Transversus Abdominis Plane Block

A Systematic Review

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Abstract: Ultrasound guidance has led a surge of interest in transversus abdominis plane (TAP) block for postoperative analgesia following abdominal surgery. Despite or because of the numerous descriptive applications and techniques that have recently populated the literature, results of comparative studies for TAP block have been inconsistent. This systematic review pragmatically addresses many unanswered questions, specifically the following: what are the effects of surgical procedure, block dose, block technique, and block timing on TAP block analgesia?

Eighteen intermediate- to good-quality randomized trials that included diverse surgical procedures were identified. Improved analgesia was noted in patients undergoing laparotomy for colorectal surgery, laparoscopic cholecystectomy, and open and laparoscopic appendectomy. There was a trend toward superior analgesic outcomes when 15 mL of local anesthetic or more was used per side compared with lesser volumes. All 5 trials investigating TAP block performed in the triangle of Petit and 7 of 12 trials performed along the midaxillary line demonstrated some analgesic advantages. Eight of 9 trials using preincisional TAP block and 4 of 9 with postincisional block revealed better analgesic outcomes. Although the majority of trials reviewed suggest superior early pain control, we were unable to definitively identify the surgical procedures, dosing, techniques, and timing that provide optimal analgesia following TAP block. This review suggests that our understanding of the TAP block and its role in contemporary practice remains limited.

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With the advent of ultrasound (US) guidance, the transversus abdominis plane (TAP) block has enjoyed a surge in popularity. First described by Rafi[1] in 2001 as an anatomic landmark–guided field block for abdominal surgeries, the TAP block reportedly provided analgesia by blocking the 7th to 11th intercostal nerves (T7-T11), the subcostal nerve (T12), and the ilioinguinal nerve (IIN) and iliohypogastric nerve (IHN) (L1-L2). Despite the promising findings of cadaveric[2–5] and observational human studies,[2,6,7] the results of comparative trials examining TAP block for abdominal surgery have been inconsistent. Whereas TAP block failed to add any analgesic benefit in some trials,[8–11] pain control was clearly superior in others.[12–16] Such discrepancies may be due to the myriad of reported TAP block techniques and applications. It is therefore not surprising that the conclusions of recently published review articles and meta-analyses[17–19] examining the analgesic efficacy of TAP blocks varied widely, from cautious and questionable[19] to enthusiastic and decisive.[17] Limited by the modest number of source studies, recurring authors, and small number of subjects, these reviews did not distinguish between laparoscopy and laparotomy,[17–19] nor did they examine the effect of block technique, dose, or timing on analgesia. One review excluded cesarean deliveries outright.[19] Since these reviews[17–19] first appeared in the literature, 11 new trials, including 872 patients in total, have been published. Yet, anesthesia providers—ourselves included—remain uncertain of the role for TAP block in modern anesthetic practice.

We hypothesize that TAP block is not equally effective for all types of abdominal surgery and that its analgesic efficacy is dependent on the surgical procedure, block technique, local anesthetic dose and volume, and timing of injection. Therefore, the purpose of this review was to determine how the analgesic effect of the TAP block may be influenced by each of these 4 factors.

METHODS

The authors searched for the terms "transversus abdominis plane," "transverse abdominis plane," and "TAP block" in the following electronic databases: US National Library of Medicine database (MEDLINE), Excerpta Medica database (EMBASE), the Cochrane Central Register of Controlled Clinical Studies, and the database of the Cumulative Index to Nursing and Allied Health Literature (CINAHL). The search was conducted through the National Library of Health Web site, the Cochrane library, PUBMED (free citation database of MEDLINE), and Grey literature online. The "related article" function was used to widen results. The search was limited to randomized controlled trials (RCTs) on human subjects published in English between January 2005 and June 2011. Search results were screened by F.W.A. to identify trials comparing TAP block to placebo or systemic analgesia or any other analgesic modality. Both single-injection and continuous TAP blocks were included. A hand search of the bibliography of all articles was conducted to identify any relevant articles not captured by the original electronic search. A flowchart of the literature search for comparative trials is shown in Figure 1.

Each article was critically reviewed by 2 authors (F.W.A. and R.B.) for eligibility of inclusion in this review. The authors performed data extraction independently and resolved any discrepancy before compiling the review. A self-designed form extracting trial characteristics and the most relevant outcomes common to more than 1 article was used to assist in data collection.

Demographic data extracted for comparison included year of publication, author, study design, and total number of subjects. To address the unanswered questions surrounding analgesia of the TAP block, specific analgesic outcomes were sought

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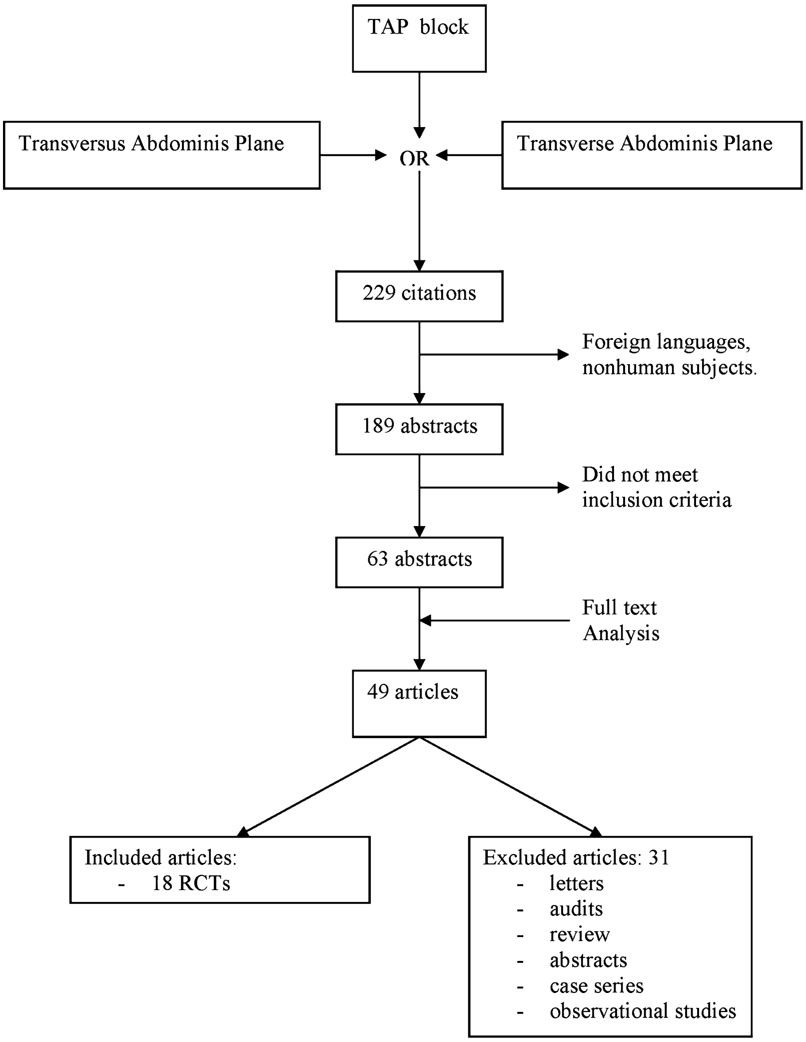

