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REVIEW ARTICLE

Analgesic efficacy of the ultrasound-guided blockade of the transversus abdominis plane – a systematic review

Javier Ripollés[a,*], Sandra Marmaña Mezquita[b], Alfredo Abad[c], José Calvo[a]

[a] *Service of Anesthesiology and Reanimation, Hospital Universitario Infanta Leonor, Madrid, Spain*
[b] *Service of Anesthesiology and Reanimation, Hospital Universitario Moisés Broggi, Sant Joan Despí, Barcelona, Spain*
[c] *Service of Anesthesiology and Reanimation, Hospital Universitario La Paz, Madrid, Spain*

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Abstract
Background: The transverse abdominal plan blockade is a block of abdominal wall that has diffused rapidly in the clinical practice as part of a multimodal analgesia for abdominal surgery. The performance of the ultrasound-guided technique has allowed the lowering of potential complications, as well as new approaches that were carried out according to the descriptions, and the prospective studies would make it possible to utilize the transverse abdominal plan blockade in different surgical interventions; however, the results obtained in randomized clinical trials are inconsistent.
Objectives: To prepare a systematic review aiming to determine the efficacy of the ultrasound-guided transverse abdominal plan blockade for different surgical interventions, as well as the indications according to the approaches and their influences.
Methods: Two research approaches, one manual, and the other in Pubmed returned 28 randomized clinical trials where intervention with ultrasound-guided transverse abdominal plan blockades was performed to compare the analgesic efficacy in contrast to another technique in adults, published between 2007 and October 2013, in English or Spanish, with Jadad score > 1, according to the inclusion criteria for this review. The authors analyzed independently all the randomized clinical trials.
Conclusions: The transverse abdominal plan blockades have been shown to be an effective technique in colorectal surgery, cesarean section, cholecystectomy, hysterectomy, appendectomy, donor nephrectomy, retropubic prostatectomy, and bariatric surgery. However, the data found in randomized clinical trial are not conclusive, and as a result, it is necessary to develop new and well designed randomized clinical trial, with enough statistical power to compare different approaches, drugs, doses, and volumes for the same intervention, aiming to answer the current questions and their effects in the habitual clinical practice.

* Corresponding author.
E-mails: ripo542@gmail.com, ripo542@hotmail.com (J. Ripollés).

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PALAVRAS-CHAVE
Bloqueio TAP;
Plano transverso do abdome;
Ecoguiada;
Revisão sistemática

Eficácia analgésica do bloqueio ecoguiado do plano transverso do abdome – revisão sistemática

Resumo

Justificativa: O bloqueio do plano transverso abdominal (TAP) é um bloqueio da parede abdominal que se difundiu rapidamente na prática clínica como parte de analgesia multimodal em cirurgia abdominal. A técnica ecoguiada permitiu reduzir as possíveis complicações, assim como as novas abordagens, que, de acordo com as descrições feitas e os estudos prospectivos, permitiram usar o TAP em vários procedimentos cirúrgicos; no entanto, os resultados obtidos em ensaios clínicos randomizados (ECR) são inconsistentes.
Objetivos: Revisão sistemática para determinar a eficácia analgésica do TAP ecoguiado em diversos procedimentos cirúrgicos, assim como determinar as indicações de acordo com abordagens e sua influência.
Métodos: Foi feita uma pesquisa no PubMed e outra livre e foram encontrados 28 ECR em que intervenção com o TAP ecoguiado era feita e se comparava sua eficácia analgésica com outra técnica em humanos adultos, publicados entre 2007 e outubro de 2013 com escore de Jadad > 1, em inglês ou espanhol, de acordo com os critérios de inclusão para esta revisão. Todos os ECR foram analisados de forma independente pelos autores.
Conclusões: O TAP mostrou ser uma técnica eficaz em cirurgia colorretal, cesárea, colecistectomia, histerectomia, apendicectomia, nefrectomia em doador, prostatectomia retropúbica e cirurgia bariátrica. No entanto, os dados encontrados nos ECR são inconclusivos, de modo que mais ECR bem desenhados são necessários e com poder estatístico suficiente na comparação de diferentes abordagens, drogas, doses e volumes para uma mesma intervenção, a fim de resolver os temas da atualidade e seu impacto na prática clínica habitual.

Introduction

The block of the transversus abdominis plane (TAP) had been first described as a block of the abdominal wall based on anatomical references to introduce local anesthetic (LA) in the TAP through the Petit triangle by loss of resistance technique.[1] In 2007 the first description of the ultrasound-guided TAP appeared,[2] and its use has become popular since then in high and low abdominal surgeries, although it has not been fully integrated in the regular clinical practice.[3] The apparition of the ultrasound-guided technique has allowed the reduction of block failure risk, unacceptably high in the anatomical technique[4] as well as reduction of possible complications associated with this technique[5] even though they have been described[6] but probably underestimated because of publication bias.

