

Effect of Epinephrine on Pharmacokinetics and Spread of Ropivacaine in Erector Spinae Plane Blocks: A Randomized Controlled Trial

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BACKGROUND

- Erector Spinae Plane (ESP) blocks are used for thoracic and abdominal postoperative pain relief, offering comparable efficacy to paravertebral blocks with improved safety profiles^{1,2}.
- ESP block outcomes can be variable, especially regarding local anesthetic (LA) spread and systemic absorption.
- Ropivacaine is commonly used for ESP blocks, and the addition of **epinephrine** may:
 - Delay systemic uptake
 - Prolong analgesia³
- However, epinephrine's effects on **pharmacokinetics** and **anatomical spread** via ESP blocks remain insufficiently studied⁴.

OBJECTIVES

- Primary Objective:** To assess the impact of epinephrine on systemic absorption ($C_{\max}$), pharmacokinetics, and volume of distribution (V_d) of ropivacaine.
- Secondary Objectives:**
 - Evaluate the difference in dermatomal spread and sensory block extent.
 - Assess the anatomical distribution of injectate via MRI over time.

METHODS

- Design:** Randomized, double-blinded, prospective controlled trial.
- Subjects:** 12 healthy volunteers (18-60 yrs), screened and consented.
- Intervention:** Single ESP block with 20 mL of 0.5% ropivacaine **with epinephrine (RE Group)** or **without epinephrine (R Group)** at the T₅ transverse process.
- Blinding:** Subjects, anesthesiologist, radiologist, and research staff were blinded.
- Blood sampling:**
 - Venous samples collected at 0, 20, 40, 60-, 90-, 120-, and 240-min post-injection.
 - Analyzed via **reverse-phase HPLC** for serum ropivacaine concentrations.
- MRI Protocol:**
 - Performed at ~30 and ~90 min post-block.
 - T₁ anatomical + fluid-sensitive sequences from C₄–L₄ evaluated cranial-caudal and medial-lateral spread.
- Sensory Testing:**
 - Cold (isopropanol) and pinprick (toothpick) testing at 20, 60-, 120-, 240-, and 360-min post-injection.
 - Cutaneous sensory blocked area measured with SketchAndCalc software.
- Statistical Analysis:**
 - Mann-Whitney U-test and Chi-square tests for group comparison.
 - Pharmacokinetics modeled using two-phase decay curve fitting in Prism 10.