FIGURE 1. Flowchart of screened, excluded, and analyzed studies.

in each article. Outcomes were based on the American Society of Regional Anesthesia and Pain Medicine's Acute Postoperative Pain database initiative.[20] Acute pain outcomes sought were as follows: (i) pain severity, (ii) opioid consumption, (iii) time to first analgesic request, and (iv) sensory block duration. Pain severity and opioid consumption were further divided into early (<24 hrs) versus late (>24 hrs). Pain severity was also categorized as rest versus dynamic. If not otherwise stated, it was assumed that pain severity was assessed at rest. Additional outcomes sought included (v) opioid-related adverse effects (nausea and vomiting, pruritus, sedation), (vi) patient satisfaction, and (vii) block-related complications. It was noted whether each outcome was primary or secondary. Other data collected included (viii) type of surgery, (ix) type of anesthesia used, and (x) definition of success. The intervention (TAP block) and comparator, the number of subjects per group, and the details of the block technique were also recorded. Each outcome was then evaluated qualitatively for each intervention and comparator and the data recorded in tables.

The likelihood of methodological bias of each RCT was independently assessed by the 2 authors using the Jadad score.[21]

RESULTS

We identified 18 RCTs, including 1236 patients, which fulfilled the systematic review criteria.[8–16,22–30] Seventeen of the articles identified were of intermediate to high quality, according to the Jadad score.[8–16,22–26,28–30] Table 1 lists the characteristics of the trials, whereas Table 2 summarizes the specific outcomes sought for this review.

Surgery

To address the question of which surgical procedures may benefit from TAP block analgesia, we summarized trial results according to surgery type in Table 3. Three trials[15,24,30] were limited to pediatric patients and 8 trials[8–10,13,14,16,25,28] to female patients undergoing various abdominal surgeries.

Cesarean delivery (via Pfannenstiel incision) was the most common surgical procedure for which TAP block was performed and investigated (Table 3).[8,10,13,16,25,28] Postoperative analgesic regimens used included systemic opioids, acetaminophen, and nonsteroidal anti-inflammatory drugs (NSAIDs), except in 1 trial,[28] where intravenous (IV) patient-controlled analgesia (PCA) was the sole modality (Table 4). Compared with sham TAP, 3 trials involving spinal anesthesia without

TABLE 1. Trial Characteristics

Author/Year	Quantity (n)	Percentage
Jadad score		
5 (good quality)	9	50
4	5	27.8
3 (intermediate quality)	3	16.7
2	1	5.6
1 (poor quality)	0	0
No. subjects		
<50	6	33.3
50–100	11	61.1
101–150	0	0
151–200	0	0
>200	1	5.6
Age		
Adult (≥18 y)	15	83.3
Pediatric (<18 y)	3	16.7
Unspecified	0	0
Sex		
Male	0	0
Female	8	44.4
Both	10	55.6
Unspecified	0	0
Comparator		
TAP vs systemic analgesia	4	22.2
TAP vs sham	9	50.0
TAP vs IIN/IHN	2	11.1
TAP vs ITM	2	11.1
TAP vs epidural	1	5.6
Location of surgery		
Upper abdominal	1	5.6
Lower abdominal	14	77.8
Laparoscopic	3	16.7
Type of surgery		
Laparotomy: colorectal	2	11.1
Laparotomy: hepatobiliary and renal	1	5.6
Cesarean	6	33.3
Laparotomy: gynecology	2	11.1
Open appendectomy	2	11.1
Open inguinal hernia repair	2	11.1
Laparoscopic cholecystectomy	2	11.1
Laparoscopic appendectomy	1	5.6
Surgical anesthesia		
General	12	66.7
Spinal	6	33.3
Disposition		
Inpatient	13	72.2
Outpatient	2	11.1
Both	0	0
Unspecified	3	16.7
Provider expertise with blocks		
Expert	9	50
Trainee supervised by expert	2	11.1
Novice	0	0
Unspecified	7	38.9
Block localization technique		
Loss of resistance	6	33.3
Ultrasound	11	61.1
Both	1	5.6
Site of injection		
TOP	5	27.8
Midaxillary line	12	66.7
Subcostal	1	5.6
No. blocks per patient		
1 (unilateral) block	4	22.2
2 (bilateral) blocks	14	77.8
Nature of block		
Single injection	17	94.4
Continuous	1	5.6
Timing of the block		
Preoperative	9	50
Postoperative	9	50

intrathecal morphine (ITM) demonstrated 43%,[16] 60%,[28] and 83%[13] reductions in 24-hr morphine consumption. However, when the same comparison was performed in the setting of ITM, the analgesic benefits of TAP block were significantly diminished. In fact, 1 study demonstrated no analgesic difference when TAP block is added to ITM,[8] and 2 trials demonstrated superiority of ITM analgesia over TAP block.[10,25] The 3 trials[8,10,25] using ITM also failed to show a reduction in opioid requirement with TAP block in the first 24 hrs despite a reduction in postoperative nausea and vomiting (PONV)[25] and pruritus.[10,25]

Two trials evaluated the effects of TAP block in gynecologic procedures, including tumor resection surgery[9] and total abdominal hysterectomy.[14] Both trials provided patients with IV PCA, NSAIDs, and acetaminophen for postoperative analgesia (Table 4). Compared with sham, TAP demonstrated its superiority with a clinically significant reduction of pain scores up to 36 hrs; reduction of 24- and 48-hr morphine consumption by 47% and 52%, respectively; a 3.5-fold increase in the time to first analgesic request; and reduction in incidence of sedation.[14] The same comparison, when performed in gynecologic tumor resection surgery in the setting of multimodal analgesia, found no difference in all of the previously measured parameters.[9]

The effects of TAP block in colorectal surgery were assessed in 2 trials where TAP block was compared with sham TAP[12,29] along with IV PCA, NSAIDs,[12,29] and acetaminophen[12] for postoperative analgesia. Both trials demonstrated a clinically meaningful decrease in early rest and dynamic pain scores as well as in early morphine consumption. Both trials demonstrated improved satisfaction and reduced incidence of sedation in the TAP group, and 1 trial[12] demonstrated prolonged time to first analgesic request as well as reduced incidence of PONV.