The use of ultrasonography has allowed the development of new approaches, like the subcostal, the posterior,[7] the oblique subcostal,[8] or combinations like the dual TAP[9] in which the possibilities of TAP have been increased. However, currently there is no recommendation for the use of the ultrasound-guided TAP in comparison to the classic TAP[10] due to a lack of randomized clinical trials (RCTs) that test both techniques.[11]

Potentially, the injection of LA at this level provides analgesia in the skin, muscles and parietal peritoneum from T7 to L1, once it blocks the afferent neuronal endings of the abdominal walls. However, currently there is a controversy in the specialized literature in relation to the level of distribution of the local anesthetic with a single injection, since some studies demonstrate an extension from T7 to L1[12] and others, an extension from T10 to L1.[13] The greatest extension demonstrated with the ultrasound-guided technique is T7 with oblique subcostal TAP, T9 with the classic mid-axillary approach, and paravertebral extension from T4 to L1 with the posterior approach.[14] Thereby, the mid-axillary TAP should be used for infraumbilical surgeries, the subcostal for periumbilical, and the oblique subcostal in supraumbilical incisions between T7 and T9.[15] In fact, the RCTs are poorly correlated to the expected extension and not always conclusive. Considering studies of contrast distribution[15] it is possible to suppose that the diffusion of the injected substance will vary according to the approach, with different results that may affect the analgesia. The current literature shows that not all the blockades are equal, and that the approach significantly alters the blockade's pharmacodynamics and the resultant analgesia characteristics. Currently, it is recognized that the more posterior approaches, in other words, the installation of the needle closer to the traditional approach, based on non-ultrasound-guided original, gives rise to a wider analgesia in terms of dermatomes and the temporal block probably due to the block of the sympathetic ganglia in the thoracic paravertebral space.[16] The more anterior approaches provide an analgesia in the abdominal wall in line with the pharmacokinetics of the LA used.

The ultrasound-guided TAP has been used and evaluated in RCTs in colorectal surgery,[17,18] cesarean,[19–27] cholecystectomy,[28–32] hysterectomy,[33–36] inguinal herniorrhaphy,[37,38] appendectomy,[39] nephrectomy,[40,41] bariatric surgery[42,43] and gastrectomy.[44] In addition, it has been used and evaluated in prospective studies in liver transplantation[45] and in prostatectomy.[46]

It is important to note that in spite of TAP providing analgesia in the skin, subcutaneous and parietal peritoneum, it should be always executed as an extra component in the multimodal analgesia, because it is not effective in the control of visceral pain.[47,48]

Due to the fact that diverse techniques and interventions in which the ultrasound-guided TAP has been used, its indications are not determined.[49] The objective of this review is to determine the efficacy of the ultrasound-guided TAP for different surgical interventions in those RCTs where ultrasound-guided TAP has been executed, and to observe how it affects the analgesia. It also investigates the indications according to the approaches, their influence, the influence of TAP duration, and the dose and type of the used LA, in addition to complications and the assessment, or its lack, of the blockade's sensitive level.

Methods

A systematic review about the analgesic efficacy of the ultrasound-guided TAP is performed according to the recommendation established by Preferred Reporting Items for Systematic reviews and Meta-Analysis (PRISMA).[50]

The authors searched in the US National Library of Medicine database (MEDLINE) for the terms «TAP block», «Transversus Abdominal Plane Block», «Transversus Abdominis Plane Block», «Bloqueo del Plano Transverso del Abdomen» and «Bloqueo TAP», as well as manually. The search was restricted to prospective RCT in humans, published between January 2007 and October 2013, in English or Spanish. The found RCTs were evaluated in order to identify those in which ultrasound-guided TAP is compared to another analgesic modality in adult patient. The RCTs with Jadad score < 2[51] (Fig. 1) were not included. The RCTs selected for the systematic review were the ones in which an intervention is performed with ultrasound-guided TAPs that compare the analgesic efficacy in relation to another technique in adult humans, published between 2007 and October 2013, in English or Spanish, with Jadad score > 1. There are RCTs in which the analgesic efficacy is evaluated according to the approach based on references or attended by a surgeon. However, in this review, the authors limited the search to RCT with ultrasound-guided TAP since they consider that currently this technique should be the technique of election, because of the diminution of block failure, the avoidable complications with the ultrasound-guided technique, and the greater possible variety of approaches.

Two independent investigators (J. Ripollés and S. Marmaña) reviewed each article in order to determine the eligible ones. The investigators have extracted the data independently by means of tables made for this purpose and solved discrepancies before analyzing the results. Demographic data, which included author, year of publication, participant, intervention, outcomes, design and Jadad score were extracted from the included RCT (Table 1). For the analysis of the analgesic efficacy, the data extracted were: pain score at rest and in early and late movement, early and late consumption of analgesic (by means of <12 h as early and >12 h as late), time until rescue analgesia, and secondary effects of opioids: postoperative nausea and vomit (PONV), sedation and itching (Table 2). An analysis of the technique used for the TAP was performed, including: type of surgery, type of block, duration, laterality of the block, the needle used, drug, doses and volume utilized, supplemental analgesia administered, identification of sensitive level and complications associated with the TAP (Table 3). The use of mid-axillary approach is assumed in those trials in which it has not been specified.

The probability of methodological bias of each RCT was independently evaluated by two authors, adopting the Jadad score.

Results

Thirty-one RCTs were obtained, which aligned with the inclusion criteria for the systematic review,[17–44] A, D, C, including 2193 patients. The flow diagram of the selection of the RCT is shown in Fig. 2.

