Application of TAP Block in Laparoscopic Urological Surgery: Current Status and Future Directions

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Abstract

Purpose of Review Amid the opioid crisis, postoperative pain management is a major challenge for practitioners. Recent pain management guidelines emphasize the importance of using regional anesthesia as part of opioid-sparing multimodal analgesia. This report aims to review recent evidence regarding the utilization of transversus abdominis plane (TAP) block in minimally invasive urologic surgery.

Recent Findings TAP block has been shown to improve early and late pain at rest, and to reduce opioid consumption after minimally invasive surgery. These benefits have indirectly reduced the incidence of postoperative delirium, pneumonia, urinary retention, and falls. Compared to epidural analgesia, TAP block provides similar pain control, has a lower incidence of hypotension, and is associated with a shorter length of stay.

Summary Few studies focus specifically on the outcomes of TAP block in minimally invasive urologic surgery. TAP block decreases postoperative pain and reduces opioid consumption without increasing complications. TAP block should be integrated as an indispensable component in enhanced recovery after surgery protocols.

Keywords TAP block · Laparoscopic urological surgery · Endourology

Introduction

Over the last two decades, there has been an increase in the use of laparoscopic and robotic urological surgical procedures, such as prostatectomy, nephrectomy, partial nephrectomy, cystectomy, pyeloplasty, and other reconstructive procedures [1, 2]. The adoption of laparoscopic and robotic surgery has improved patient-related outcomes and perioperative outcomes for a variety of complex urological surgical procedures [3, 4]. Although laparoscopic and robotic surgery might be associated with decreased pain as compared to open surgery, patients still experience moderate pain from the incision sites [5, 6]. Acute postoperative pain is associated with patient

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dissatisfaction and is a significant risk factor for the development of chronic pain [7, 8]. Postoperative pain is traditionally managed with narcotics, known to cause significant side effects, including nausea, vomiting, sedation, ileus, constipation, and respiratory depression [9]. Moreover, even a short course of narcotics exposes the patient to the risk of long-term opioid abuse [10].

In the last decade, there has been heightened interest in exploring the effects of perioperative immunosuppression on the long-term oncological outcomes of patients, which is marked by increased glucocorticosteroid secretion as well as impaired cellular and humoral immune responses [11]. Several studies have shown that postoperative pain and opioid use might precipitate perioperative immunosuppression; however, there is emerging evidence in the literature showing that the implementation of enhanced recovery after surgery (ERAS) protocols, as well as opioid-sparing multimodal pain control (including regional anesthesia), might mitigate this phenomenon [12•, 13–16].

A range of multimodal analgesia strategies have recently been proposed to reduce postoperative pain and narcotic usage [17]. One of the main strategies relies on using long-acting local anesthetic-based regional analgesic techniques. Several regional analgesic techniques have been described in the

urology literature, including ultrasound-guided and robot-assisted percutaneous transversus abdominis plane (TAP) block for anterolateral abdominal pain, paravertebral block, epidural injection, intrathecal injection, and local wound infiltration [18–20, 21••, 22].

TAP block has been shown to improve early and late pain at rest, and to reduce opioid consumption after minimally invasive surgery [23, 24]. Indirectly, these benefits translate into reduced postoperative delirium, pneumonia, urinary retention, and falls [25]. Nevertheless, several studies have challenged the benefit of TAP block after minimally invasive surgery [26, 27].

Overview of TAP Block

The TAP block technique was developed by Rafi et al. to provide analgesia to the anterolateral abdominal wall [28]. Based on the anatomical landmarks of the triangle of Petit—formed by the external oblique muscle, the latissimus dorsi muscle, and the iliac crest—a needle is inserted perpendicular to the skin and just cephalad to the iliac crest. After a "double pop" sensation, indicating passage through the external and internal oblique fascial layers, the medication is injected between the internal oblique and transversus abdominis muscles (TAP layer) to the site where the nerves to the anterolateral abdominal wall are located. Several modifications to the original TAP block technique have subsequently been proposed, such as the use of ultrasound to guide the needle to ensure medication deposition in the proper plane, the use of alternative injection points, and inserting the needle through the peritoneum to perform reverse TAP block [29–32]. The duration and the extent of the analgesic effect provided by TAP block depend on the location of the injection (landmark, anterior oblique subcostal, midaxillary, and posterior), type of local anesthetic, and timing of the block (perioperative vs. postoperative) [23].