Another 2 trials examined TAP block in open appendectomy[15,26] with concomitant IV PCA, diclofenac, and acetaminophen for postoperative pain. One trial used US-guided TAP block and demonstrated reduced rest and dynamic pain scores as well as analgesic consumption in the first 24 hrs.[26] The other used landmark-guided TAP block via the triangle of Petit (TOP) and demonstrated superior analgesia with reduction of

TABLE 2. Trial Outcomes

Author/Year	Jadad Score	Surgery	N	Groups (n)	Anesthesia	Definition of Success	Primary Outcome
McDonnell et al,[12] 2007	5	Laparotomy: colorectal surgery	32	1. TAP block (16) 2. Sham block (16)	GA	N/D	Opioid consumption
McDonnell et al,[13] 2008	5	Cesarean delivery	52	1. TAP block (25) 2. Sham block (25)	Spinal	N/D	Opioid consumption
Carney et al,[14] 2008	4	Total abdominal hysterectomy	53	1. TAP block (24) 2. Sham block (26)	GA	N/D	Opioid consumption
El-Dawlatly et al,[22] 2009	4	Lap. cholecystectomy	42	1. TAP block (21) 2. Systematic analgesia (21)	GA	N/D	Opioid consumption
Niraj et al,[26] 2009	4	Open appendectomy	52	1. TAP block (24) 2. Systematic analgesia (23)	GA	N/D	Opioid consumption
Belavy et al,[16] 2009	4	Cesarean delivery	50	1. TAP block (23) 2. Sham block (24)	Spinal	N/D	Opioid consumption
Costello et al,[8] 2009	5	Cesarean delivery	100	1. TAP block (49) 2. Sham block (47)	Spinal	N/D	Dynamic pain scores
Ra et al,[27] 2010	2	Laparoscopic cholecystectomy	54	1. TAP block with 0.5% solution (18) 2. TAP block with 0.25% solution (18) 3. Systematic analgesia (18)	GA	N/D	Pain scores
Baaj et al,[28] 2010	3	Cesarean delivery	40	1. TAP block (19) 2. Sham block (20)	Spinal	N/D	Opioid consumption
Kanazi et al,[25] 2010	5	Cesarean delivery	60	1. TAP block (29) 2. Sham block + ITM (28)	Spinal	N/D	Time to first analgesic request
Griffiths et al,[9] 2010	5	Laparotomy: gynecologic malignancy	65	1. TAP block (32) 2. Sham block (33)	GA	N/D	Pain scores
Carney et al,[15] 2010	5	Open appendectomy	42	1. TAP block (19) 2. Sham block (21)	GA	N/D	Opioid consumption
Fredrickson et al,[24] 2010	3	Open inguinal hernia repair	44	1. TAP block (20) 2. US IIN/IHN (21)	GA	N/D	Emergence pain scores
Aveline et al,[23] 2011	5	Open inguinal hernia repair	275	1. TAP block + sham IIN/IHN (132) 2. Blind IIN/IHN + sham scan (134)	GA	N/D	Dynamic pain scores at 6 months
McMorrow et al,[10] 2011	5	Cesarean delivery	80	1. TAP block + ITM (20) 2. Sham TAP + ITM (20) 3. TAP block (20) 4. Sham TAP (20)	Spinal	N/D	Dynamic pain scores
Bharti et al,[29] 2011	4	Laparotomy: colorectal surgery	40	1. TAP block (20) 2. Sham block (20)	GA	N/D	Opioid consumption
Niraj et al,[11] 2011	3	Laparotomy: hepatobiliary and renal surgery	62	1. TAP block + sham epidural (27) 2. Epidural (31)	GA	N/D	Dynamic pain scores
Sandeman et al,[30] 2011	5	Laparoscopic appendectomy	93	1. TAP block + infiltration (42) 2. Systemic analgesia + infiltration (45)	GA	N/D	Patient proportion requiring opioids

Abbreviations: GA indicates general anesthesia; N/D, not defined.

rest and dynamic pain lasting 48 hrs but no difference in opioid-related adverse effects.[15]

Two additional trials evaluated TAP block in open inguinal hernia repair performed under general anesthesia and compared US-guided TAP block performed along the midaxillary line with IIN/IHN block.[23,24] Complementing a postoperative analgesic regimen consisting of NSAIDs and acetaminophen, TAP block was found to be superior to landmark-guided IIN/IHN block[23] but inferior to US-guided IHN block[24] for early rest pain and early analgesic consumption.

Three trials examined TAP block in the setting of laparoscopic surgery.[22,27,30] Postoperative pain was managed with IV opioids,[22,27,30] NSAIDs,[27] paracetamol,[30] and infiltration[30] with local anesthetics. For laparoscopic cholecystectomy, a

Pain Scores at Rest	Dynamic Pain Scores	Opioid Consumption	Time to First Analgesic Request	Sensory Block Duration	Opioid-Related Adverse Effects	Patient Satisfaction	Block-Related Complications
•	•	•	•		•	•	
•	•	•	•		•		
•	•	•	•		•		
		•					•
•	•	•			•		•
•	•	•	•		•	•	•
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•		•	•		•		•

preoperative TAP block resulted in a 63% reduction of intraoperative analgesic requirement (>14 μg sufentanil) as well as a 54% reduction in early postoperative analgesic requirements in 1 study[22] and a 44% reduction in intraoperative opioid consumption (>200 μg remifentanil) but no clinically significant reduction in postoperative opioid consumption in the second study.[27] For laparoscopic appendectomy,[30] preoperative TAP block improved early pain at rest but had no effect on time to first analgesic request, intraoperative and postoperative opioid consumption, or opioid-related adverse effects.

A single study compared continuous TAP block to thoracic epidural for postoperative analgesia in hepatobiliary and renal surgery.[11] The study demonstrated superiority of epidural analgesia in terms of the reduction of early and late opioid consumption, but no difference was shown in rest and dynamic pain scores, PONV, and patient satisfaction.

TABLE 3. Trial Results According to Surgery Type

			Pain Scores at Rest		Dynamic Pain Scores		Analgesic Consumption	
Surgery/Author, Year	**N**	**Groups (n)**	**Early**	**Late**	**Early**	**Late**	**Early**	**Late**
Cesarean delivery								
McDonnell et al,[13] 2008	52	1. TAP block (25) 2. Sham block (25)	+	+	+	←→	+	+
Belavy et al,[16] 2009	50	1. TAP block (23) 2. Sham block (24)	+		+		+	
Costello et al,[8] 2009	100	1. TAP block (49) 2. Sham block (47)	←→	←→	←→	←→	←→	←→
Baaj et al,[28] 2010	40	1. TAP block (19) 2. Sham block (20)	←→		+		+	
Kanazi et al,[25] 2010	60	1. TAP block (29) 2. Sham block + ITM (28)	−	←→	−	←→	−	
McMorrow et al,[10] 2011	80	1. TAP block + ITM (20) 2. Sham TAP + ITM (20) 3. TAP block (20) 4. Sham TAP (20)	−	←→	−	←→	−	←→
Laparotomy: gynecologic surgery								
Carney et al,[14] 2008	53	1. TAP block (24) 2. Sham block (26)	+	+	+	+	+	+
Griffiths et al,[9] 2010	65	1. TAP block (32) 2. Sham block (33)	←→		←→		←→	
Laparotomy: colorectal surgery								
McDonnell et al,[12] 2007	32	1. TAP block (16) 2. Sham block (16)	+		+		+	
Bharti et al,[29] 2011	40	1. TAP block (20) 2. Sham block (20)	+		+		+	
Open appendectomy								
Niraj et al,[26] 2009	52	1. TAP block (24) 2. Systemic analgesia (23)	+		+		+	
Carney et al,[15] 2010	42	1. TAP block (19) 2. Sham block (21)	+	+	+	+	+	←→