The RCTs were divided into subgroups according to the type of the surgery in which TAP was used for its analysis: colorectal,[17,18] cesarean,[19–28] cholecystectomy,[28–33] hysterectomy,[34–37] inguinal herniorrhaphy,[38–40] appendectomy,[41] nephrectomy,[42,43] bariatric,[44,45] gastrectomy[46] and retropubic prostatectomy.[47] Of the articles included, 93.5% had a good quality according to Jadad score.

The characteristics of the RCT included in the systematic review are shown in Table 1.

Intervention and surgery

The ultrasound-guided TAP in colorectal surgery was evaluated in 2 RCTs,[17,18] in which the TAP was compared to TAP vs. epidural anesthesia[17] and TAP vs. placebo TAP[18]; in the first case, it is specified for high abdominal surgery, whereas in the second RCT, an analysis of subgroups is performed distinguishing in left (supraumbilical incision) and right (infraumbilical incision). In the first RCT,[17] a subcostal postoperative approach is utilized, and no differences were found between visual analog scale (VAS) score for pain at rest or in movement in the first 72 h with TAP or

Does the study describe itself as randomized? Yes = 1 point; No = 0 points
Is the method utilized for producing the sequence of randomization described? and Is this method appropriate? Yes = 1 point; No = 0 points; the method is not appropriate = - 1 point
Does the study describe itself as double-blind?
Yes = 1 point; No = 0 points
Is the blinding method described? and Is this method appropriate?
Yes = 1 point; No = 0 points; the method is not appropriate = - 1 point
Is there a description of withdrawals and dropouts?
Yes = 1 point; No = 0 points This questionnaire returns a punctuation in a scale that goes from 0 to 5, so that the higher punctuation means that the evaluated RCT has a better methodological quality. Rigorous 5 points; low quality < 3 points.

Figure 1 Jadad score.

Table 1 PICOs (Patient, Intervention, Comparison, Outcome).

Surgery Author, year	*N*	Intervention	Comparison	Outcome	Design	Jadad Score
C. colorectal						
Niraj et al., 2011[17]	62	Bilateral TAP with catheter in high abdominal surgery	TAP vs. epidural	VAS pain score at rest and in movement in the first 72 h	Randomized double-blind trial	5
Walter et al., 2013[18]	68	Bilateral TAP in c. colorectal	TAP vs. no TAP	Consumption of opioids in the first 24 h	Randomized double-blind trial	5
Cesarean						
Belavy et al., 2009[19]	57	Bilateral TAP in cesarean with spinal anesthesia	TAP vs. placebo TAP	Consumption of opioids in the first 24 h	Randomized blind trial	5
Costello et al., 2009[20]	96	Bilateral TAP in cesarean with spinal anesthesia with ITM	TAP vs. placebo TAP	VAS pain score at rest and in movement in the first 24 h	Randomized double-blind trial	5
Baaj et al., 2010[21]	40	Bilateral TAP in cesarean with spinal anesthesia	TAP vs. placebo TAP	Consumption of opioids in the first 24 h	Randomized double-blind trial	3
Kanazi et al., 2010[22]	57	ITM in cesarean	TAP vs. ITM + placebo TAP	Time until the opioid rescue	Randomized double-blind trial	4
Loane et al., 2012[23]	66	Bilateral TAP in cesarean under spinal anesthesia	TAP vs. ITM + placebo TAP	Consumption of opioids in the first 24 h	Randomized double-blind trial	5
Tan et al., 2012[24]	40	Bilateral TAP in cesarean with general anesthesia	TAP vs. placebo TAP	Consumption of opioids in the first 24 h	Randomized double-blind trial	5
Bollag et al., 2012[25]	90	Bilateral TAP with clonidine in cesarean with spinal anesthesia	clonidine TAP vs. TAP vs. placebo TAP	Hyperalgesia index of the wound following TAP	Randomized double-blind trial	5
Eslamian et al., 2012[26]	50	Bilateral TAP in cesarean with general anesthesia	TAP vs. no TAP	VAS pain score at rest and in movement in the first 24 h	Randomized double-blind trial	5
Cánovas et al., 2013[27]	90	Bilateral TAP in cesarean with spinal anesthesia	TAP vs. placebo TAP vs. ITM + placebo TAP	VAS pain score at rest and in movement in the first 24 h	Randomized double-blind trial	5
Lee et al., 2013[28]	51	Bilateral TAP in cesarean with spinal anesthesia with ITM	TAP vs. placebo TAP	VAS pain score in movement in the first 48 h	Randomized double-blind trial	5
Cholecystectomy						
El-Dawlatly et al., 2009[29]	42	Bilateral TAP in laparoscopic cholecystectomy	TAP vs. no TAP	Consumption of opioids in the first 24 h	Randomized double-blind trial	3
Ra et al., 2010[30]	54	Bilateral TAP in laparoscopic cholecystectomy	TAP vs. placebo TAP	Numerical and verbal pain score in the first 24 h	Randomized blind trial	3

Table 1 (*Continued*)

