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Intrathecal hydromorphone vs. transversus abdominis plane block for upper abdominal surgery: a propensity score-matching study

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Abstract

Background Multimodal analgesia is vital for enhanced recovery after upper-abdominal surgery. While both Intrathecal hydromorphone (ITH) and transversus abdominis plane (TAP) block are widely applied in upper-abdominal surgery, evidence comparing the two techniques remains limited. This retrospective study employs a propensity score-matching (PSM) design to evaluate the analgesic efficacy of TAP block and ITH in upper-abdominal surgeries.

Methods PSM analysis was performed to minimize differences in baseline characteristics. The primary outcome was defined as the incidence of moderate-to-severe pain during movement within 24 h (hr) postoperatively. The secondary outcomes included the incidence of moderate-to-severe pain at rest or during movement at different times within 72 h postoperatively, numerical rating scale score (NRS) score at rest or during movement within 72 h, complications, morphine equivalent, and indicators of postoperative rehabilitation.

Results Among the 182 patients analyzed after PSM, patients in the ITH group presented a lower incidence of moderate-to-severe pain on movement at 24 h after surgery (TAP vs. ITH, 44.0% vs. 27.5%; $p=0.02$) compared to the TAP group. However, the median NRS of patients in the ITH group at rest at 48 and 72 h after surgery was higher (48 h: TAP vs. ITH, 0 vs. 1; $p=0.01$) (72 h: TAP vs. ITH, 0 vs. 1; $p=0.01$) than that of patients in the TAP group. Pruritus within the first 24 h after surgery occurred more frequently in the ITH group (TAP vs. ITH, 6.6% vs. 29.7%; $p<0.001$). The first flatus occurred earlier in the TAP group (TAP vs. ITH, 57.0 h vs. 68.0 h; $p=0.03$). The first-day morphine equivalent was significantly lower in the ITH group (TAP vs. ITH, 15.0 mg vs. 12.3 mg; $p=0.01$).

Conclusion This study revealed that ITH was better at reducing the incidence of moderate-to-severe pain during movement within the first day after surgery. These findings suggest that ITH could be an effective choice for upper abdominal surgery. Further validation through randomized controlled trials (RCT) is required to establish optimal pain management protocols.

Keywords Intrathecal hydromorphone, Transversus abdominis plane block, Upper abdominal surgery, Postoperative rehabilitation, Acute pain

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Key points Summary

Question: Which is the superior postoperative analgesic for upper abdominal surgery, intrathecal hydromorphone or transversus abdominis plane block?

Findings: Compared with transversus plane block, intrathecal hydromorphone improved postoperative pain relief during movement.

Meaning: Intrathecal hydromorphone could be an effective option for patients underwent upper abdominal surgeries.

Introduction

The incidence of moderate-to-severe pain among the population who underwent upper-abdominal surgery is as high as 37–55% on the first postoperative day [1]. Inadequate management of acute pain not only delays recovery but also elevates the risk of postoperative complications such as chronic pain and gastrointestinal paralysis, while adequate pain management reduces request for opioids [2–4].

Over a long period, thoracic epidural analgesia has been the "gold standard" of postoperative analgesia in upper-abdominal surgery [5]. However, the hypotension and management difficulties of the thoracic epidural analgesia system hinder the widespread adoption of this technique in clinical practice.

The intrathecal opioid injection is a widely used technique for postoperative analgesia in thoracic and abdominal surgeries [6, 7]. This technique involves administering opioids directly into the cerebrospinal fluid within the subarachnoid space, allowing the drug to act on the μ, κ, and δ receptors in the dorsal horn of the spinal cord and even the brainstem through rostral spread [8]. Compared with intravenous opioid administration, intrathecal injection reduces systemic complications and prolonged duration of analgesia with a lower medication dose [9, 10].

TAP block is a commonly used analgesic technique for abdominal surgeries [11, 12]. It involves the administration of a large volume of local anesthetic into the plane between the internal oblique and transversus abdominis muscles, targeting the branches from the anterior rami of the T6–L1 nerves that traverse this plane [13, 14]. This nerve block interrupts the T6–T11 intercostal and T12 subcostal nerves that are supplied for the peritoneum, abdominal wall, and skin [15, 16]. Its high safety profile, few complications, and ease of acquisition for a trained anesthesiologist make it valuable component of multimodal analgesia for abdominal surgery [17].

While numerous studies have compared the efficacy of pain management with intrathecal opioids and TAP block in lower abdominal surgeries, especially cesarean sections, no studies have compared these two techniques in upper abdominal surgeries. Therefore, this retrospective study aimed to compare the analgesic efficacy of intrathecal hydromorphone and that of TAP block in upper abdominal surgeries.

Method

This retrospective study received approval from the Biological and Medical Ethics Committee of West China Hospital of Sichuan University (2023–2382) and was registered in the Chinese Clinical Trial Registry (ChiCTR2400079577, http://www.chictr.org.cn; Principal Investigator: Fei Liu) on October 31, 2023. Human Ethics and Consent to Participate declarations were not applicable, and the requirement for written informed consent was waived by the Ethics Committee of West China Hospital of Sichuan University.

We reviewed the perioperative outcomes of patients who underwent upper abdominal surgeries at West China Hospital between January 2023 and June 2023. Patients aged from 18 to 75 years with an American Society of Anesthesiologists (ASA) classification of II–III undergoing elective upper abdominal surgeries (including hepatic, gastric, pancreatic, and biliary procedures) via either open or laparoscopic approach were included. All of the patients received either ITH or TAP block as postoperative analgesia. We excluded patients with operative durations < 2 h. Participants were categorized based on the postoperative analgesic technique employed (ITH group vs. TAP group).