Time to First Analgesic Request	Opioid-Related Adverse Effects			Patient Satisfaction	Remarks
	PONV	Pruritus	Sedation		
+	←→		+		TAP reduces rest VAS by ≥20 mm at 4, 6, 12 hrs ($P < 0.05$) TAP reduces dynamic VAS by ≥20 mm at 4, 5 hrs ($P < 0.05$) TAP reduces 24-hr morphine consumption by 83%; TAP 9 mg, sham 52 mg ($P < 0.001$) TAP prolongs time to first opioid request by 2.4-folds TAP 220 mins, sham 90 mins ($P < 0.05$)
+	←→	←→	←→	+	TAP reduces 24-hr mean rest and dynamic VAS by ≥20 mm ($P = 0.008$) TAP reduces 24-hr morphine consumption by 43%; TAP 18 mg, sham 31.5 mg ($P < 0.05$) TAP prolongs time to first opioid request by 50%, TAP 3 hrs, sham 2 hrs ($P = 0.01$)
				+	
	←→			+	TAP reduces 24-hr mean dynamic VAS by ≥20 mm ($P < 0.05$) TAP reduces 24-hr morphine consumption by 60%; TAP 25.8 mg, sham 62.5 mg ($P < 0.05$)
−	+	+	←→	←→	
		+	←→	←→	
+	←→		+		TAP reduces rest pain scores at 4, 6, 24, 36 hrs by ≥20 mm ($P < 0.05$) TAP reduces 24-hr morphine consumption by 47%; TAP 21.1 mg, sham 39.6 mg ($P < 0.001$) TAP reduces cumulative 48-hr morphine consumption by 52%; TAP 26.8 mg, sham 55.3 mg ($P < 0.001$) TAP prolongs time to first opioid request by 3.5-fold; TAP 12.5 mins, sham 45 mins
	←→	←→	←→	←→	
+	+		+	+	TAP reduces rest and dynamic pain scores at 0, 2, 4 hrs by ≥20 mm ($P < 0.001$) TAP reduces 24-hr morphine consumption by 73%; TAP 21.9 mg, sham 80.4 mg ($P < 0.01$) TAP increases time to first opioid request 6.5-fold; TAP 157.2 mins, sham 24.1 mins ($P < 0.001$)
←→	←→		+	+	TAP reduces rest and dynamic VAS by ≥20 mm at 0, 0.5 hr ($P < 0.05$) TAP reduces 24-hr morphine consumption by 65%; TAP 6.5 mg, sham 17.5 mg ($P < 0.0001$)
	+				TAP reduces rest and dynamic pain scores by ≥20 mm at 0.5, 24 hrs ($P < 0.001$) TAP reduces 24-hr morphine consumption by 44%; TAP 28 mg, sham 50 mg ($P < 0.002$)
+	←→		←→		TAP reduces rest and dynamic VAS by ≥20 mm at all intervals up to 48 hrs ($P < 0.05$) TAP reduces 24-hr morphine consumption by 75%; TAP 55 mg, sham 217 mg ($P < 0.05$) TAP reduces cumulative 48-hr morphine consumption by 54%; TAP 10.3 mg, sham 22.3 mg ($P < 0.01$) TAP prolongs time to first opioid request by 3.4-fold; TAP 55 mins, sham 16 mins ($P < 0.001$)

(Continued on next page)

TABLE 3. *(Continued)*

			Pain Scores at Rest		Dynamic Pain Scores		Analgesic Consumption	
Surgery/Author, Year	**N**	**Groups (n)**	**Early**	**Late**	**Early**	**Late**	**Early**	**Late**
Open inguinal hernia repair								
Fredrickson et al,[24] 2010	44	1. TAP block (20) 2. US IIN/IHN (21)	−				−	←→
Aveline et al,[23] 2011	275	1. TAP block + sham IIN/IHN (132) 2. Blind IIN/IHN + sham scan (134)	+	←→		←→	+	←→
Laparoscopic surgery cholecystectomy								
El-Dawlatly et al,[22] 2009	42	1. TAP block (21) 2. Systemic analgesia (21)					+	
Ra et al,[27] 2010	54	1. TAP block 0.5% solution (18) 2. TAP block 0.25% solution (18) 3. Systemic analgesia (18)	+				+	
Laparoscopic appendectomy								
Sandeman et al,[30] 2011	93	1. TAP block + infiltration (42) 2. Systemic analgesia + infiltration (45)	+				←→	
Laparotomy: hepatobiliary and renal surgery								
Niraj et al,[11] 2011	62	1. TAP block (27) 2. Epidural (31)	←→	←→	←→	←→	−	−

Abbreviations: + indicates favors TAP; −, favors comparator; ←→, no difference; VAS, visual analog scale score.

Dosing

The local anesthetic solution, volume, and delivery method for all TAP blocks performed are summarized in Table 4. For single-injection TAP, the dose and volume of local anesthetic were calculated based on weight in 7 trials.[10,13–15,23,24,30] The total doses varied between 2 mg/kg[30] and 3 mg/kg[13,14] of ropivacaine or 2 mg/kg of bupivacaine.[10] The remaining 10 trials described a predetermined volume of local anesthetic injection varying between 15 mL[22,27] and 20 mL[8,9,12,16,25,26,28,29] per side of the block. The weight-based doses corresponding to these volumes varied between 2.2 to 3.5 mg/kg of ropivacaine[9] and between 1.2 and 2.4 mg/kg of bupivacaine.[25,26]

A range of volumes of local anesthetics were used among the various trials and occasionally within the same trial. Improved analgesic outcomes were noted in 2[13,14] of 4[10,11,13,14] trials using lower volumes (≤15 mL); 4[15,22,23,27] of 5[15,22–24,27] trials using intermediate volumes (15–20 mL); and 6[12,16,26,28–30] of 9[8,9,12,16,25,26,28–30] trials using high volumes (≥20 mL).

The influence of local anesthetics concentration on analgesic outcomes could not be discerned. Improved analgesic outcomes were observed in all 4[27–30] trials that were using dilute solutions (0.2% ropivacaine, 0.25% bupivacaine), 1[12] of 5[8,10–12,25] trials using intermediate concentrations (0.375% ropivacaine, 0.375% bupivacaine, and 0.375% levobupivacaine), 4[16,22,23,26] of 5[9,16,22,23,26] trials using concentrated solutions (0.5% ropivacaine, 0.5% bupivacaine, and 0.5% levobupivacaine), and 3[13–15] of 4[13–15,24] trials using highly concentrated solutions (0.75% and 0.1% ropivacaine).

Perineural catheter–based TAP block was investigated in a single trial,[11] and this was only for delivery of intermittent boluses of local anesthetic. No trials investigated the use of continuous local anesthetic infusion.

Technique

The location of needle insertion for TAP block was at the level of the TOP just above the iliac crest in 5 trials,[12–15,27] at the level of the midaxillary line halfway between iliac crest and costal margin in 12 trials,[8–10,16,22–26,28–30] and below the subcostal margin in 1 study (Table 5).[11] The method of localization was most often sonographic,[8,9,11,16,22–26,28,30] with anatomic landmarks (loss of resistance)[10,12–15,27] and direct surgical visualization[29] less frequent.

