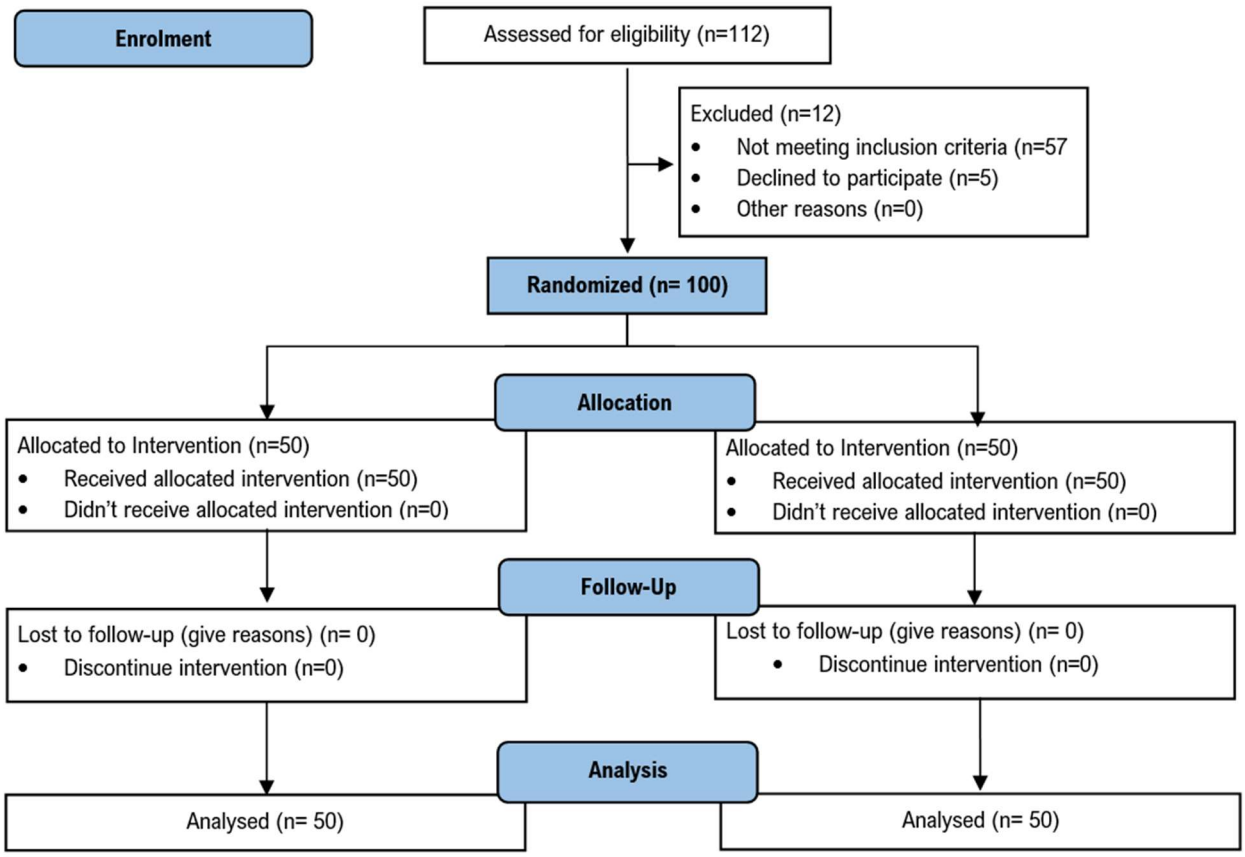

Figure 1: CONSORT 2010 Flow Diagram

Outcome Measures and Postoperative Monitoring

The primary outcome measure was the duration of postoperative analgesia, defined as the time interval from TAP block administration to the patient's first request for rescue analgesia, corresponding to a Visual Analogue Scale (VAS) score of 4 or greater. Secondary outcomes included postoperative pain intensity assessed on the 10-point VAS at 2, 4, 6, 12, and 24 hours postoperatively; hemodynamic parameters including pulse rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure recorded at identical time points; total rescue analgesic requirement expressed as the number of doses of intravenous tramadol 50 mg administered; and the incidence of adverse effects, including nausea, vomiting, sedation, pruritus, and respiratory depression.