In the ITH group, the anesthesiologist punctured at either the L2–3 or L3–4 interspace with hydromorphone 100 mcg combined with 0.1% ropivacaine 3 mg (3 ml total volume). In the TAP group, the anesthesiologist performed the TAP block via the right/left subcostal approach and lateral approach with 20 ml of analgesic solution (0.2% ropivacaine + 0.1 mg/ml dexamethasone) at each site. In our hospital, we regularly conduct sensory tests after performing these two techniques. No patient experienced failed block in this study.

Under monitoring, midazolam (2 mg IV), sufentanil (0.3–0.4 μg/kg IV), cisatracurium (0.2 mg/kg IV), and propofol (1–2 mg/kg IV) were administered to perform tracheal intubation. Sevoflurane and remifentanil were

used for maintenance of general anesthesia after tracheal intubation.

All patients were administered patient-controlled intravenous analgesia (PCA; 50 mcg/ml hydromorphone) initiated immediately upon operating room discharge. The PCA pump contained a total dose of 100 ml, with a background infusion rate of 1 ml/h and a 4 ml bolus volume for each additional pump, with a 10-minute lockout interval and a maximum volume of 25 ml per hour.

The primary outcome was the incidence of moderate-to-severe pain during movement at 24 h postoperatively. Pain intensity was systematically assessed using the validated 11-point NRS (range 0–10), with standardized categorical interpretation: 0 (no pain), 1–3 (mild pain), 4–6 (moderate pain), and 7–10 (severe pain) [18].

The secondary outcomes included complications (postoperative nausea and vomiting, PONV, pruritus, and respiratory depression), first day morphine equivalent consumption, postoperative rehabilitation indicators (ambulation, exhaust, and urinary catheter removal), postoperative length of stay, and satisfaction score (a scale from 0 to 5, with 5 indicating full satisfaction). We also compared NRS and incidence of moderate-to-severe pain at rest and during movement at 24, 48, and 72 h postoperatively between the groups.

PSM was performed to minimize differences in baseline characteristics and reduce potential confounding in outcome comparisons. This model was developed via multivariable logistic regression with seven baseline characteristics: age, sex, body mass index, ASA classification, surgery approaches (laparotomy and laparoscopy), and surgery sites (liver, biliary tract, pancreas, and stomach). A 1-to-1 match was performed with a caliper distance of 0.02. Given the significant proportion of liver surgeries, surgery sites were categorized into liver surgery and other sites.

Continuous data were tested for normality using Q-Q plots and Shapiro-Wilk tests. Categorical variables are presented as numbers and percentages and were compared using Fisher's exact test before PSM and McNemar's test after PSM. Continuous variables are presented as medians (P25, P75) and were compared using the Wilcoxon rank sum test before PSM or the Wilcoxon signed-rank test after PSM. All tests utilized a two-sided alpha level of 0.05, with 95% CI reported. For subgroup analyses on the pain assessment and rehabilitation was divided into 2 datasets, 1 containing only open surgeries and 1 containing only laparoscopic surgeries. We performed item mean substitution for missing data. Statistical analyses were conducted using SPSS software (version 27.0, IBM; Chicago, USA).

Result

A total of 527 patients who underwent upper abdominal surgery and received ITH or TAP were identified during the study period. Four hundred and seventy-two patients (103 patients in the ITH group, and 369 patients in the TAP group) who met the inclusion criteria were included in the analysis (Fig. 1). The patients' characteristics, and surgical data are shown in Table 1. After matching, 91 patients were compared in each group, and the baseline characteristics were evenly distributed.

Primary outcome

The incidence of moderate-to-severe pain during movement in patients in the ITH group at 24 h after surgery was significantly lower (ITH vs. TAP, 27.5% vs. 44.0%; $p = 0.02$), corresponding to a relative risk (RR) of 0.48 (95% CI 0.26 to 0.90).

Secondary outcomes

Pain assessment

The incidence of moderate-to-severe pain at rest (24 h: ITH vs. TAP, 5.5% vs. 7.7%; $p = 0.77$) (48 h: ITH vs. TAP, 2.2% vs. 0%; $p = 0.16$) (72 h: ITH vs. TAP, 1.1% vs. 0%; $p = 0.32$) and during movement (48 h: ITH vs. TAP, 35.2% vs. 38.5%; $p = 0.78$) (72 h: ITH vs. TAP, 24.2% vs. 15.4%; $p = 0.15$) at the remaining time points had no significant difference. A summary of the pain assessment is shown in Table 2.

Compared with the ITH group, the TAP group had a lower postoperative NRS at rest at 48 (ITH vs. TAP, 1.0 [0.0, 1.0] vs. 0 [0.0, 1.0]; $p = 0.01$; Cliff's delta 0.23, 95% CI 0.06 to 0.38), and a same difference of NRS was found at rest at 72 (ITH vs. TAP, 1.0 [0.0, 1.0] vs. 0 [0.0, 1.0]; $p = 0.01$; Cliff's delta 0.24, 95% CI 0.10 to 0.37) hr. However, there was no significant difference between the two groups in terms of the postoperative NRS among the remaining time points at rest (24 h: ITH vs. TAP, 1.0 [0, 2.0] vs. 1.0 [0, 2.0]; $p = 0.45$) or during movement (24 h: ITH vs. TAP, 3.0 [3.0, 4.0] vs. 3.0 [3.0, 4.0]; $p = 0.12$) (48 h: ITH vs. TAP, 3.0 [3.0, 4.0] vs. 3.0 [2.0, 4.0]; $p = 0.74$) (72 h: ITH vs. TAP, 3.0 [2.0, 3.0] vs. 3.0 [2.0, 3.0]; $p = 0.44$).