Among the 5 trials[12–15,27] where injection was performed at the level of the TOP, patients receiving TAP block experienced clinically meaningful benefits affecting early rest pain in 5 trials,[12–15,27] late rest pain in 3,[13–15] early dynamic pain in 4,[12–15] late dynamic pain in 2,[14,15] early analgesic consumption in 5,[12–15,27] late analgesic consumption in 2,[13,14] time to first analgesic request in 4,[12–15] PONV in 1,[12] and sedation in 3.[12–14]

Among the 12 trials where injection was performed at the level midaxillary line, patients receiving TAP block experienced clinically meaningful benefits affecting early rest pain in 5 trials,[16,23,26,29,30] late rest pain in none, early dynamic pain in 4,[16,26,28,29] late dynamic pain in none, early analgesic consumption in 6,[16,22,23,26,28,29] late analgesic consumption in none, time to first analgesic request in 1,[16] PONV in 2,[25,26] pruritus in 2,[10,25] and sedation in 1.[29] Performing a subcostal TAP did not demonstrate any benefits in the single trial that used this approach.[11]

Timing

Preoperative (preincisional) TAP block was performed in fully one half of the trials,[12,14,15,22–24,26,27,30] whereas the other

Time to First Analgesic Request	Opioid-Related Adverse Effects PONV	Pruritus	Sedation	Patient Satisfaction	Remarks
				←→	
	←→				
					TAP reduces 24-hr morphine consumption by 54%; TAP 10.5 mg, sham 22.8 mg ($P < 0.05$)
					TAP reduces intraoperative opioid consumption by 63%, TAP 8.6 μg, sham 23 μg ($P < 0.01$)
					TAP block reduces rest VAS ≥20 mm at all intervals up to 24 hrs ($P < 0.001$)
					TAP reduces intraoperative opioid consumption by 44% ($P < 0.001$)
←→	←→				TAP reduces rest VAS by ≥20 mm at 2 hrs ($P = 0.03$)
	←→			←→	

half performed TAP blocks postoperatively, with patients still under spinal[8,10,13,16,25,28] or general anesthesia[9,11,29] (Table 6). Whereas 8[12,14,15,22,23,26,27,30] of 9 trials demonstrated some analgesic benefit when preincisional TAP block was performed, only 4[13,16,28,29] of 9 demonstrated analgesic benefits when postincisional TAP block was administered.

DISCUSSION

This review suggests that our collective understanding of the TAP block and its role in contemporary practice remains limited. Although clinically significant improvement in acute pain and acute pain-related outcomes was noted in certain surgeries,[12,15,22,26,27,29,30] there are insufficient data to determine the efficacy of TAP block in others. Trends indicative of improved analgesic outcomes with larger local anesthetic volumes,[12,16,26,28–30] block performance at the TOP location,[12–15,27] and preincisional timing for injection[12,14,15,22,23,26,27,30] have yet to be subjected to randomized comparison. The lack of block-related complications reported by any of the trials reviewed endorses the safety of this technique. Methodological flaws limit the reliability and validity of many of the trials reviewed herein, which may not necessarily be reflected in the Jadad score. For example, none of the 18 RCTs reviewed defined criteria of a successful TAP block, although 1 used a therapeutic level of analgesia as an indicator of success.[11] Several important TAP procedure–related outcomes were missing in all of the trials reviewed, such as onset of sensory block, block level, and block duration. Moreover, despite repeated calls,[31,32] only 1 trial[11] compared TAP block to the arguable criterion standard analgesic for abdominal surgery, epidural analgesia. Finally, the heterogeneity between each of the 18 trials reviewed herein precludes statistical meta-analysis. Gross variability in the nature of the comparator or control group, surgical procedure, block location, and nerve localization technique, as well as the type, concentration, and volume of block solution, render reliable quantification of effect highly vulnerable to bias.

Surgery

We could not find sufficient evidence to identify the surgical procedures where TAP block has definite analgesic benefits. The data indicate some analgesic benefits for TAP block in colorectal surgery,[12,29] open and laparoscopic appendectomy,[15,26,30] and laparoscopic cholecystectomy[22,27]; however, results are less clear for hepatobiliary and renal surgeries,[11] cesarean delivery,[8,10,13,16,25,28] gynecologic surgeries,[9,14] and open inguinal hernia repair.[23,24] One plausible explanation for the lack of analgesic efficacy of TAP block noted in some trials[8–11,25] may be the reliance on TAP block for analgesia in surgeries where the visceral component of pain significantly contributes to postoperative pain. Ideally, TAP block provides analgesia to the abdominal wall and works best when postoperative pain is primarily somatic.[18,33] Finally, we could not identify a clinical advantage for TAP block in the setting of multimodal analgesia because many trials either did not use multimodal approaches[22,27,28] or omitted important components, such as ITM for cesarean deliveries[13,16,28] or epidural analgesia for colorectal surgery.[12,29] Among the 5 trials[10,11,23–25] that did compare TAP block to active comparators, such as ITM for cesarean delivery,[10,25] epidural for laparotomy,[11] and IIN/IHN block for inguinal hernia repair,[23,24] TAP block failed to demonstrate any analgesic benefits in 4.[10,11,24,25]

Dosing

There is lack of clear consensus regarding the optimal local anesthetic type, its dose, and the volume of injection. This has led some investigators to used a weight-based dose of local anesthetics, whereas others used a predetermined arbitrary injection volume, the latter being a practice that may increase the

TABLE 4. Single-Injection TAP Block Technique

Author/Year	Block Type	Timing	Localization	Needle	Needle Advancement Endpoint
McDonnell et al,[12] 2007	Bilateral	Preoperative	Anatomic	22-gauge	Double pop
McDonnell et al,[13] 2008	Bilateral	Postoperative	Anatomic	22-gauge	Double pop
Carney et al,[14] 2008	Bilateral	Preoperative	Anatomic	N/D	Double pop
El-Dawlatly et al,[22] 2009	Bilateral	Preoperative	Ultrasound	21-gauge 90 mm	Needle tip in TAP plane
Niraj et al,[26] 2009	Unilateral	Preoperative	Ultrasound	23-gauge 60 mm	Needle tip in TAP plane
Belavy et al,[16] 2009	Bilateral	Postoperative	Ultrasound	20-gauge 150 mm	Needle tip in TAP plane
Costello et al,[8] 2009	Bilateral	Postoperative	Ultrasound	20-gauge 64 mm	Needle tip in TAP plane
Ra et al,[27] 2010	Bilateral	Preoperative	Anatomic + US	22-gauge 50 mm	Double pop + needle tip in TAP plane
Baaj et al,[28] 2010	Bilateral	Postoperative	Ultrasound	20-gauge 100 m	Needle tip in TAP plane
Kanazi et al,[25] 2010	Bilateral	Postoperative	Ultrasound	21-gauge 100 mm	Needle tip in TAP plane
Griffiths et al,[9] 2010	Bilateral	Postoperative	Ultrasound	22-gauge 150 mm	Needle tip in TAP plane
Carney et al,[15] 2010	Unilateral	Preoperative	Anatomic	22-gauge 25 mm	Double pop
Fredrickson et al,[24] 2010	Unilateral	Preoperative	Ultrasound	22-gauge	Needle tip in TAP plane
Aveline et al,[23] 2011	Unilateral	Preoperative	Ultrasound	22-gauge 80 mm	Needle tip in TAP plane
McMorrow et al,[10] 2011	Bilateral	Postoperative	Anatomic	18-gauge Tuohy 80 mm	Double pop
Bharti et al,[29] 2011	Bilateral	Postoperative	Surgical	22-gauge 50 mm	Single pop
Sandeman et al,[30] 2011	Bilateral	Preoperative	Ultrasound	N/D	Needle tip in TAP plane