Surgery Author, year	*N*	Intervention	Comparison	Outcome	Design	Jadad Score
Petersen et al., 2012[31]	80	Bilateral TAP in laparoscopic cholecystectomy	TAP vs. placebo TAP	VAS pain score in movement in the first 24 h	Randomized double-blind trial	5
Ortiz et al., 2012[32]	80	Bilateral TAP in laparoscopic cholecystectomy	TAP vs. infiltration	VAS pain score in the first 24 h	Randomized blind trial	3
Tolchard et al., 2012[33]	43	Bilateral TAP in laparoscopic cholecystectomy	TAP vs. infiltration	Consumption of opioids in the first 24 h Reduction of VAS	Randomized double-blind trial	5
Gynecological						
Griffiths et al., 2010[34]	65	Bilateral TAP in oncologic gynecological surgery	TAP vs. placebo	Consumption of opioids in the first 24 h Reduction of VAS	Randomized double-blind trial	5
Atim et al., 2011[35]	55	Bilateral TAP in hysterectomy	TAP vs. TAP placebo vs. local infiltration	VAS pain score at rest and in movement in the first 24 h	Randomized double-blind trial	2
De Oliveira et al., 2011[36]	75	Bilateral TAP in gynecological c. laparoscopic	TAP vs. placebo TAP	QoR-40 satisfaction score	Randomized double-blind trial	5
Kane et al., 2012[37]	56	Bilateral TAP in laparoscopic hysterectomy	TAP vs. no TAP	Satisfaction score QoR-40	Randomized blind trial	3
H. inguinal						
Aveline et al., 2011[38]	275	Unilateral TAP in inguinal herniorrhaphy	TAP vs. b. ileoinguinal-ileohipogastric	VAS pain score at rest and in movement in the first 24 h	Randomized blind trial	3
López González et al., 2013[39]	41	Unilateral TAP in inguinal herniorrhaphy	TAP vs. infiltration	VAS pain score at rest and im movement in the first 24 h	Randomized blind trial	2
Petersen et al., 2013[40]	90	Unilateral TAP in inguinal herniorrhaphy	TAP vs. Placebo TAP vs. IIB + infiltration LA	VAS pain score at rest and in movement in the first 24 h	Randomized double-blind trial	5
Appendectomy						
Niraj et al., 2009[41]	52	Unilateral TAP in open appendectomy	TAP vs. no TAP	Consumption of opioids in the first 24 h	Randomized double-blind trial	5

Table 1 (*Continued*)

Surgery Author, year	*N*	Intervention	Comparison	Outcome	Design	Jadad Score
Nephrectomy						
Hosgood et al., 2012[42]	46	TAP in donor nephrectomy	TAP vs. placebo TAP	Consumption of opioids in the first 48 h and VAS pain score	Randomized double-blind trial	5
Parikh et al., 2013[43]	60	TAP in donor nephrectomy	TAP vs. placebo TAP	Consumption of opioids in the first 24 h	Randomized double-blind trial	5
Bariatric						
Sinha et al., 2013[44]	100	TAP in bariatric surgery (laparoscopic Y-Roux anastomosis)	TAP vs. placebo TAP	Consumption of opioids in the first 24 h	Randomized double-blind trial	5
Albrecht et al., 2013[45]	70	TAP in bariatric surgery with local infiltration LA	TAP vs. no TAP	Consumption of opioids in the first 24 h	Randomized double-blind trial	5
Gastrectomy						
Wu et al., 2013[46]	90	TAP in radical gastrectomy	TAP vs. epidural vs. no intervention	Consumption of opioids in the first 24 h and VAS pain score	Randomized double-blind trial	5
Elkassabany et al., 2013[47]	52	Bilateral TAP in retropubic radical prostatectomy	TAP vs. placebo TAP	VAS pain score and consumption of opioids in the first 24 h	Randomized double-blind trial	5

LA, local anesthetic; IIB, ilioinguinal block; VAS, visual analog scale; ITM, intrathecal morphine; TAP, transverse abdominis plan.

Table 2 Analgesic efficacy.

Author, year	*N*	Groups (*n*)	Pain score – at rest		Pain score – in movement		Consumption of analgesics		Opioid rescue time	Adverse effects related to opioids			Conclusions
			Early	Late	Early	Late	Early	Late		NVPO	Itching	Sedation	
Niraj et al., 2011[17]	62	1 – TAP n 27 2 – TAP n 31						NA	–	NA		NA	There is no difference between VAS score in rest and during movements in the first 72 h with TAP or epidural
Walter et al., 2013[18]	68	1 – TAP n 33 2 – No TAP n 35						NA	NA				TAP reduces around 33% the mean consumption of opioids in the first 24 h (20 mg); $p < 0.05$
Belavy et al., 2009[19]	57	1 – TAP n 23 2 – placebo TAP n 24						NA	+	–			TAP reduces the mean consumption of opioids in the first 24 h (13.5 mg); $p < 0.05$
Costello et al., 2009[20]	96	1 – TAP n 47 2 – placebo TAP n 49						ND	No	NA	NA	NA	TAP does not reduce the VAS score in the first 24 h
Baaj et al., 2010[21]	40	1 – TAP n 20 2 – placebo TAP n 20	+	+	+	+		NA	NA	+	NA	NA	TAP reduces the mean consumption of opioids in the first 24 h (25.89 mg vs. 62 mg; $p < 0.05$)
Kanazi et al., 2010[22]	57	1 – ITM n 28 2 – TAP n 29	–		–			NA	–	+	+		TAP extends around 50% (TAP 8 h, MIT 4 h) the time since the first opioid rescue ($p < 0.05$)
Loane et al., 2012[23]	66	1 – TAP n 33 2 – ITM + placebo TAP n 33	–	–	–	–		NA		+	+		TAP increases the mean consumption of opioids in the first 24 h (7.5 mg vs. 2.7 mg; $p = 0.03$)