Location of Injection

In the landmark-guided TAP block, the analgesic effect usually targets the anterior rami of the intercostal nerves T7–T11, subcostal nerve T12, and the ilioinguinal and iliohypogastric nerves L1 [28]. These nerves run in the TAP plane and provide sensory innervation to the skin, muscles, and parietal peritoneum of the anterolateral abdominal wall. Injecting local anesthetic at the midaxillary line has been shown to target T10 to L1 and may also affect intercostal nerves T7–T9. Anterior oblique subcostal deposition of the local anesthetic affects T8 to L1, while the posterior TAP block cover T5 to L1 [33]. Intriguingly, one cadaveric study demonstrated that pneumoperitoneum did not affect the spread of local

anesthetics in midaxillary TAP block [34]. Table 1 summarizes different TAP block approaches.

Timing of Block (Perioperative vs. Postoperative)

The optimal timing for administration of TAP block for minimally invasive surgical procedures has been extensively debated. A recent meta-analysis has shown that the preoperative administration of TAP block before minimally invasive surgery reduces early pain at rest and postoperative opioid consumption as compared with the postoperative block administration [23]. This might be attributed to the preemptive analgesic effect of preoperative TAP block and a subsequent reduction in central pain sensitization during surgery [17].

Type of Local Anesthetic

Several local anesthetic agents have been used during TAP blocks, such as bupivacaine, ropivacaine, and liposomal bupivacaine, with or without epinephrine or dexmedetomidine used as adjunct agents [17]. Liposomal bupivacaine has been designed to provide a sustained release and to increase the duration of the local anesthetic effects of bupivacaine, which has a terminal half-life 9.8 times longer than conventional bupivacaine [35]. Early evidence from single-center randomized clinical trials shows that liposome bupivacaine used in TAP block provides superior analgesic effects and results in less opioid consumption as compared to non-liposomal bupivacaine [36]. However, two recent metanalyses dispute these results, showing that liposome bupivacaine provides no additional analgesic advantages over conventional local anesthesia for patients undergoing surgical procedures [37, 38]. Of note, Beachler et al. estimates that the cost of liposomal bupivacaine is 11 times higher than traditional bupivacaine [39].

TAP Block vs. Epidural Analgesia

In the early 2000s, the Multicenter Australian Study of Epidural Anesthesia and Analgesia in Major Surgery (MASTER Trial) demonstrated the benefits of epidural analgesia for improving postoperative pain and for reducing the rate of respiratory failure in high-risk patients undergoing major intra-abdominal surgery [40]. Consequently, epidural anesthesia has been considered the gold standard in pain control following abdominal surgery. Several randomized clinical trials have compared the efficacy of TAP block to epidural anesthesia after abdominal anesthesia but have reported inconsistent findings [41, 42]. Consequently, a metanalysis of these trials was conducted to infer a conclusion based on these studies; consequently, the authors analyzed 10 controlled trials with a cumulative total of 505 patients. Pain scores at rest on postoperative day 1 were comparable for TAP block and

Table 1 Comparison between different TAP block approaches

Author	Year of publication	Approach	Anatomic landmark	Targeted nerves	Spread to paravertebral space*	Duration of action
Rafi et al. [28]	2001	Triangle of Petit approach "Landmark"	The triangle between oblique muscle, the latissimus dorsi muscle, and the iliac crest	T7-L1	Yes	Gold standard
Hebbard et al. [30]	2010	Anterior oblique subcostal	Anterior to the anterior axillary line, below the costal margin, and lateral to the rectus sheath	T10-L1	No	Shorter duration of action
Furuya et al. [32]	2018	Posterior	Posterior to the midaxillary line between the costal margin and iliac crest	T5-L1	Yes	Equivalent
Furuya et al. [32]	2018	Midaxillary	In the midaxillary line between the iliac crest and the costal margin	T8-T12	Equivocal	Shorter duration of action

*Spread to the paravertebral space: It has been postulated that TAP block analgesic effect might be a combination of blockade of distal sensory efferents and a more proximal effect, at the level of the paravertebral space [33]

epidural analgesia groups (mean difference 0.5; 95% CI − 0.1 to 1.0; I^2 = 81%; p = 0.10). On the other hand, the epidural analgesia group experienced a higher rate of hypotension (relative risk 0.13; 95% CI 0.04–0.38; I^2 = 0%; p = 0.0002), while hospital length of stay was shorter in the TAP block group (mean difference − 0.6 days; 95% CI − 0.9 to − 0.3 days; I^2 = 0%; p < 0.0001), without impact on functional outcomes [43].