Abbreviations: IM, intramuscular; N, no; N/D, not defined.

risk of local anesthetic toxicity in patients with low body weight.[34] Although plasma levels of local anesthetics may exceed the toxic threshold level following a TAP block,[35] none of the trials reported episodes of toxicity, and we could not discern whether the addition of epinephrine to the block solution (used in 2 trials)[24,25] is protective. Nevertheless, realizing the limits posed by toxicity, the dose parameters are still subject to 2 conflicting priorities: duration and spread. Although it is logical to assume that the use of higher local anesthetic doses (and concentrations) in TAP block prolongs the duration of analgesia, TAP block remains a compartmental field block[1] with an extent of dermatomal spread dependent on the volume of local anesthetic injected. Our limited understanding of the physiology behind TAP block analgesia[35] and data on distant local anesthetic spread beyond the TAP compartment[36] to the quadratus lumborum muscle and into the intrathoracic paravertebral regions further complicates the selection of block solution. To date, no trials have investigated the effects of local anesthetic volume, concentration, or dose on block duration, spread, and safety for both single-injection and continuous TAP blocks.

Technique

Our review revealed a trend toward improved and prolonged TAP block analgesia when the block was performed in the TOP[13–15] rather than along the midaxillary line. Although earlier reviews could not identify an association between prolongation of analgesia and injection at the TOP, 1 review did report a more profound reduction in 24-hr morphine consumption when TAP block was performed at the TOP.[18] One possible anatomic explanation relates to the diversity and relative variability in the trajectory of the thoracolumabar, subcostal, and IIN/IHN nerves in the TAP.[3,37,38] These lateral cutaneous branches of the T6-L1 nerves arise proximal to the angle of the rib, run a short distance with the main nerve, and emerge obliquely through overlying muscles, passing through the TAP at the midaxillary line level.[37] The points of entry of the T6-T11, subcostal, and IIN/IHN nerves into of the TAP, as well as the

Block Solution Per Injection	Sensory Block Assessment	Sensory Block Level	Block Duration	Supplementary Analgesia
20 mL of 0.375% levobupivacaine up to a total dose of 1 mg/kg	N	N/D	N/D	IV PCA morphine, rectal diclofenac, oral acetaminophen
1.5 mg/kg ropivacaine 0.75% to a total dose of 150 mg	N	N/D	N/D	IV PCA morphine, rectal diclofenac, oral acetaminophen
1.5 mg/kg 0.75% ropivacaine up to a total dose of 150 mg	N	N/D	N/D	IV PCA morphine, rectal diclofenac, rectal acetaminophen
15 mL 0.5% bupivacaine	N	N/D	N/D	IV PCA morphine
20 mL 0.5 % bupivacaine	N	N/D	N/D	IV PCA morphine, oral diclofenac, oral acetaminophen
20 mL 0.5% ropivacaine	N	N/D	N/D	IV PCA morphine, oral acetaminophen, oral ibuprofen
20 mL 0.375% ropivacaine	N	N/D	N/D	IV morphine, oral diclofenac, oral acetaminophen
15 mL 0.25% levobupivacaine or 15 mL 0.5% levobupivacaine	N	N/D	N/D	IV fentanyl, IV ketorolac
20 mL 0.25% bupivacaine	N	N/D	N/D	IV PCA morphine
20 mL 0.375% bupivacaine + epinephrine	N	N/D	N/D	IV tramadol, rectal diclofenac. oral or IV paracetamol
20 mL 0.5% ropivacaine	N	N/D	N/D	IV PCA morphine, oral or IV acetaminophen.
2.5 mg/kg 0.75% ropivacaine	N	N/D	N/D	IV morphine, oral acetaminophen, rectal diclofenac
0.3 mg/kg 50:50 lidocaine 1% + ropivacaine 1% + epinephrine	N	N/D	N/D	IV morphine, oral ibuprofen, oral acetaminophen
1.5 mg/kg 0.5% levobupivacaine	N	N/D	N/D	IV morphine, then oral morphine, oral paracetamol, oral ketoprofen
1 mg/kg 0.375% bupivacaine	N	N/D	N/D	IV PCA morphine, oral paracetamol, rectal diclofenac
20 mL 0.25% bupivacaine	N	N/D	N/D	IV morphine + IM diclofenac
1 mg/kg 0.2% ropivacaine	N	N/D	N/D	Infiltration, IV PCA morphine, oral paracetamol

distances they travel in this plane, are highly variable. The anatomic relationship of these nerves relative to the TAP is perhaps more consistent and reliable posteriorly[37] (ie, at the TOP) rather than along the midaxillary line. The TOP and midaxillary line injection points are nearly 10 cm apart from one another[39] and have been shown to produce different sensory block dermatomal distribution in volunteers as well as dissimilar patterns of dye spread in cadavers.[2,5,7] Also, recent evidence suggests that injection in the TOP may result in paravertebral injectate spread, whereas midaxillary injection results in predominantly anterior spread.[40] Finally, the presence of extensive anastomoses[38] between these nerves may offer an alternative explanation to the difference in analgesic efficacy between the various TAP block injection approaches. A posterior injection point, as in the TOP, may capture higher-order branches of the T6-L1 nerves in close proximity to one another before their distal anastomoses.

Timing

Although the timing of injection, whether preincisional or postincisional, may have effects on some acute postoperative analgesic outcomes,[41,42] the absence of trials comparing analgesic outcomes based on preincisional and postincisional TAP blocks in the same surgical procedures limits our ability to answer this question. However, given the large volumes of local anesthetic often injected for TAP blocks, one important safety consideration may be the timing of injection. Indeed, recent evidence[35] that examined plasma ropivacaine level in females undergoing open gynecologic surgery who received bilateral TAP blocks with 3 mg/kg ropivacaine diluted to a total of 40 mL, followed by serial venous blood sampling, revealed a mean plasma ropivacaine concentration of 2.54 ± 0.75 μg/mL with a peak concentration (C_{max}) of 4.0 μg/mL reached at 30 mins. These plasma levels are above the toxic threshold (2.2 μg/mL) and are potentially neurotoxic. This raises 2 additional (and unanswered) questions: (i) can TAP block analgesia be fully or partially the result of a systemic local anesthetic effect? And (ii) is it potentially safer to perform TAP blocks while patients are under general anesthesia? Whereas systemic absorption may partly explain the early analgesic effect of TAP block, persistent analgesia despite the decay of plasma at local anesthetic levels