Table 2 (*Continued*)

Author, year	*N*	Groups (*n*)	Pain score – at rest		Pain score – in movement		Consumption of analgesics		Opioid rescue time	Adverse effects related to opioids			Conclusions
			Early	Late	Early	Late	Early	Late		NVPO	Itching	Sedation	
Tan et al., 2012[24]	40	1 – TAP n 20 2 – placebo TAP n 20						NA	NA				TAP reduces the mean consumption of opioids in the first 24 h (12.3 mg vs. 31.4 mg; $p < 0.01$)
Bollag et al., 2012[25]	90	1 – TAP placebo n 30 2 – TAP n 25 3 – TAP clonidine n 26	–		–		+	+	NA	NA	NA	NA	To add clonidine to TAP with bupivacaine does not improve the injuries hyperalgesia rate, and it does not improve the VAS score at rest and in movement
Eslamian et al., 2012[26]	50	1 – TAP n 23 2 – No TAP n 25	+		+	+	+	+	+	NA	NA	NA	TAP reduces the VAS score at rest and in movement, as well as the consumption of opioids in the first 24 h (50 mg tramadol vs. 150 mg tramadol; $p = 0.0001$)
Cánovas et al., 2013[27]	90	1 – ITM + placebo TAP n 30 2 – placebo TAP 3 – TAP	+	+	+	+	+	+	+	+	+		TAP reduces the VAS score at rest, 12/24 h ($p < 0.05$), and in movement ($p \leq 0.02$)
Lee et al., 2013[28]	51	1 – TAP n 26 2 – placebo TAP n 25	+		+		+	+					TAP reduces the pain score at rest and in movement in the first 2 postoperative hours (0.5 and 1.9 vs. 2.8 and 4.9; $p < 0.001$)

Table 2 (*Continued*)

Author, year	*N*	Groups (*n*)	Pain score – at rest		Pain score – in movement		Consumption of analgesics		Opioid rescue time	Adverse effects related to opioids			Conclusions
			Early	Late	Early	Late	Early	Late		NVPO	Itching	Sedation	
El-Dawlatly et al., 2009[29]	42	1 – TAP n 21 2 – No TAP n 21	NA	NA	NA	NA	+	+	NA	NA	NA	NA	TAP reduces the intraoperative consumption of sufentanyl ($p < 0.01$), and also reduces the consumption of morphine in the first 24 h (12.3 mg; $p < 0.05$)
Ra et al., 2010[30]	54	1 – TAP 0.5% n 18 2 – TAP 0.25% n 18 3 – No TAP	+	+	+	+	+	+	NA	NA	NA	+	TAP 0.25% and TAP 0.5% reduce verbal-numerical pain score in the first 24 h ($p < 0.001$). There are no differences between TAP 0.25% and TAP 0.5%. TAP reduces the consumption of intraoperative remifentanyl and also reduces the consumption of analgesics in postoperative ($p < 0.001$). There are no differences between TAP 0.25% and TAP 0.5%
Petersen et al., 2012[31]	80	1 – TAP n 37 2 – placebo TAP n 37		+		+	+		NA		NA		TAP reduces the VAS pain score in movement, calculated as the area under the curve in the first 24 h (26 mm vs. 34 mm; $p = 0.04$)

Table 2 (*Continued*)

Author, year	*N*	Groups (*n*)	Pain score – at rest		Pain score – in movement		Consumption of analgesics		Opioid rescue time	Adverse effects related to opioids			Conclusions
			Early	Late	Early	Late	Early	Late		NVPO	Itching	Sedation	
Ortiz et al., 2012[32]	80	1 – TAP n 39 2 – local infiltration n 35						NA	NA	NA	NA	NA	TAP does not reduce the VAS score in the first 24 h
Tolchard et al., 2012[33]	43	1 – TAP n 21 2 – local infiltration n 22	+	NA	+	NA		–	NA	NA	NA	NA	TAP reduces VAS in the first 8 h ($p < 0.01$) TAP reduces the consumption of opioids in the first 8 h (9.2 mg vs. 16.8 mg; $p < 0.01$)
Griffiths et al., 2010[34]	65	1 – TAP n 32 2 – placebo TAP n 33							NA				TAP does not reduce the consumption of opioids in the first 24 h. TAP does not reduce VAS in the first 2 postoperative hours.
Atim et al., 2011[35]	55	1 – TAP n 18 2 – placebo TAP n 18 3 – local infiltration n 19	+	+	+	+	+		NA		NA		TAP and infiltration reduce the pain score at rest and in movement at the hours 1, 2, 4, 6, 24 ($p < 0.0001$). TAP reduces the pain score at rest and in movement at the hours 6 and 24 regarding the infiltration ($p < 0.001$)