Complications

The incidence of pruritus in the ITH group was significantly higher than that in the TAP group (ITH vs. TAP, 29.7% vs. 6.6%; $p < 0.001$; RR 5.98, 95% CI 2.33 to 15.33). The incidence of PONV (ITH vs. TAP, 13.2% vs. 22.0%; $p = 0.20$) and respiratory depression (ITH vs. TAP, 1.1% vs. 0%; $p = 0.32$) in the first postoperative 24 h has no significant difference between two groups. A summary of the results of the complications assessment is shown in Table 3.

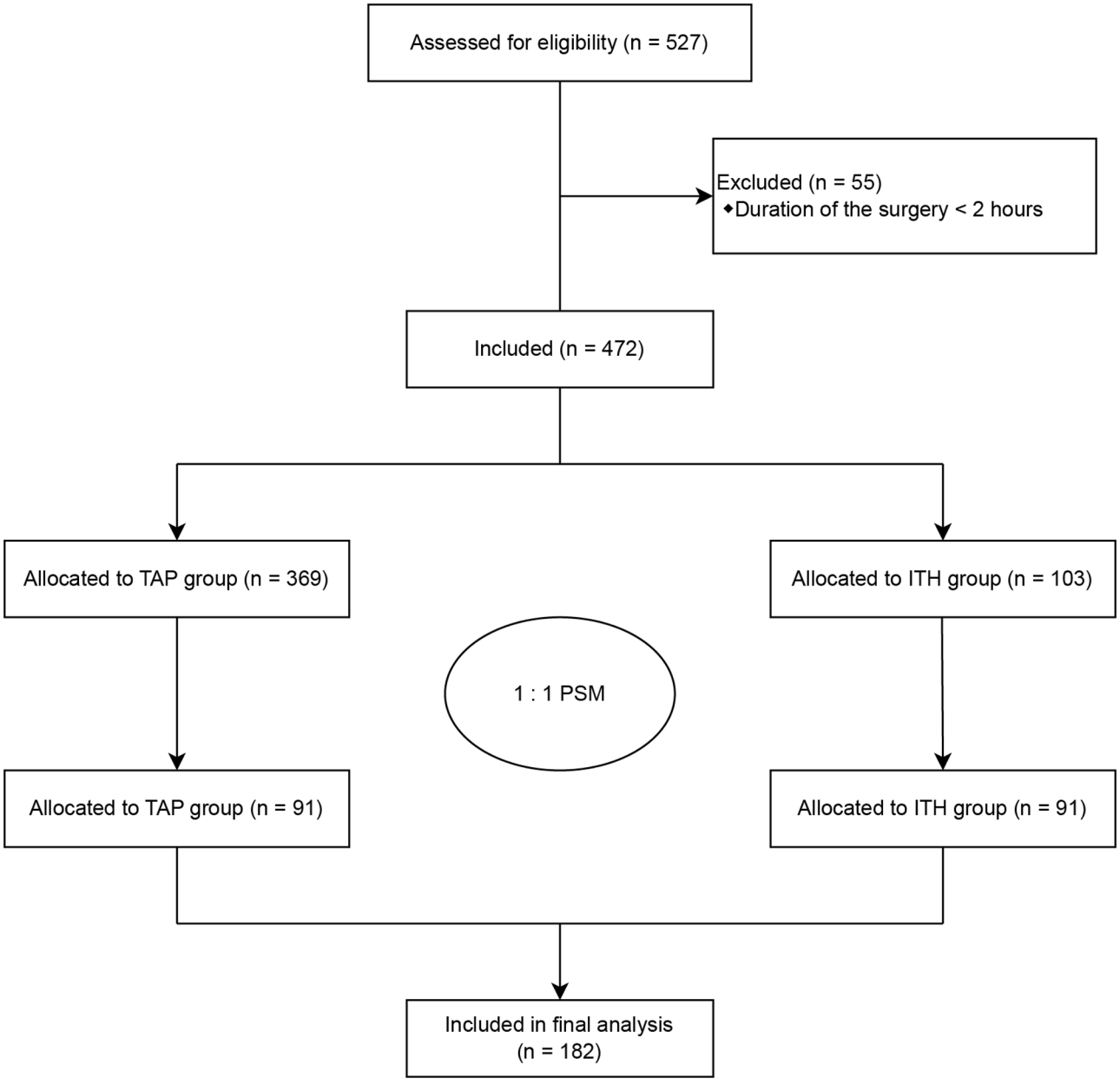

Fig. 1 Patient flow of propensity score-matching cohorts. PSM = propensity score-matching

Rehabilitation assessment

The patients in the TAP group had their first flatus significantly earlier than the patients in the ITH group did (ITH vs. TAP, 68 h [48, 72] vs. 57 h [41, 78]; $p = 0.03$; Cliff's delta 0.17, 95% CI -0.01 to 0.34). There was no significant difference in urinary catheter removal time (ITH vs. TAP, 39 h [22, 46] vs. 37 h [19, 43]; $p = 0.25$) or first time of ambulation (ITH vs. TAP, 29 h [24, 45] vs. 33 h [21, 44]; $p = 0.84$).