All patients were monitored in the post-anaesthesia care unit and subsequently in the ward for 24 hours following surgery. Vital signs were recorded every 15 minutes during the first postoperative hour and thereafter at 2, 4, 6, 12, and 24 hours. Pain scores were assessed by a blinded observer, and rescue analgesia in the form of tramadol 50 mg intravenously was administered whenever the VAS score reached 4 or above, with the option of repetition every 6 hours if required. The flow of participants through the study is illustrated in the CONSORT 2010 flow diagram (Figure 1).

Statistical Analysis: Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables as frequencies and percentages. Between-group comparisons were made using the unpaired Student's t-test for continuous variables and the Chi-square test for categorical data. A $p < 0.05$ was considered statistically significant. Data were entered into Microsoft Excel and analysed using SPSS version 24 (IBM Corp., USA).

RESULTS

Table 1 presents participants' baseline demographic and intraoperative variables. The results showed no statistically significant differences between the dexamethasone group (M = 45.78 years, SD = 6.42) and the fentanyl group (M = 46.32 years, SD = 5.89) in age, $p = .624$. Body mass index, ASA physical status distribution, and operative and anaesthetic durations were also comparable (all $p > 0.40$).

As shown in Table 2, the prevalence of comorbidities such as hypertension, diabetes mellitus, and hypothyroidism did not differ significantly between groups (all $p > 0.05$). Approximately one fifth of participants in each group were hypertensive, while fewer than 10% reported thyroid dysfunction. The comparable comorbidity profiles indicate that systemic disease burden was evenly distributed, minimizing confounding influences on postoperative pain perception or hemodynamic response.

Table 3 summarizes the mean Visual Analogue Scale (VAS) pain scores across five postoperative time points. Two-way repeated-measures analyses indicated a significant main effect of group, $p < 0.001$, such that participants receiving dexamethasone reported consistently lower VAS scores at 4, 6, and 12 hours.

Table 1: Demographic characteristics of study participants

Variable	Group D (n = 50) Levobupivacaine + Dexamethasone	Group F (n = 50) Levobupivacaine + Fentanyl	*p*-value
Age (years)	45.78 ± 6.42	46.32 ± 5.89	0.624
BMI (kg m⁻²)	25.10 ± 2.48	25.36 ± 2.62	0.671
ASA I/II (no.)	28/22	26 / 24	0.684
Duration of surgery (min)	95.6 ± 11.4	94.1 ± 12.0	0.544
Duration of anaesthesia (min)	110.3 ± 10.6	112.1 ± 11.8	0.412

Table 2: Distribution of comorbid conditions

Comorbidity	Group D (n = 50) (%)	Group F (n = 50) (%)	*p*-value
Hypertension	10 (20)	12 (24)	0.62 (NS)
Diabetes mellitus	8 (16)	9 (18)	0.79 (NS)
Hypothyroidism	4 (8)	5 (10)	0.72 (NS)
Others (minor)	2 (4)	1 (2)	0.55 (NS)

Table 3: Post-operative Visual Analogue Scale (VAS) pain scores

Time post-surgery (h)	Group D (Mean ± SD)	Group F (Mean ± SD)	*p*-value
2 h	0.00 ± 0.00	0.00 ± 0.00	-
4 h	0.84 ± 0.37	1.46 ± 0.52	<0.001*
6 h	1.62 ± 0.49	2.38 ± 0.68	<0.001*
12 h	2.56 ± 0.71	3.44 ± 0.83	<0.001*
24 h	3.02 ± 0.95	3.64 ± 0.98	0.052 (NS)

*Highly Significant; NS: Non-Significant

At 4 hours, the dexamethasone group's mean score (M = 0.84, SD = 0.37) was markedly lower than the fentanyl group's (M = 1.46, SD = 0.52). The between-group difference remained significant at 6 hours ($\Delta \approx 0.76$ points) and 12 hours ($\Delta \approx 0.88$ points). Scores converged by 24 hours, indicating waning analgesic effect.