Table 2 (*Continued*)

Author, year	*N*	Groups (*n*)	Pain score – at rest		Pain score – in movement		Consumption of analgesics		Opioid rescue time	Adverse effects related to opioids			Conclusions
			Early	Late	Early	Late	Early	Late		NVPO	Itching	Sedation	
De Oliveira et al., 2011[36]	75	1 – TAP 0.25% n 23 2 – TAP 0.5% n 24 3 – placebo TAP n 23	+	+	+	+	+	+	NA	NA	NA	NA	TAP improves the QoR-40 satisfaction score; average of 16 ropivacaine 0.5% and 17 ropivacaine 0.25% vs. saline ($p < 0.05$). There are no differences between ropivacaine 0.5% vs. ropivacaine 0.25%
Kane et al., 2012[37]	56	1 – TAP n 28 2 – No TAP n 28								NA	NA	NA	TAP does not reduce the QoR-40 score or VAS scale. It does not reduce or increase the consumption of opioids
Aveline et al., 2011[38]	275	1 – TAP n 132 2 – IHB n 139	+	+			+	+	NA	NA	NA	NA	TAP reduces the pain score at early (average 11 vs. 15; $p = 0.04$) and late (average 29 vs. 33; $p = 0.013$) rest. TAP reduces the mean consumption of opioids in the first 24 h; $p = 0.03$
López González et al., 2013[39]	41	1 – TAP n 20 2 – local infiltration n 21					+	+	[a]				Significant differences were not detected in VAS pain score between rest and movement. TAP reduces the mean consumption of opioids in the first 24 h (0.3 mg vs. 1.05 mg; $p < 0.05$)

Table 2 (*Continued*)

Author, year	*N*	Groups (*n*)	Pain score – at rest		Pain score – in movement		Consumption of analgesics		Opioid rescue time	Adverse effects related to opioids			Conclusions
			Early	Late	Early	Late	Early	Late		NVPO	Itching	Sedation	
Petersen et al., 2013[40]	90	1 – TAP n 30 2 – Infiltration/IIB 30 3 – placebo TAP n 30	—		—	—							TAP does not reduce the pain score at rest or in movement in the first 24 h
Niraj et al., 2009[41]	52	1 – TAP n 25 2 – No TAP n 26	+	+	+	+			NA	+	NA	NA	TAP reduces the mean consumption of opioids in the first 24 h (28 mg vs. 50 mg; $p < 0.002$)
Hosgood et al., 2012[42]	51	1 – TAP n 25 2 – placebo TAP n 25	+	+	+	+	+	+	+		NA		TAP reduces the mean consumption of opioids in the first 24 postoperative hours (12.4 mg vs. 21. 6 mg; $p = 0.015$). There is no significant difference in the cumulative consumption of opioids in the first 48 h
Parikh et al., 2013[43]	60	1 – TAP n 30 2 – placebo TAP n 30	+		+		+	+	+		NA		TAP reduces the mean consumption of opioids in the first 24 h (103.8 ± 32.18 mg vs. 235.8 ± 47.5 mg)
Sinha et al., 2013[44]	100	1 – TAP n 50 2 – placebo TAP n 50	+	+	+	+	+	+	NA			+	TAP reduces the mean consumption of opioids in the first 24 h (8 mg vs. 48 mg; $p = 0.000$)

Table 2 (*Continued*)

Author, year	*N*	Groups (*n*)	Pain score – at rest		Pain score – in movement		Consumption of analgesics		Opioid rescue time	Adverse effects related to opioids			Conclusions
			Early	Late	Early	Late	Early	Late		NVPO	Itching	Sedation	
Albrecht et al., 2013[45]	70	1 – TAP n 25 2 – No TAP n 28											There are no differences between the consumption of opioids TAP and control in the first 4 postoperative hours (32.2 mg vs. 35.6 mg; $p = 0.41$)
Wu et al., 2013[46]	90	1 – TAP n 29 2 – Epidural n 27 3 – Control n 26					−/+	−/+	NA				TAP is better than general anesthesia regarding the consumption of opioids in the first 24 h. Epidural is better than TAP regarding the consumption of opioids in the first 24 h
Elkassabany et al., 2013[47]	52	1 – TAP n 16 2 – placebo TAP n 16	+	−	+	−	+	−	+	−	NA	NA	TAP reduces the mean consumption of opioids in the first 24 h (22.1 mg vs. 45.5 mg,)

IHB, iliohypogastric block; IIB, ilioinguinal block; VAS, visual analog scale; ITM, intrathecal morphine; NA, not available; TAP, transverse abdominis plan; +, favorable to TAP; −, favorable to comparator.

[a] No differences.

Table 3 Technique of block.