A comparison of the first postoperative day morphine equivalent consumption between the two groups revealed that the consumption in the ITH group was significantly lower than that in the TAP group (ITH vs. TAP, 12.3 mg [7.6, 17.0] vs. 15 mg [9.7, 22.7]; $p = 0.01$; Cliff's delta – 0.21, 95% CI -0.38 to -0.06).

Patients in the TAP group had significantly lower satisfaction scores than patients in the ITH group (ITH vs. TAP, 4.0 [3.8, 4.0] vs. 3.0 [3.0, 4.0]; $p = 0.02$; Cliff's delta 0.18, 95% CI 0 to 0.36). There was no statistical difference in the postoperative length of stay (ITH vs. TAP, 5.9 h [4.9, 6.9] vs. 5.8 h [3.8, 6.7]; $p = 0.34$). A summary of the results of the rehabilitation assessment is shown in Table 4.

Table 1 Patients' baseline characteristics

	Before PSM			After PSM		
	TAP, *N* = 369	ITH, *N* = 103	*p*-value[1]	TAP, *N* = 91	ITH, *N* = 91	*p*-value[1]
Sex, n (%)			0.05			0.65
Male	246 (67%)	58 (56%)		55 (60%)	58 (64%)	
Female	123 (33%)	45 (44%)		36 (40%)	33 (36%)	
Age (years), Mean (SD)	54.13 (12.00)	49.26 (9.62)	< 0.001	51.57 (12.19)	50.20 (9.08)	0.13
BMI (kg/m2), Mean (SD)	22.60 (3.25)	23.06 (2.82)	0.19	23.36 (3.18)	23.09 (2.67)	0.53
ASA, n (%)			0.002			0.32
II	295 (80%)	96 (93%)		80 (88%)	84 (92%)	
III	74 (20%)	7 (6.8%)		11 (12%)	7 (7.7%)	
Surgical approach, n (%)			0.003			0.37
Open	261 (71%)	57 (55%)		50 (55%)	56 (62%)	
Laparoscopy	108 (29%)	46 (45%)		41 (45%)	35 (38%)	
Surgical site, n (%)			< 0.001			0.69
Liver	184 (50%)	89 (86%)		75 (82%)	77 (85%)	
Others[2]	185 (50%)	14 (14%)		16 (18%)	14 (15%)	
Length of surgery(min), Mean (SD)	223.14 (76.84)	226.58 (67.53)	0.32	226.38 (79.77)	224.21 (64.35)	0.82

Abbreviation: PSM = propensity score match, TAP = transversus abdominis plane block, ITH = intrathecal hydromorphone, SD = standard deviation

[1]Pearson's Chi-squared test; Wilcoxon rank sum test

[2]Biliary; Cholecyst; Pancreas; Stomach

Table 2 Pain assessment

	Before PSM			After PSM				
	ITH, *N* = 103	TAP, *N* = 369	*p*-value[1]	ITH, *N* = 91	TAP, *N* = 91	Effect size	95% CI	*p*-value[2]
Moderate-to-severe pain (rest), n (%)								
24 h	5 (4.9%)	22 (6.0%)	0.81	5 (5.5%)	7 (7.7%)	RR 0.70	0.21, 2.29	0.77
48 h	2 (1.9%)	2 (0.5%)	0.21	2 (2.2%)	0	/	/	0.16
72 h	1 (1%)	1 (0.3%)	0.39	1 (1.1%)	0	/	/	0.32
Moderate-to-severe pain (movement), n (%)								
24 h	29 (28.2%)	156 (42.3%)	0.01	25(27.5%)	40 (44.0%)	RR 0.48	0.26, 0.90	0.02
48 h	37 (35.9%)	130 (35.2%)	0.48	32(35.2%)	35 (38.5%)	RR 0.87	0.48, 1.59	0.78
72 h	26 (25.2%)	69 (18.7%)	0.16	22(24.2%)	14 (15.4%)	RR 1.75	0.83, 3.69	0.15
Median NRS at rest, Md (P25, P75)								
24 h	1.0 (0.0, 2.0)	1.0 (0.0, 2.0)	0.24	1.0 (0.0, 2.0)	1.0 (0.0, 2.0)	Cliff's delta −0.04	-0.19, 0.13	0.45
48 h	1.0 (0.0, 1.0)	0.0 (0.0, 1.0)	< 0.001	1.0 (0.0, 1.0)	0.0 (0.0, 1.0)	Cliff's delta 0.23	0.06, 0.38	0.01
72 h	1.0 (0.0, 1.0)	0.0 (0.0, 0.0)	< 0.001	1.0 (0.0, 1.0)	0.0 (0.0, 1.0)	Cliff's delta 0.24	0.10, 0.37	0.01
Median NRS during movement, Md (P25, P75)								
24 h	3.0 (3.0, 4.0)	3.0 (3.0, 4.0)	0.01	3.0 (3.0, 4.0)	3.0 (3.0, 4.0)	Cliff's delta −0.18	-0.34, -0.03	0.12
48 h	3.0 (2.0, 4.0)	3.0 (2.0, 4.0)	0.84	3.0 (2.0, 4.0)	3.0 (2.0, 4.0)	Cliff's delta −0.01	-0.18, 0.15	0.74
72 h	3.0 (2.0, 4.0)	3.0 (2.0, 3.0)	0.36	3.0 (2.0, 3.0)	3.0 (2.0, 3.0)	Cliff's delta 0.09	-0.08, 0.26	0.44