RESULTS

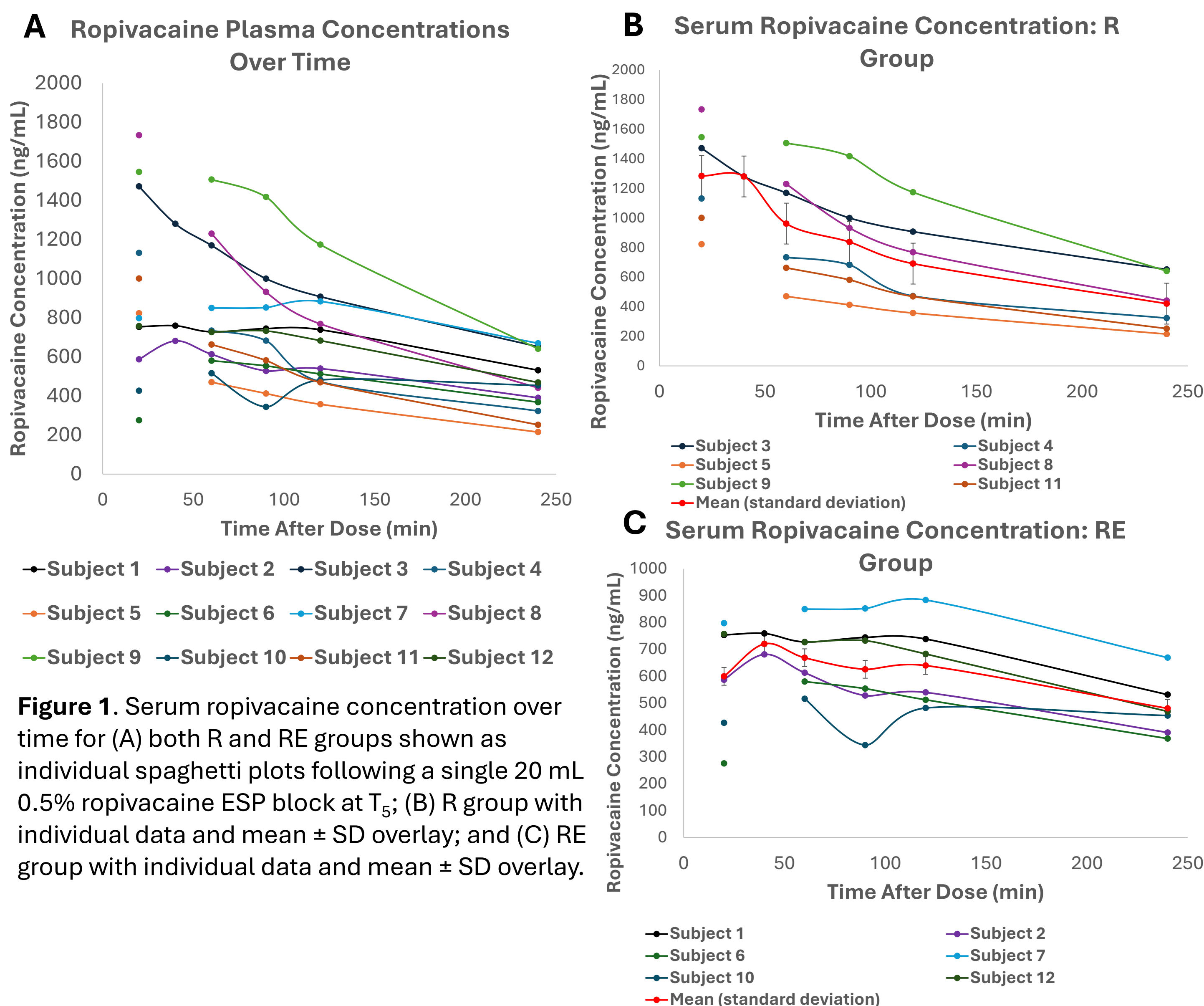


Figure 1. Serum ropivacaine concentration over time for (A) both R and RE groups shown as individual spaghetti plots following a single 20 mL 0.5% ropivacaine ESP block at T₅; (B) R group with individual data and mean $\pm$ SD overlay; and (C) RE group with individual data and mean $\pm$ SD overlay.