As indicated in Table 4, the mean time to first analgesic request was significantly longer for the dexamethasone group (M = 9.70 h, SD = 1.07) than for the fentanyl group (M = 5.10 h, SD = 0.63), $p < 0.001$. Both groups required at least one rescue dose of intravenous tramadol within 24 hours, but total tramadol consumption was substantially lower in the dexamethasone group (M = 52 mg) than in the fentanyl group (M = 74 mg). This indicates superior duration and quality of analgesia when dexamethasone is used as an adjuvant.

Table 4: Analgesic duration and rescue analgesia requirement

Parameter	Group D	Group F	*p*-value
Time to first analgesic request (h) (mean ± SD)	9.70 ± 1.07	5.10 ± 0.63	< 0.001 **
Patients requiring rescue analgesia (n %)	50 (100 %)	50 (100 %)	1.000 (NS)
Total tramadol consumed (mg / 24 h) (mean ± SD)	52.0 ± 15.8	74.4 ± 18.2	< 0.001 **

Table 5: Post-operative haemodynamic parameters (Mean ± SD)

Parameter	Group D (Mean ± SD)	Group F (Mean ± SD)	*p*-value
Pulse rate (bpm)	78.22 ± 5.91	82.84 ± 6.17	0.014*
Systolic BP (mm Hg)	118.3 ± 7.2	123.1 ± 8.0	0.027*
Diastolic BP (mm Hg)	74.2 ± 5.8	76.6 ± 6.2	0.131 (NS)
Mean arterial pressure (mm Hg)	89.9 ± 6.4	92.5 ± 6.7	0.087 (NS)

Table 5 displays postoperative hemodynamic trends. The results revealed significantly lower mean pulse rates (p = 0.014) and systolic blood pressures (p = 0.027) in the dexamethasone group, while diastolic pressure and mean arterial pressure differences were no significant (p >0.05). The results indicate that dexamethasone maintained slightly greater hemodynamic stability without clinically important hypotension or bradycardia. No adverse cardiovascular or respiratory events were observed in either group.

DISCUSSION

The present randomized controlled trial compared the postoperative analgesic effects of adding dexamethasone or fentanyl to 0.5% levobupivacaine in bilateral ultrasound-guided TAP blocks for patients undergoing total abdominal hysterectomy (TAH). The findings demonstrate that the levobupivacaine-dexamethasone combination provided significantly longer duration of analgesia, lower postoperative pain scores, reduced rescue opioid consumption, and more stable hemodynamic parameters compared with the levobupivacaine-fentanyl combination.

Analgesic duration and time to first rescue analgesia: The prolonged duration of analgesia observed in the dexamethasone group aligns with previously published data on the benefits of corticosteroid adjuvants in regional anaesthesia. Dexamethasone has been shown to significantly extend the duration of sensory blockade in peripheral nerve blocks through anti-inflammatory effects, inhibition of nociceptive C-fiber activity, and suppression of neurogenic inflammation [1]. A TAP block-specific meta-analysis by Zhang D et al.[13] demonstrated that dexamethasone significantly prolongs postoperative analgesia and reduces opioid requirements compared with local anesthetic alone. Similar findings were reported by Yildiz I and Bayır H, who observed enhanced analgesic duration when dexamethasone was added to levobupivacaine for TAP block [9].

In contrast, fentanyl, although effective in enhancing early postoperative analgesia, demonstrated a shorter duration of action when used as a perineural adjuvant. Chatrath et al. reported that adding fentanyl to levobupivacaine in TAP block improved early analgesia but did not produce a sustained prolongation of block duration compared with local anesthetic alone [16]. These findings are consistent with the results of the present study and may be explained by fentanyl's rapid systemic absorption and redistribution rather than prolonged local neural action.