Abbreviation: PSM = propensity score match, n = number(s), Md = Median

[1]Fisher's exact test; Wilcoxon rank sum test; [2]McNemar's test; Wilcoxon signed-rank test

Subgroup analysis (Tables 5 and 6)

In subgroup analysis, patients underwent open surgery in the ITH group showed significantly lower incidence of moderate-to-severe pain during movement at 24 (ITH vs. TAP, 25.0% vs. 56.0%; $p < 0.001$) and 48 (ITH vs. TAP, 33.9% vs. 54.0%; $p = 0.05$) hr after surgery. However, there was no statistical difference in the incidence of moderate-to-severe pain in laparoscopic subgroup.

Table 3 Complications in first 24 h

	Before PSM			After PSM				
	ITH, *N* = 103	TAP, *N* = 369	*p*-value[1]	ITH, *N* = 91	TAP, *N* = 91	Effect size	95% CI	*p*-value[2]
Complications, n (%)								
Postoperative nausea and vomiting	13 (12.6%)	62 (16.8%)	0.36	12(13.2%)	20(22.0%)	RR 0.54	0.25, 1.18	0.20
Pruritus	31 (30.1%)	23 (6.2%)	< 0.001	27(29.7%)	6(6.6%)	RR 5.98	2.33, 15.33	< 0.001
Respiratory depression	1 (1.0%)	3 (0.8%)	> 0.999	1(1.1%)	0	/	/	0.32

Abbreviation: PSM = propensity score match, n = number(s), Md = Median

[1]Fisher's exact test; Wilcoxon rank sum test; [2]McNemar's test; Wilcoxon signed-rank test

Table 4 Rehabilitation assessment

	Before PSM			After PSM				
	ITH, *N* = 103	TAP, *N* = 369	*p*-value[1]	ITH, *N* = 91	TAP, *N* = 91	Effect size	95% CI	*p*-value[2]
First day morphine equivalent consumption (mg), Md (P25, P75)	12.3 (7.7, 17.5)	16.0 (10.0, 32.3)	< 0.001	12.3 (7.6, 17.0)	15.0 (9.7, 22.7)	Cliff's delta −0.21	-0.38, -0.06	0.01
Rehabilitation time (hours)								
First time of ambulation, Md (P25, P75)	29.0 (24.0, 45.0)	40.0 (24.0, 49.8)	0.06	29 (24, 45)	33 (21, 44)	Cliff's delta 0.06	-0.12, 0.22	0.84
First time of flatus, Md (P25, P75)	68.0 (48.0, 72.0)	66.0 (48.0, 84.8)	0.56	68 (48, 72)	57 (41, 78)	Cliff's delta 0.17	-0.01, 0.34	0.03
Urinary catheter removal time, Md (P25, P75)	39.0 (22.0, 45.0)	41.0 (20.0, 63.0)	0.39	39 (22, 46)	37 (19, 43)	Cliff's delta 0.19	0.03, 0.35	0.25
Satisfaction score, Md (P25, P75)	4.0 (3.8, 4.0)	3.0 (3.0, 4.0)	< 0.001	4.0 (3.8, 4.0)	3.0 (3.0, 4.0)	Cliff's delta 0.18	0, 0.36	0.02
Postoperative length of stay (d), Md (P25, P75)	5.9 (4.8, 6.8)	5.9 (4.8, 7.8)	0.45	5.9 (4.9, 6.9)	5.8 (3.8, 6.7)	Cliff's delta 0.24	0.06, 0.41	0.34

Abbreviation: PSM = propensity score match, n = number(s), Md = Median

[1]Fisher's exact test; Wilcoxon rank sum test; [2]McNemar's test; Wilcoxon signed-rank test

Patients underwent open surgery in the ITH group showed significantly lower postoperative NRS at 24 h at rest (ITH vs. TAP, 1.0 [0, 1.0] vs. 1.0 [1.0, 3.0]; $p = 0.02$; Cliff's delta −0.22, 95% CI -0.40 to -0.03) and during movement (ITH vs. TAP, 3.0 [2.0, 3.75] vs. 4.0 [3.0, 5.0]; $p < 0.001$; Cliff's delta −0.32, 95% CI -0.49 to -0.13). On the contrary, patients underwent laparoscopic surgery in the ITH group showed significantly higher postoperative NRS at 24 (ITH vs. TAP, 1.0 [0, 2.0] vs. 1.0 [0, 1.5]; $p = 0.05$; Cliff's delta 0.22, 95% CI 0.02 to 0.43), 48 (ITH vs. TAP, 1.0 [0, 1.0] vs. 0 [0, 0]; $p = 0.004$; Cliff's delta 0.28, 95% CI 0.09 to 0.46), and 72 (ITH vs. TAP, 0 [0, 1.0] vs. 0 [0, 0]; $p = 0.001$; Cliff's delta 0.21, 95% CI -0.01 to 0.40) hr at rest and 72 (ITH vs. TAP, 3.0 [2.0, 3.0]vs. 2.0 [1.0, 3.0]; $p = 0.04$; Cliff's delta 0.23, 95% CI 0.03 to 0.44) hr during movement.