Cost

A recent cost-effectiveness analysis of epidural, patient-controlled intravenous opioid analgesia, or transversus abdominis plane infiltration for postoperative pain management, has shown that patient-controlled intravenous opioid analgesia is the most cost-effective strategy, both in terms of cost and for triggering a 1-point reduction in Numeric Rating scale (NRS) pain scores, which is an 11-point scale for adult patient self-reporting of pain. Nevertheless, the use of TAP block was associated with a small increase in costs as compared with patient-controlled intravenous opioid analgesia while offering the same analgesic effect. In this analysis, the authors assumed that the cost of TAP block, as well as other local block approaches, includes both the medication used as well as any possible expenses associated with failed infiltration, or adverse events and equipment [44•]. However, they did not account for any increase in turnover time between surgical cases, the reduction in available operative time for surgery, or the associated loss of opportunity cost [45]. The physician's decision to choose the postoperative pain management approach should not solely be based on the abovementioned factors, but should take into consideration the hospital setting, the availability of equipment, and the risk of opioid abuse and its associated socioeconomic burden [46].

TAP Block in Minimally Invasive Urologic Surgery

There is a paucity of studies evaluating the effectiveness of TAP block in minimally invasive urologic surgery. Table 2 summarizes a number of randomized controlled trials of TAP block in minimally invasive urologic surgery.

Robot-Assisted Radical Prostatectomy

Two randomized controlled trials examined the potential role of TAP block administration in patients undergoing robot-assisted radical prostatectomy (RARP) and concluded that TAP block was associated with decreased mean postoperative pain in the first 24 h, reduced opiate use, and shorter length of stay (Table 2). The difference in the magnitude of the mean postoperative pain and opioid use reduction between the trials can be attributed to several factors, such as the treatment of the control arm (local anesthetic wounds infiltration vs. placebo), TAP block technique used (midaxillary vs. triangle of Petit approach), and the type of local anesthetic administered (levobupivacaine vs. ropivacaine) [21••, 22].

Recently, our group has described a robot-assisted approach to performing TAP block at the conclusion of RARP [50]. Compared to local anesthetic port infiltration, the robot-assisted TAP block cohort had less pain at 6–12 h (2.05 vs. 3.21, p = 0.0016) and 12–18 h (2.19 vs. 2.97, p = 0.0495) postoperation. In addition, those in the robot-assisted TAP block cohort had less narcotic use than those in the local anesthetic port-site infiltration group [50].

Briefly, at the conclusion of RARP, a butterfly needle attached to IV extension tubing is introduced through the assistant port; the preferred injection point is located just cranial and dorsal to the lateral-most port on both sides. The tip of the butterfly needle is subsequently advanced through the peritoneum and transversus muscle to reach the TAP plane. To

Table 2   Randomized controlled trials of TAP block in minimally invasive urologic surgery

Author	Year of Publication	Study design	Operation	No of treatment/control	Treatment	TAP block technique
Cacciamani.et al [21••]	2018	Randomized double blinded clinical trial	Robot-assisted Radical Prostatectomy	57/43	Postoperative bilateral Ultrasound guided TAP block and local anaesthetic wounds infiltration with 0.35% of Ropivacaine vs local anaesthetic wounds infiltration with 0.35% of Ropivacaine	Mid-axillary
Dal Moro.et al. [22]	2018	Randomized double blinded clinical trial	Robot-assisted Radical Prostatectomy	50/50	Postoperative bilateral Ultrasound guided TAP block using 200 ml of 0.25% levobupivacaine vs. Placebo	Triangle of Petit approach
Güner et al.[47]	2015	Randomized double blinded clinical trial	Laparoscopic donor nephrectomy	25/22	Postoperative unilateral Ultrasound guided TAP block using 20 ml of either 0.5% bupivacaine or saline	Anterior oblique–subcostal
Hosgood et al.[48]	2012	Randomized double blinded clinical trial	Laparoscopic donor nephrectomy	25/25	Preoperative bilateral Ultrasound guided TAP block using 20 ml of either 0.375% bupivacaine or saline	Triangle of Petit approach
Parikh et al. [49]	2013	Randomized double blinded clinical trial	Laparoscopic retroperitoneal donor nephrectomy	30/30	Postoperative unilateral Ultrasound guided TAP block using 25 ml of either 0.375% bupivacaine or saline.	Anterior oblique–subcostal
Aniskevich et al. [24]	2014	Randomized double blinded clinical trial	Laparoscopic hand-assisted nephrectomy	10/11	Preoperative bilateral Ultrasound guided TAP block using 20 mL of 0.5% ropivacaine or saline.	Triangle of Petit approach