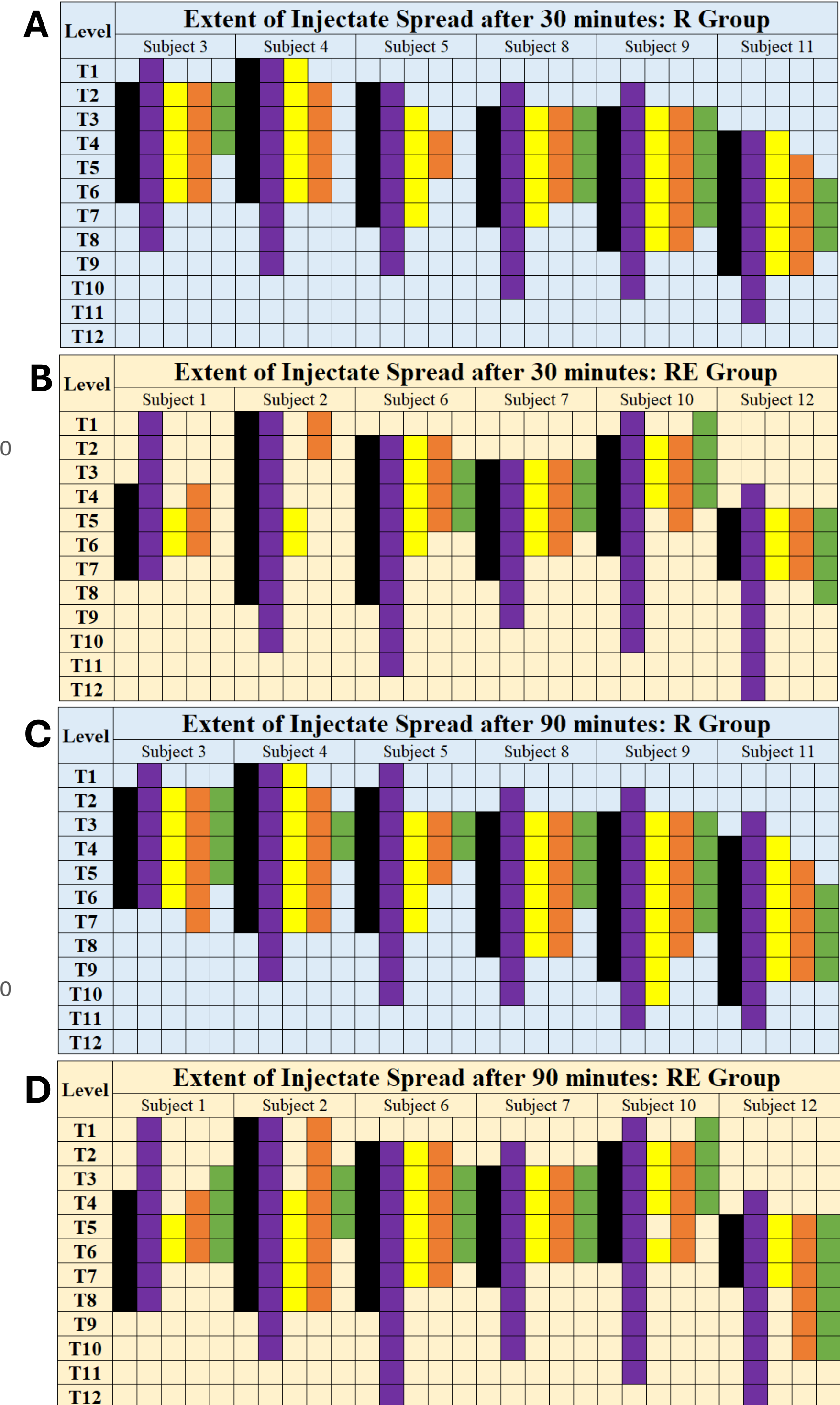
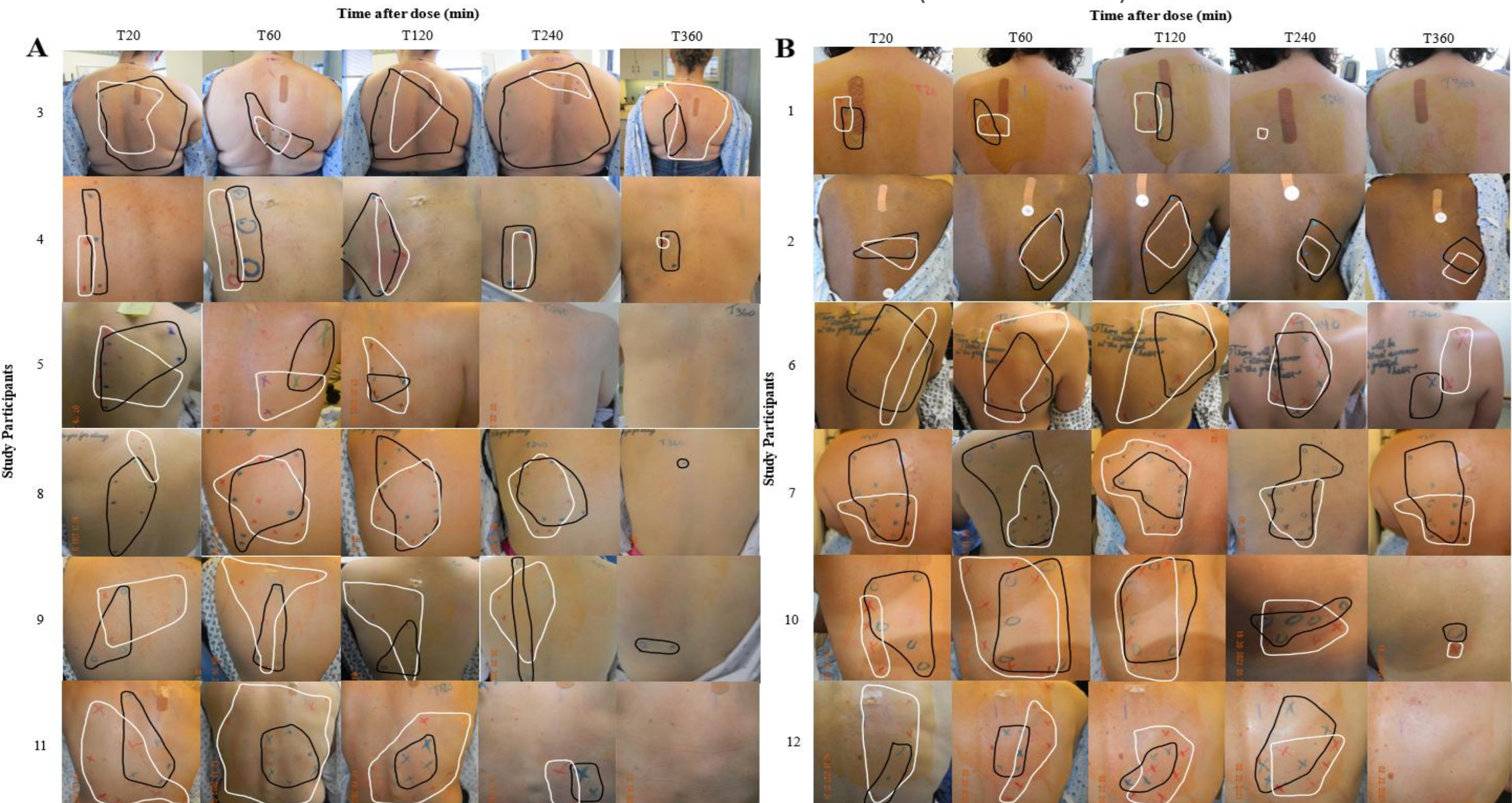