Patients underwent open surgery in the ITH group gave a significantly higher satisfaction score (ITH vs. TAP, 4.0 [3.0, 4.0] vs. 3.0 [3.0, 4.0]; $p = 0.001$; Cliff's delta 0.20, 95% CI 0.08 to 0.31). However, patients underwent laparoscopic surgery in the TAP group have their first flatus passage at an earlier time (ITH vs. TAP, 61.0 h [46.0, 72.0] vs. 46.0 h [24.0, 64.0]; $p = 0.01$; Cliff's delta 0.30, 95% CI 0.07 to 0.52) compared with the patients in the ITH group. At the same time, patients underwent laparoscopic surgery in the TAP group removed their urinary catheter at an earlier time (ITH vs. TAP, 28.0 h [21.0, 62.0] vs. 22.0 h [19.0, 42.0]; $p = 0.05$; Cliff's delta 0.22, 95% CI -0.01 to 0.45) compared with the patients in the ITH group. There was no statistical difference in the first postoperative day morphine equivalent consumption, first time of ambulation, and postoperative length of stay between both subgroups.

Discussion

The findings of this study reveal that ITH is superior to TAP block in preventing moderate-to-severe pain during movement on the first postoperative day after upper abdominal surgery. Furthermore, patients receiving ITH required significantly less opioid medication and reported higher comfort levels compared to those receiving TAP block on the first postoperative day. However, the ITH group had a higher incidence of pruritus and experienced delayed first flatus than the TAP group. This study is the first comparative evaluation of the analgesic efficacy between ITH and TAP block for postoperative pain management in upper abdominal surgeries.

In our study, ITH significantly reduced the incidence of moderate-to-severe pain during movement at 24 h postoperatively. Although both the ITH and TAP block groups exhibited no significant difference in the incidence of moderate-to-severe at rest and during

Table 5 Subgroup analyses of open surgery (after PSM)

	ITH, *N* = 56	TAP, *N* = 50	Effect size	95% CI	*p*-value[1]
Moderate-to-severe pain (rest), n (%)					
24 h	4 (7.1)	6 (12.0)	RR 0.56	0.15, 2.13	0.51
48 h	1 (1.8)	0	/	/	> 0.999
72 h	1 (1.8)	0	/	/	> 0.999
Moderate-to-severe pain (movement), n (%)					
24 h	14 (25.0)	28 (56.0)	RR 0.26	0.12, 0.60	< 0.001
48 h	19 (33.9)	27 (54.0)	RR 0.44	0.20, 0.96	0.05
72 h	14 (25.0)	11 (22.0)	RR 1.18	0.48, 2.91	0.82
Median NRS at rest, Md (P25, P75)					
24 h	1.0 (0, 1.0)	1.0 (1.0, 3.0)	Cliff's delta − 0.22	-0.40, -0.03	0.02
48 h	1.0 (0, 2.0)	1.0 (0, 1.0)	Cliff's delta 0.14	-0.05, 0.33	0.14
72 h	0 (1.0, 1.0)	0 (0, 1.0)	Cliff's delta 0.14	-0.03, 0.30	0.13
Median NRS during movement, Md (P25, P75)					
24 h	3.0 (2.0, 3.75)	4.0 (3.0, 5.0)	Cliff's delta − 0.32	-0.49, -0.13	< 0.001
48 h	3.0 (2.0, 4.0)	4.0 (3.0, 4.0)	Cliff's delta − 0.17	-0.35, 0.03	0.08
72 h	3.0 (2.0, 3.0)	3.0 (2.0, 3.75)	Cliff's delta − 0.04	-0.23, 0.15	0.66
First day morphine equivalent consumption (mg), Md (P25, P75)	21.0 (15.0, 35.0)	30.5 (20.0, 43.0)	Cliff's delta − 0.08	-0.27, 0.13	0.16
Rehabilitation time (hours)					
First time of ambulation, Md (P25, P75)	41.0 (24.0, 46.0)	37.5 (23.8, 47.5)	Cliff's delta 0.04	-0.15, 0.24	0.68
First time of flatus, Mean (Std)	67.9 (20.4)	67.2 (28.9)	Cohen's d 0.03	-0.41, 0.36	0.89
Urinary catheter removal time, Md (P25, P75)	41.0 (22.0, 46.0)	39.5 (20.0, 45.0)	Cliff's delta 0.11	-0.11, 0.31	0.28
Satisfaction score, Md (P25, P75)	4.0 (3.0, 4.0)	3.0 (3.0, 4.0)	Cliff's delta 0.20	0.08, 0.31	0.001
Postoperative length of stay (d), Md (P25, P75)	6.8 (5.0, 8.9)	5.9 (4.8, 7.7)	Cliff's delta 0.08	-0.03, 0.21	0.22

Abbreviation: PSM = propensity score match, n = number(s), Md = Median, Std = Standard deviation

[1]Fisher's exact test; Wilcoxon rank sum test; Student's t test

Table 6 Subgroup analyses of laparoscopic surgery (after PSM)