Author, year	Type of block	Technique	Time	Needle	Anesthetic used by injection	Complications	Sensitive level of the block	Block duration	Additional analgesia	Conclusions
Niraj et al., 2011[17]	Bilateral	Subcostal	Postoperative	16 G 80 mm	1 mg kg^{-1} bupivacaine 0.375%	No	No	NA	Paracetamol 1 g Tramadol 50–100 mg	There are no differences between VAS pain score at rest or in movement in the first 72 h, with TAP or epidural
Walter et al., 2013[18]	Bilateral	ND	Preoperative	ND	40 ml. Levobupiva-caine 2 mg kg^{-1} (maximum 150 mg)	No	No	NA	Paracetamol 1 g	TAP reduces in 33% the mean consumption of opioids in the first 24 h (20 mg), $p < 0.05$
Belavy et al., 2009[19]	Bilateral	Mid-axillary	Postoperative	20 G 150 mm	20 ml ropivacaine 0.5%	No	No	NA	Paracetamol 1 g Diclofenac 100 mg	TAP reduces the mean consumption of opioids in the first 24 h (13.5 mg), $p < 0.05$
Costello et al., 2009[20]	Bilateral	Mid-axillary	Postoperative	20 G 64 mm	20 ml ropivacaine 0.375%	No	No	No	Ketorolac 30 mg Paracetamol 1.3 g rectal	TAP does not reduce VAS score in the first 24 h
Baaj et al., 2010[21]	Bilateral	Mid-axillary	Preoperative	20 G 100 mm	20 ml bupivacaine 0.25%	No	No	NA	No	TAP reduces the mean consumption of opioids in the first 24 h, (25.89 mg vs. 62 mg; $p < 0.05$)
Kanazi et al., 2010[22]	Bilateral	Mid-axillary	Postoperative	21 G 100 mm	20 ml levobupiva-caine 0.375 + adrenaline	No	No	NA	Paracetamol 1 g Diclofenac 100 mg	TAP extends 50% (TAP 8 h, MIT 4 h) of the time until the first opioid rescue, $p < 0.05$
Loane et al., 2012[23]	Bilateral	Mid-axillary	Postoperative	22 G 80 mm	Ropivacaine 1.5 mg kg^{-1} maximum 20 ml	No	No	NA	Naproxen 500 mg Paracetamol 1 g	TAP increases the mean consumption of opioids in the first 24 h, (7.5 mg vs. 2.7 mg; $p = 0.03$)
Tan et al., 2012[24]	Bilateral	Mid-axillary	Postoperative	22 G 70 mm	20 ml levobupiva-caine 0.25%	No	No	NA	Morphine chloride 0.15 mg kg^{-1}	TAP reduces the mean consumption of opioids in the first 24 h (12.3 mg vs. 31.4 mg; $p < 0.01$)

Table 3 (*Continued*)

Author, year	Type of block	Technique	Time	Needle	Anesthetic used by injection	Complications	Sensitive level of the block	Block duration	Additional analgesia	Conclusions
Bollag et al., 2012[25]	Bilateral	Mid-axillary	Postoperative	20 G	20 ml ropivacaine 0.375%	No	No	NA	Paracetamol 1 g Diclofenac 75 mg Tramadol	To add clonidine to TAP with bupivacaine does not improve the wound hyperalgesia rate, and it does not improve the VAS score at rest and in movement
Eslamian et al., 2012[26]	Bilateral	Mid-axillary	Postoperative	22 G 50 mm	15 ml bupivacaine 0.25%	No	No	NA	Diclofenac 100 mg	TAP reduces the VAS score at rest and in movement, as well as the consumption of opioids in the first 24 h (50 mg tramadol vs. 150 mg tramadol; $p = 0.0001$)
Cánovas et al., 2013[27]	Bilateral	Mid-axillary	Postoperative	20 G	20 ml levobupiva-caine 0.5%	No	No	NA	Morphine chloride	TAP reduces VAS at rest, 12/24 h ($p < 0.05$), and in movement ($p \leq 0.02$)
Lee et al., 2013[28]	Bilateral	Mid-axillary	Postoperative	21 G 90 mm	20 ml ropivacaine 0.5%	No	No	NA	Paracetamol 1 g Ketorolac 50 mg Morphine chloride	TAP reduces the pain score at rest and in movement in the first 2 postoperative hours (0.5 and 1.9 vs. 2.8 and 4.9; $p < 0.001$)
El-Dawlatly et al., 2009[29]	Bilateral	Mid-axillary	Preoperative	21 G 90 mm	15 ml bupivacaine 0.5	No	No	NA	NA	TAP reduces the intraoperative consumption of sufentanil ($p < 0.01$) as well as the consumption of morphine in the first 24 h (12.3 mg; $p < 0.05$)

Table 3 (*Continued*)