Author	Postoperative analgesia	Type	Early pain at rest (NRS score at 0–2 h postoperatively)	Late pain at rest (NRS score at 24 h postoperatively)	Postoperative opioid consumption (up to 24 h postoperatively), (iv morphine, mg)	Length of stay
Cacciamani.et al [21••]	Acetaminophen 1 g Q 8hrs/Tramadol 100mg PRN	TAP Control	2.2(P=0.63) 2.6	1.8 (P=0.04) 2.7	Not reported	4.2(P= 0.04) 4.7
Dal Moro.et al. [22]	Paracetamol 1g Q 8 hrs/ Ketoprofen and Tramadol PRN NRS was > 3.	TAP Control	0.98(P=0.86) 0.99	1.8 (P= < 0.0001) 3.57	20(P= < 0.0001) 70	Not reported
Güner et al.[47]	PCA morphine + acetaminophen 1 g Q 6 Hrs.	TAP Control	3 (P=0.012) 3.5	1.2(P=0.02) 1.8	20 (P= <0.001) 35	2.92 (P=0.453) 2.7
Hosgood et al.[48]	PCA morphine	TAP Control	Not reported	19 (P=0.003) 37	45.6 (P=0.771) 52.7	3.7(P=0.242) 3.1

Table 2 (continued)

Author	Postoperative analgesia	Type	Early pain at rest (NRS score at 0–2 h postoperatively)	Late pain at rest (NRS score at 24 h postoperatively)	Postoperative opioid consumption (up to 24 h postoperatively), (iv morphine, mg)	Length of stay
Parikh et al. [49]	Tramadol (1 mg/kg) PRN VAS> 3	TAP	1 (P<0.05)	1.9 (P> 0.05)	10.4(P<0.05)	Not reported
		Control	2.4	2.3	23.6	
Aniskevich et al. [24]	PCA morphine	TAP	1 (P= 0.61)	1 (P=0.002)	26.6 (P=0.13)	2 (P> 0.05)
		Control	2	5	48.7	2

ensure deposition of the local anesthetic in the desired plane, an initial 1 cc by volume of local anesthetic is injected to visualize a wheal of fluid under the peritoneum and transversus abdominis muscle. After confirming the location of the needle, the rest of the local anesthetic is injected on both sides [50]. The distance between peritoneum and TAP plane is not affected by either the pneumoperitoneum nor body mass index [51].

Minimally Invasive Renal Surgery

Minimally invasive renal surgery is among the preferred approaches for performing partial nephrectomy, nephrectomy for malignant and benign conditions, and donor nephrectomy [1]. We identified three randomized clinical trials focused on assessing the value of TAP block in kidney donors undergoing laparoscopic donor nephrectomy and one randomized clinical trial that explored the effect of TAP block in a mixed population of kidney donors and kidney cancer patients undergoing laparoscopic hand-assisted nephrectomy [24, 47–49] (Table 2). The four clinical trials proved the efficacy of TAP block for decreasing the mean pain score in the first 24 h after surgery. However, postoperative opioid consumption was reduced significantly in two randomized clinical trials, both using the anterior oblique subcostal approach for TAP block rather than the triangle of Petit approach (Table 2).

Cystectomy

Matulewicz and colleagues included TAP block as an integral component of their ERAS protocol for open and robotic cystectomy. In a retrospective review of their experience before and after implementing the ERAS protocol, they found that the ERAS cohort consumed less opioids throughout their hospitalization period (~ 7 days): 89 vs. 336 mg ($p < 0.01$), had a shorter time to pass flatus (3 vs. 4 days, $p < 0.01$), and to first bowel movement (4 vs. 5 days, $p < 0.01$) (Table 2). This rapid resumption of normal bodily processes translated into a shorter median length of stay for the ERAS cohort (7 vs. 8.5 days, $p < 0.01$), without increasing the 30-day/90-day readmission rate [52].

Future Directions

In this review, we found few high-quality studies that examined the role of TAP block in minimally invasive urologic surgery. There is a need for clinical trials comparing the effectiveness of different regional anesthetic techniques. Such clinical trials should include the ERAS protocols as an integral component of the study design. Moreover, these trials should identify novel outcome measures, such as patient mobility, functional recovery, inflammatory biomarkers, circulating tumor cells, response to immunotherapy, and disease recurrence.

Future studies involving TAP block should focus on identifying the proper location of local anesthetic injection, and the timing of TAP block. Also, there is a need to develop perioperative quality measures pertaining to the proper perioperative utilization of regional anesthesia, opioid-sparring analgesia, and opioid consumption.

Conclusion

TAP block is an effective pain control modality for early pain and might reduce postoperative opioid consumption after minimally invasive urologic surgery. Compared to other neuraxial analgesic techniques, TAP block is associated with fewer episodes of hypotension and reduced length of stay.

Compliance with Ethical Standards

Conflict of Interest   Mohammed Shahait and David I. Lee each declare no potential conflicts of interest.

Human and Animal Rights and Informed Consent   This article does not contain any studies with human or animal subjects performed by any of the authors.

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•• Of major importance

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