	ITH, *N* = 35	TAP, *N* = 41	Effect size	95% CI	*p*-value[1]
Moderate-to-severe pain (rest), n (%)					
24 h	1 (2.9)	1 (2.4)	RR 1.18	0.07, 19.53	> 0.999
48 h	1 (2.9)	0	/	/	0.46
72 h	0	0	/	/	/
Moderate-to-severe pain (movement), n (%)					
24 h	11 (31.4)	12 (29.3)	RR 1.11	0.42, 2.95	> 0.999
48 h	13 (37.1)	8 (19.5)	RR 2.44	0.87, 6.85	0.12
72 h	8 (22.9)	3 (7.3)	RR 3.75	0.91, 15.46	0.10
Median NRS at rest, Md (P25, P75)					
24 h	1.0 (0, 2.0)	1.0 (0, 1.5)	Cliff's delta 0.22	0.02, 0.43	0.05
48 h	1.0 (0, 1.0)	0 (0, 0)	Cliff's delta 0.28	0.09, 0.46	0.004
72 h	0 (0, 1.0)	0 (0, 0)	Cliff's delta 0.21	-0.01, 0.40	0.001
Median NRS during movement, Md (P25, P75)					
24 h	3.0 (3.0, 4.0)	3.0 (3.0, 4.0)	Cliff's delta 0.07	-0.12, 0.26	0.49
48 h	3.0 (2.0, 4.0)	3.0 (2.0, 3.0)	Cliff's delta 0.21	0, 0.40	0.06
72 h	3.0 (2.0, 3.0)	2.0 (1.0, 3.0)	Cliff's delta 0.23	0.03, 0.44	0.04
First day morphine equivalent consumption (mg), Md (P25, P75)	20.0 (10.0, 33.0)	24.0 (11.0, 35.0)	Cliff's delta − 0.01	-0.13, 0.12	0.90
Rehabilitation time (hours)					
First time of ambulation, Md (P25, P75)	28.0 (22.0, 46.0)	27.0, (20.0, 42.0)	Cliff's delta 0	-0.06, 0.07	0.93
First time of flatus, Md (P25, P75)	61.0(46.0, 72.0)	46.0 (24.0, 64.0)	Cliff's delta 0.30	0.07, 0.52	0.01
Urinary catheter removal time, Md (P25, P75)	28.0 (21.0, 62.0)	22.0 (19.0, 42.0)	Cliff's delta 0.22	-0.01, 0.45	0.05
Satisfaction score, Md (P25, P75)	4.0 (4.0, 4.0)	4.0 (3.0, 4.0)	Cliff's delta 0.06	-0.04, 0.16	0.29
Postoperative length of stay (d), Md (P25, P75)	4.9 (4.0, 5.9)	4.7 (3.7, 6.2)	Cliff's delta 0.06	-0.05, 0.17	0.39

Abbreviation: PSM = propensity score match, n = number(s), Md = Median

[1]Fisher's exact test; Wilcoxon rank sum test

movement at the rest time points postoperatively. In a recent meta-analysis, Yang et al. included six RCTs and compared the analgesic effects of intrathecal morphine (ITM) and TAP block in patients undergoing cesarean Sect. [19]. This meta-analysis revealed no significant differences in postoperative pain scores between these two techniques, which appears inconsistent with our findings. We hypothesize that this discrepancy may be attributed to variations in surgical sites. A review reported that upper abdominal surgeries, which are more complex and extensive, often result in more severe pain and a higher incidence of moderate-to-severe postoperative pain [20]. Consequently, ITH may exhibit superior analgesic efficacy in upper abdominal surgeries, which typically involve more severe postoperative pain. Water-soluble opioids provide analgesia for 6–16 h [10], while 0.2% ropivacaine in TAP blocks lasts 3–8 h [21]. In our study, the analgesic for the TAP group was consistently supplemented with dexamethasone, and extensive studies have suggested that dexamethasone can prolong the analgesic duration of TAP by 2 to 8 h [22, 23]. This suggests that during the effective duration of the two analgesic techniques, ITH provides better movement pain relief. Since the effective duration for both techniques is similar, there is no significant difference in the incidence of moderate-to-severe pain at 48 and 72 h. As the analgesic effectiveness running out, the incidence of moderate-to-severe pain during movement in the ITH group at 48 h is even higher than that at 24 h. Further RCTs are needed to explore how the benefits of ITH can be integrated into multimodal analgesia for upper abdominal surgeries, which may be an important direction for future research.

In our retrospective study, patients in the ITH group required fewer opioids on the first postoperative day. This reduction may be due to the lower incidence of moderate-to-severe pain in the ITH group at 24 h postoperatively, suggesting superior early analgesic efficacy. However, the differences in the medians of the two groups (2.7 mg of morphine equivalent consumption, which was less than 10 mg morphine equivalent consumption that is considered the minimal clinically significant difference in opioids use [24]) showed limited clinical significance.

The incidence of postoperative pruritus was significantly lower in the TAP group than in the ITH group. However, the records revealed that the pruritus experienced by the patients was predominantly mild and did not require medical intervention. An RCT conducted by Sharpe et al. reported that the incidence of pruritus in the first 24 h after ITH was 62%, though their protocol did not include routine postoperative antipruritic prophylaxis [25]. In contrast, we used a 5-HT3 antagonist in all patients who received opioids perioperatively and dexamethasone in patients at high risk. The incidence of pruritus was lower in our study (Sharpe vs. us, 62% vs. 29.7%), and we used a higher dosage of hydromorphone (Sharpe vs. us, 75 mcg vs. 100 mcg). Pruritus can prompt patients to scratch the surgical area, leading to potential infections and prolonged healing times. These factors may lead to resistance to postoperative pain management, which can subsequently heighten their perception of pain [26, 27]. We recommend the regular use of antipruritic treatment in patients who receive ITH.