Figure 3. Distribution of visible spread on MRI to the paravertebral space, erector spinae muscle, intercostal muscle, neural foramina, and epidural space from T₁ to T₁₂ following single-injection ESP blocks at the T₅ vertebral level after 30 minutes in R Group (A) and RE Group (B) and 90 minutes in R Group (C) and RE Group (D).

Figure 2. Photographic outline of cutaneous sensory block areas to cold and pinprick. Black outline indicates area of cutaneous sensory loss to cold touch. White outline indicates area of cutaneous sensory loss to pinprick. Image panel of R Group in (A) and RE Group in (B).

DISCUSSION

- Reduced systemic absorption with epinephrine**
 - Ropivacaine with epinephrine resulted in significantly lower peak plasma concentration ($C_{\max}$: 0.67 mg/L [range: 0.28–0.8]) compared to ropivacaine alone ($C_{\max}$: 1.3 mg/L [range: 0.8–1.7]; $p = 0.002$).
 - This supports epinephrine's vasoconstrictive effect in reducing vascular uptake and systemic absorption.
- Increased volume of distribution**
 - The apparent volume of distribution (V_d) was greater in RE Group (148 L) compared to R group (40 L), representing a 270% increase in V_d .
 - This suggests delayed systemic distribution and prolonged local tissue retention of ropivacaine with epinephrine.
- Biphasic pharmacokinetics**
 - Ropivacaine-only group demonstrated two-phase elimination: redistribution half-life ($t_{1/2\alpha}$) of 9 minutes and elimination half-life ($t_{1/2\beta}$) of 315 minutes.
 - Indicates rapid redistribution followed by sustained systemic clearance.
- MRI findings: difference in anatomical spread**
 - R group showed broader injectate spread across the paravertebral space, erector spinae muscle, intercostal muscle, neural foramina, and epidural space.
 - RE group demonstrated more localized spread (typically T₄–T₇), consistent with reduced diffusion due to vasoconstriction.
- Sensory blockade duration and area**
 - Despite reduced anatomical spread, there was no significant difference in the duration or extent of sensory blockade (to cold or pinprick) between the two groups.
- Clinical implications**
 - Adding epinephrine to ropivacaine in ESP blocks may enhance safety by limiting systemic exposure.
 - Maintains adequate dermatomal coverage and sensory block effectiveness while reducing potential toxicity risks.

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