TABLE 5. Trial Results According to Site of Injection

Injection Site/Author, Year	N	Groups (n)	Pain Scores at Rest		Dynamic Pain Scores		Analgesic Consumption	
			Early	Late	Early	Late	Early	Late
Triangle o f Petit								
McDonnell et al,[12] 2007	32	1. TAP block (16) 2. Sham block (16)	+		+		+	
McDonnell et al,[13] 2008	52	1. TAP block (25) 2. Sham block (25)	+	+	+	←→	+	+
Carney et al,[14] 2008	53	1. TAP block (24) 2. Sham block (26)	+	+	+	+	+	+
Ra et al,[27] 2010	54	1. TAP block 0.5% solution (18) 2. TAP block 0.25% solution (18) 3. Systemic analgesia (18)	+				+	
Carney et al,[15] 2010	42	1. TAP block (19) 2. Sham block (21)	+	+	+	+	+	←→
Subcostal								
Niraj et al,[11] 2011	62	1. TAP block (27) 2. Epidural (31)	←→	←→	←→	←→	−	−
Midaxillary line								
El-Dawlatly et al,[22] 2009	42	1. TAP block (21) 2. Systemic analgesia (21)					+	
Niraj et al,[26] 2009	52	1. TAP block (24) 2. Systemic analgesia (23)	+		+		+	
Belavy et al,[16] 2009	50	1. TAP block (23) 2. Sham block (24)	+		+		+	
Costello et al,[8] 2009	100	1. TAP block (49) 2. Sham block (47)	←→	←→	←→	←→	←→	←→
Baaj et al,[28] 2010	40	1. TAP block (19) 2. Sham block (20)	←→		+		+	
Kanazi et al,[25] 2010	60	1. TAP block (29) 2. Sham block + ITM (28)	−	←→	−	←→	−	
Griffiths et al,[9] 2010	65	1. TAP block (32) 2. Sham block (33)	←→		←→		←→	
Fredrickson et al,[24] 2010	44	1. TAP block (20) 2. US IIN/IHN (21)	−				−	←→
Aveline et al,[23] 2011	275	1. TAP block + sham IIN/IHN (132) 2. Blind IIN/IHN + sham scan (134)	+	←→		←→	+	←→
McMorrow et al,[10] 2011	80	1. TAP block + ITM (20) 2. Sham TAP + ITM (20) 3. TAP block (20) 4. Sham TAP (20)	−	←→	−	←→	−	←→
Bharti et al,[29] 2011	40	1. TAP block (20) 2. Sham block (20)	+		+		+	
Sandeman et al,[30] 2011	93	1. TAP block + infiltration (42) 2. Systemic analgesia + infiltration (45)	+				←→	

Abbreviations: + indicates favors TAP; −, favors comparator; ←→, no difference; VAS, visual analog scale score.

Time to First Analgesic Request	Opioid-Related Adverse Effects			Patient Satisfaction	Remarks
	PONV	Pruritus	Sedation		
+	+		+	+	TAP reduces rest and dynamic pain scores at 0, 2, 4 hrs by ≥20 mm (*P* < 0.001) TAP reduces 24-hr morphine consumption by 73%; TAP 21.9 mg, sham 80.4 mg (*P* < 0.01) TAP increases time to first opioid request 6.5-fold; TAP 157.2 mins, sham 24.1 mins (*P* < 0.001)
+	←→		+		TAP reduces rest VAS by ≥20 mm at 4, 6, 12 hrs (*P* < 0.05) TAP reduces dynamic VAS by ≥20 mm at 4, 5 hrs (*P* < 0.05) TAP reduces 24-hr morphine consumption by 83%; TAP 9 mg, sham 52 mg (*P* < 0.001) TAP prolongs time to first opioid request by 2.4-fold; TAP 220 mins, sham 90 mins (*P* < 0.05)
+	←→		+		TAP reduces rest pain scores at 4, 6, 24, 36 hrs by ≥20 mm (*P* < 0.05) TAP reduces 24-hr morphine consumption by 47%; TAP 21.1 mg, sham 39.6 mg (*P* < 0.001) TAP reduces cumulative 48-hr morphine consumption by 52%; TAP 26.8 mg, sham 55.3 mg (*P* < 0.001) TAP prolongs time to first opioid request by 3.5-fold; TAP12.5 mins, sham 45 mins
					TAP block reduces rest VAS ≥20 mm at all intervals up to 24 hrs (*P* < 0.001) TAP reduces intraoperative opioid consumption by 44% (*P* < 0.001)
+	←→		←→		TAP reduces rest and dynamic VAS by ≥20 mm at all intervals up to 48 hrs (*P* < 0.05) TAP reduces 24-hr morphine consumption by 75%; TAP 55 mg, sham 217 mg (*P* < 0.05) TAP reduces cumulative 48-hr morphine consumption by 54%; TAP 10.3 mg, sham 22.3 mg (*P* < 0.01) TAP prolongs time to first opioid request by 3.4-fold; TAP 55 mins, sham 16 mins (*P* < 0.001)
	←→			←→	
					TAP reduces 24-hr morphine consumption by 54%; TAP 10.5 mg, sham 22.8 mg (*P* < 0.05) TAP reduces intraoperative opioid consumption by 63%, TAP 8.6 μg , sham 23 μg (*P* < 0.01)
	+				TAP reduces rest and dynamic pain scores by ≥20 mm at 0.5, 24 hrs (*P* < 0.001) TAP reduces 24-hr morphine consumption by 44%; TAP 28 mg, sham 50 mg (*P* < 0.002)
+	←→	←→	←→	+	TAP reduces 24-hr mean rest and dynamic VAS by ≥20 mm (*P* = 0.008) TAP reduces 24-hr morphine consumption by 43%; TAP 18 mg, sham 31.5 mg (*P* < 0.05) TAP prolongs time to first opioid request by 50%, TAP 3 hrs, sham 2 hrs (*P* = 0.01)
				+	
	←→			+	TAP reduces 24-hr mean dynamic VAS by ≥20 mm at 0, 0.5 hr (*P* < 0.05) TAP reduces 24-hr morphine consumption by 60%; TAP 25.8 mg, sham 62.5 mg (*P* < 0.05)
−	+	+	←→	←→	
	←→	←→	←→	←→	
				←→	
	←→				
		+	←→	←→	
←→	←→		+	+	TAP reduces rest and dynamic VAS by ≥20 mm at 0, 0.5 hr (*P* < 0.05) TAP reduces 24-hr morphine consumption by 65%; TAP 6.5 mg, sham 17.5 mg (*P* < 0.0001)
←→	←→				TAP reduces rest VAS by ≥20 mm at 2 hrs (*P* = 0.03)