The time to first flatus was earlier in the TAP group than in the ITH group. Enhanced recovery after surgery (ERAS) strategies have been shown to enhance postoperative gastrointestinal recovery, and in gastrointestinal surgeries, they can advance the time to first flatus by approximately 1–2 days [28]. Adequate pain relief is an important part of ERAS. The analgesic effect of TAP can enhance gastrointestinal function recovery [29]. Opioids provide stronger pain relief, but this kind of medicine can also result in delayed intestinal motility, which may ultimately delay the recovery of gastrointestinal function [30, 31]. These findings were in accordance with the results of an RCT conducted by Jarraya et al. [32]. What's more, the analysis of the time to first flatus showed inconsistent results before and after PSM, with the matched results demonstrating the superiority of TAP compared to ITH. The differences in statistical results before and after PSM highlight its statistical advantages (such as reducing confounding bias). This method can, to some extent, simulate an RCT, but also underscores the necessity of conducting future RCTs to find the potential differences.

In the ITH group, one patient experienced respiratory depression in the post-anesthesia care unit (PACU). Previous studies comparing intrathecal morphine with TAP block reported intrathecal morphine dosages between 0.075 mg and 0.2 mg without any occurrence of respiratory depression [25, 31, 33, 34–36]. In our center, the dosage of hydromorphone in the ITH analgesic is consistent with or below these levels, and hydromorphone is known to have a lower incidence of adverse reactions, such as respiratory depression, than morphine [37, 38]. Thus, anesthesiologists can be confident in intrathecal hydromorphone without excessive concern about respiratory depression occurring in the ward.

The statistically difference in satisfaction scores was not clinically meaningful, as evidenced by the substantial overlap in interquartile ranges between groups. This indicates that ITH and TAP block provided comparable levels of patient satisfaction with postoperative analgesia.

A subgroup analysis (open surgery vs. laparoscopic surgery) was performed. We found that in the open surgery subgroup, the patients received ITH had a lower incidence of moderate-to-severe pain during movement and higher satisfaction scores. However, TAP block also showed its own advantages. In the laparoscopic

subgroup, patients who received TAP block showed a shorter recovery time, including earlier time to first flatus and urinary catheter removal. Although patients in the TAP group had lower NRS scores at several time points in the laparoscopic subgroup, these differences did not reach the MCID, and the effect size (Cliff's delta) was low. In conclusion, we propose to select a postoperative analgesia based on surgical approach: ITH may be preferred for open surgeries due to its superior analgesic efficacy, while TAP blocks appear better suited for laparoscopic surgeries given their association with enhanced recovery outcomes.

Limitations

This retrospective study has several limitations. First, we conducted propensity score matching to correct baseline characteristics, which could be a strength of the present study. However, the inability of PSM in dealing with unknown confounders and existence of observer bias must be acknowledged. Secondly, though primary outcomes in the ITH group seem to be superior to the TAP group, it is important to consider opioid use intraoperatively, and surgeon variability, which were not accounted for in this study. We didn't perform sensitivity analyses to assess these factors. Therefore, results are susceptible to heterogenous results and should be interpreted with caution. Thirdly, intraoperative opioid use can reflect the analgesic efficacy of TAP block or ITM; however, these factors were not accounted for in this study. Fourthly, there is a lack of studies comparing TAP block and ITH in upper abdominal surgeries in the past, and all the previous studies we referenced in this study were TAP block vs. intrathecal morphine. In a recent RCT, Sharpe et al. reported that intrathecal hydromorphone and intrathecal morphine had similar analgesic efficacy [25]. Fifthly, owing to the retrospective design of this study, we could not collect detailed pain scores for each interval within the first day after surgery. The analgesic effects of ITH and TAP block generally persist for only approximately 12 h. Consequently, future studies should be designed prospectively to analyze pain scores at detailed time intervals. Sixthly, a power analysis based on the sample size was performed, which offered a power size of 0.46. This is relatively low, likely due to the small sample size, which limits the external validity of the results. Larger cohort studies or RCTs are needed for further validation.

Conclusion

Within the context of these limitations, in this PSM analysis of patients who underwent upper abdominal surgeries, ITH performed better in terms of postoperative pain management during movement and had superior clinical outcomes in rehabilitation compared with TAP block. However, the TAP group presented a lower incidence of pruritus and an earlier time to the first flatus. ITH may represent a superior analgesic technique for upper abdominal surgeries. Future well-designed RCTs are needed to validate these results and should specifically compare TAP, ITH, and potentially their combination, to determine the most effective analgesic technique for this surgical population.

Supplementary Information

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Supplementary Material 1

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Author contributions

Y.H. was responsible for the original draft writing and analysis. Y.C. was responsible for manuscript editing and analysis. W.W. was responsible for the original draft writing. T.L. was responsible for manuscript editing and supervision. L.D. was responsible for data curation and analysis. F.G. was responsible for data curation. X.Z. was responsible for manuscript editing and linguistic revision. F.L. was responsible for review, conceptualization, and methodology. All the authors have read and approved the final version of the manuscript.

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Data availability

This research was conducted on human data and adhered to the Helsinki Declaration. Researchers can email the corresponding author to request the data (e-mail: 30333870@qq.com).

Declarations

Ethics approval and consent to participate

Consent for publication is not applicable. Our study has been submitted to, and approved by the Biological and Medical Ethics Committee of West China Hospital of Sichuan University. The need for consent to participate was waived by the Biological and Medical Ethics Committee of West China Hospital of Sichuan University.

Competing interests

The authors declare no competing interests.

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