Postoperative pain scores: The significantly lower VAS scores at 4, 6, and 12 hours in the dexamethasone group indicate superior early and intermediate analgesia. These findings are in agreement with systematic reviews and meta-analyses demonstrating that perineural dexamethasone reduces postoperative pain intensity within the first 24 hours across a range of abdominal procedures, including TAP block applications.[1,13] TAP block study combining dexamethasone with levobupivacaine or ropivacaine have similarly reported improved pain control compared with local anesthetic alone.[9]

In contrast, fentanyl's effect is most pronounced in the immediate postoperative period, and its analgesic impact diminishes as systemic redistribution occurs. This pattern has been reported in other regional anaesthesia study employing fentanyl as an adjuvant.[16]

Opioid consumption: Total tramadol consumption over 24 hours was significantly lower in the dexamethasone group, reflecting sustained analgesic benefit. Reduced opioid requirements are consistent with findings from meta-analyses evaluating dexamethasone in fascial plane and peripheral blocks.[1,13] Lower opioid exposure is clinically meaningful as it reduces the risk of opioid-related adverse effects such as nausea, vomiting, respiratory depression, and sedation.

Hemodynamic stability: The improved hemodynamic stability observed in patients receiving dexamethasone likely reflects superior analgesia and attenuation of the surgical stress response rather than a direct hemodynamic effect of the drug.[12] In contrast, fentanyl may produce variable hemodynamic effects due to systemic absorption and opioid-mediated sympatholysis, which may account for the comparatively greater fluctuations observed in the fentanyl group.

The analgesic benefits observed in this study are consistent with evidence supporting the role of transversus abdominis plane block in improving postoperative pain control following abdominal and gynecologic surgeries,

including hysterectomy.[2,8] The present study extends this evidence by providing direct comparative data between two commonly used adjuvants and demonstrates that dexamethasone offers superior and more sustained analgesia compared with fentanyl when combined with levobupivacaine.

No adverse effects were observed in either study group, consistent with previous transversus abdominis plane block studies reporting no significant increase in adverse effects or complications associated with dexamethasone use as an adjuvant.[12,13]

Safety profile: No adverse effects were observed in either study group, consistent with previous transversus abdominis plane block studies reporting no significant increase in adverse effects or complications associated with dexamethasone use as an adjuvant.[12,13] Similarly, low-dose fentanyl has been shown to be safe when used in TAP block, although its analgesic benefits appear limited in duration.[16] The absence of complications in the present study supports the clinical feasibility of dexamethasone-levobupivacaine TAP block for postoperative analgesia in gynecologic surgery.

LIMITATIONS

This study has certain limitations. First, it was conducted at a single tertiary care center, which may limit the generalizability of the findings to other settings. Second, postoperative follow-up was limited to 24 hours; therefore, long-term analgesic outcomes and the potential impact on chronic postoperative pain could not be assessed. Additionally, only single-shot transversus abdominis plane blocks were evaluated; continuous catheter techniques may provide prolonged analgesia and should be explored in future studies.

CONCLUSION

The addition of dexamethasone to levobupivacaine in bilateral ultrasound-guided TAP block provides significantly superior postoperative analgesia compared with levobupivacaine combined with fentanyl in patients undergoing total abdominal hysterectomy. Dexamethasone prolonged the duration of analgesia, reduced postoperative pain scores, minimized rescue opioid requirements, and contributed to more stable hemodynamic parameters. Both regimens were safe and well tolerated, with no adverse events reported. These findings support the incorporation of dexamethasone as an effective non-opioid adjuvant in TAP blocks to enhance postoperative pain control while reducing opioid exposure in gynaecologic surgery.

Individual Author's Contribution: VNP contributed to the study conception, data analysis and interpretation, and manuscript preparation. **SHB** contributed to the study design, data collection, and manuscript preparation. **PV** contributed to data collection, data analysis and interpretation, and manuscript preparation. All authors reviewed and approved the final version of the manuscript.

Availability of data: The data that support the findings of this study are available from the corresponding author on reasonable request.

Declaration of Non-use of generative AI Tools: This article was prepared without the use of generative AI tools for content creation, analysis, or data generation. All findings and interpretations are based solely on the authors' independent work and expertise.

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