TABLE 6. Results From Trials According to Timing of Injection

Timing of Injection/Author, Year	N	Groups (n)	Pain Scores at Rest		Dynamic Pain Scores		Analgesic Consumption	
			Early	Late	Early	Late	Early	Late
Preincisional injection								
McDonnell et al,[12] 2007	32	1. TAP block (16) 2. Sham block (16)	+		+		+	
Carney et al,[14] 2008	53	1. TAP block (24) 2. Sham block (26)	+	+	+	+	+	+
El-Dawlatly et al,[22] 2009	42	1. TAP block (21) 2. Systemic analgesia (21)					+	
Niraj et al,[26] 2009	52	1. TAP block (24) 2. Systemic analgesia (23)	+		+		+	
Ra et al,[27] 2010	54	1. TAP block 0.5% solution (18) 2. TAP block 0.25% solution (18) 3. Systemic analgesia (18)	+				+	
Carney et al,[15] 2010	42	1. TAP block (19) 2. Sham block (21)	+	+	+	+	+	⟷
Fredrickson et al,[24] 2010	44	1. TAP block (20) 2. US IIN/IHN (21)	−				−	⟷
Aveline et al,[23] 2011	275	1. TAP block + sham IIN/IHN (132) 2. Blind IIN/IHN + sham scan (134)	+	⟷		⟷	+	⟷
Sandeman et al,[30] 2011	93	1. TAP block + infiltration (42) 2. Systemic analgesia + infiltration (45)	+				⟷	
Postincisional injection								
McDonnell et al,[13] 2008	52	1. TAP block (25) 2. Sham block (25)	+	+	+	⟷	+	+
Belavy et al,[16] 2009	50	1. TAP block (23) 2. Sham block (24)	+		+		+	
Costello et al,[8] 2009	100	1. TAP block (49) 2. Sham block (47)	⟷	⟷	⟷	⟷	⟷	⟷
Baaj et al,[28] 2010	40	1. TAP block (19) 2. Sham block (20)	⟷		+		+	
Kanazi et al,[25] 2010	60	1. TAP block (29) 2. Sham block + ITM (28)	−	⟷	−	⟷	−	
Griffiths et al,[9] 2010	65	1. TAP block (32) 2. Sham block (33)	⟷		⟷		⟷	
McMorrow et al,[10] 2011	80	1. TAP block + ITM (20) 2. Sham TAP + ITM (20) 3. TAP block (20) 4. Sham TAP (20)	−	⟷	−	⟷	−	⟷
Bharti et al,[29] 2011	40	1. TAP block (20) 2. Sham block (20)	+		+		+	
Niraj et al,[11] 2011	62	1. TAP block (27) 2. Epidural (31)	⟷	⟷	⟷	⟷	−	−

Abbreviations: + indicates favors TAP; −, favors comparator; ⟷, no difference; VAS, visual analog scale score.

Time to First Analgesic Request	Opioid-Related Adverse Effects: PONV	Opioid-Related Adverse Effects: Pruritus	Opioid-Related Adverse Effects: Sedation	Patient Satisfaction	Remarks
+	+		+	+	TAP reduces rest and dynamic pain scores at 0, 2, 4 hrs by ≥20 mm (P < 0.001)
					TAP reduces 24-hr morphine consumption by 73%; TAP 21.9 mg, sham 80.4 mg (P < 0.01)
					TAP increases time to first opioid request 6.5-fold; TAP 157.2 mins, sham 24.1 mins (P < 0.001)
+	←→		+		TAP reduces rest pain scores at 4, 6, 24, 36 hrs by ≥20 mm (P < 0.05)
					TAP reduces 24-hr morphine consumption by 47%; TAP 21.1 mg, sham 39.6 mg (P < 0.001)
					TAP reduces cumulative 48-hr morphine consumption by 52%; TAP 26.8 mg, sham 55.3 mg (P < 0.001)
					TAP prolongs time to first opioid request by 3.5-fold; TAP12.5 mins, sham 45 mins
					TAP reduces 24-hr morphine consumption by 54%; TAP 10.5 mg, sham 22.8 mg (P < 0.05)
					TAP reduces intraoperative opioid consumption by 63%, TAP 8.6 μg , sham 23 μg (P < 0.01)
	+				TAP reduces rest and dynamic pain scores by ≥20 mm at 0.5, 24 hrs (P < 0.001)
					TAP reduces 24-hr morphine consumption by 44%; TAP 28 mg, sham 50 mg (P < 0.002)
					TAP block reduces rest VAS ≥20 mm at all intervals up to 24 hrs (P < 0.001)
					TAP reduces intraoperative opioid consumption by 44% (P < 0.001)
+	←→		←→		TAP reduces rest and dynamic VAS by ≥20 mm at all intervals up to 48 hrs (P < 0.05)
					TAP reduces 24-hr morphine consumption by 75%; TAP 55 mg, sham 217 mg (P < 0.05)
					TAP reduces cumulative 48-hr morphine consumption by 54%; TAP 10.3 mg, sham 22.3 mg (P < 0.01)
					TAP prolongs time to first opioid request by 3.4-fold; TAP 55 mins, sham 16 mins (P < 0.001)
				←→	
	←→				
←→	←→				TAP reduces rest VAS by ≥20 mm at 2 hrs (P = 0.03)
+	←→		+		TAP reduces rest VAS by ≥20 mm at 4, 6, 12 hrs (P < 0.05)
					TAP reduces dynamic VAS by ≥20 mm at 4, 5 hrs (P < 0.05)
					TAP reduces 24-hr morphine consumption by 83%; TAP 9 mg, sham 52 mg (P < 0.001)
					TAP prolongs time to first opioid request by 2.4-fold; TAP 220 mins, sham 90 mins (P < 0.05)
+	←→	←→	←→	+	TAP reduces 24-hr mean rest and dynamic VAS by ≥20 mm (P = 0.008)
					TAP reduces 24-hr morphine consumption by 43%; TAP 18 mg, sham 31.5 mg (P < 0.05)
					TAP prolongs time to first opioid request by 50%, TAP 3 hrs, sham 2 hrs (P = 0.01)
				+	
	←→			+	TAP reduces 24-hr mean dynamic VAS by ≥20 mm (P < 0.05)
					TAP reduces 24-hr morphine consumption by 60%; TAP 25.8 mg, sham 62.5 mg (P < 0.05)
−	+	+	←→	←→	
	←→	←→	←→	←→	
		+	←→	←→	
←→	←→		+	+	TAP reduces rest and dynamic VAS by ≥20 mm at 0, 0.5 hr (P < 0.05)
					TAP reduces 24-hr morphine consumption by 65%; TAP 6.5 mg, sham 17.5 mg (P < 0.0001)
	←→			←→	

suggests true sensory conduction block. Furthermore, patients under general anesthesia have increased plasma toxic thresholds[43] and diminished risk of cardiovascular collapse.[44]

This review suggests that our understanding of the TAP block and its role in contemporary practice remains limited. Future research should be directed at investigating TAP block characteristics relative to surgery type, local anesthetic solution, and location and timing of injection. Mode of TAP block delivery, including both repeated intermittent and continuous catheter-based dosing regimens, is a worthwhile subject of future study. Finally, to define its role in contemporary practice, the analgesic effects of TAP block must be evaluated in the context of standardized procedure-specific multimodal analgesia.

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