Author, year	Type of block	Technique	Time	Needle	Anesthetic used by injection	Complications	Sensitive level of the block	Block duration	Additional analgesia	Conclusions
Ra et al., 2010[30]	Bilateral	Mid-axillary	Preoperative	22 G 50 mm	15 ml bupivacaine 0.25% o 15 ml bupivacaine 0.5%	No	No	NA	Ketorolac 30 mg Fentanyl	TAP 0.25% and TAP 0.5% reduce the verbal-numerical pain score in the first 24 h ($p < 0.001$). There are no differences between TAP 0.25% and TAP 0.5%. TAP reduces the consumption of intraoperative remifentanyl as well as the use of postoperative analgesics ($p < 0.001$). There are no differences between TAP 0.25% and TAP 0.5%
L. Petersen et al., 2012[31]	Bilateral	Mid-axillary	Preoperative	22 G 80 mm	20 ml ropivacaine 0.5%	No	No	24 h	Paracetamol 1 g Ibuprofen 600 mg Morphine chloride	TAP reduces the VAS pain score movement, calculated as the area under the curve in the first 24 h (26 mm vs. 34 mm; $p = 0.04$)
Ortiz et al., 2012[32]	Bilateral	Mid-axillary	Preoperative	21 G 100 mm	15 ml bupivacaine 0>,5%	No	No	NA	Ketorolac 30 mg	TAP does not reduce the VAS score in the first 24 h
Tolchard et al., 2012[33]	Bilateral	Subcostal	Preoperative	22 G 100 mm	Bupivacaine 1 mg kg^{-1} (average 22 ml)	No	No	NA	Codeine	TAP reduces VAS in the first 8 h ($p < 0.01$) TAP reduces the consumption of opioids in the first 8 h, (9.2 mg vs. 16.8 mg; $p < 0.01$)
Griffiths et al., 2010[34]	Bilateral	Mid-axillary	Postoperative	90 mm	20 ml ropivacaine 0.5%	No	No	NA	Paracetamol 1 g, parecoxib 40 mg	TAP does not reduce the consumption of opioids in the first 24 h. TAP does not reduce VAS in the first 2 postoperative hours

Table 3 (*Continued*)

Author, year	Type of block	Technique	Time	Needle	Anesthetic used by injection	Complications	Sensitive level of the block	Block duration	Additional analgesia	Conclusions
Atim et al., 2011[35]	Bilateral	Medial armpit	Preoperative	20 G 100 mm	20 ml bupivacaine 0.25%	No	No	NA	Diclofenac 75 mg Tramadol 0.5 mg kg^{-1}	TAP and infiltration reduce the pain score at rest and in movement at the hours 1, 2, 4, 6, 24 ($p < 0.0001$). TAP reduces the pain score at rest and in movement at the hours 6 and 24 regarding the infiltration ($p < 0.001$)
De Oliveira et al., 2011[36]	Bilateral	Mid-axillary	Preoperative	21 G 90 mm	15 ml ropivacaine 0.25% o 0.5%	No	No	NA	Ketorolac 30 mg	TAP improves the QoR-40 satisfaction score; average 16 ropivacaine 0.5% and 17 ropivacaine 0.25% vs. saline; $p < 0.05$. There are no differences between ropivacaine 0.5% vs. ropivacaine 0.25%
Kane et al., 2012[37]	Bilateral	NA	Postoperative	NA	20 ml ropivacaine 0.5% + adrenaline	No	No	NA	NA	TAP does not reduce QoR-40 score or VAS score. It does not reduce or increase the consumption of opioids
Aveline et al., 2011[38]	Unilateral	Mid-axillary	Preoperative	22 G	1.5 mg kg^{-1} levobupiva-caine 0.5%	No	No	NA	Paracetamol 1 g Ketoprofen 100 mg	TAP reduces the pain score at early (average 11 vs. 15; $p = 0.04$) and late (average 29 vs. 33; $p = 0.013$) rest. TAP reduces the mean consumption of opioids in the first 24 h ($p = 0.03$)

Table 3 (*Continued*)

Author, year	Type of block	Technique	Time	Needle	Anesthetic used by injection	Complications	Sensitive level of the block	Block duration	Additional analgesia	Conclusions
López González et al., 2013[39]	Unilateral	Mid-axillary	Preoperative	NA	30 ml bupivacaine 0.25%	No	No	NA	Paracetamol 1 g Dexketoprofen 50 mg Morphine chloride	Significant differences were not detected in VAS pain score between at rest and in movement. TAP reduces the mean consumption of opioids in the first 24 h (0.3 mg vs. 1.05 mg; $p < 0.05$)
Petersen et al., 2013[40]	Unilateral	Mid-axillary	Preoperative	22 G 80 mm	25 ml ropivacaine 0.75%	No	No	NA	Ketebidona	TAP does not reduce the pain scale at rest or in movement in the first 24 h
Niraj et al., 2009[41]	Unilateral	Mid-axillary	Postoperative	23 G 60 mm	20 ml ropivacaine 0.5%	No	No	NA	Paracetamol 1 g Diclofenac 50 mg	TAP reduces the mean consumption of opioids in the first 24 h (28 mg vs. 50 mg; $p < 0.002$)
Hosgood et al., 2012[42]	Unilateral	Mid-axillary	Preoperative	22 G	20 ml ropivacaine 0.375%	No	No	NA	Paracetamol 1 g Morphine chloride	TAP reduces the mean consumption of opioids in the first 6 postoperative hours (12.4 mg vs. 21.6 mg; $p = 0.015$). There is no significant difference in the cumulative consumption of opioids in the first 48 h
Parikh et al., 2013[43]	Unilateral	Mid-axillary	Postoperative	18 G tohuy	25 ml bupivacaine 0.375%	No	No	NA	Diclofenac 1.5 mg kg^{-1} Tramadol	TAP reduces the mean consumption of opioids in the first 24 h (103.8 ± 32.18 mg vs. 235.8 ± 47.5 mg)
Sinha et al., 2013[44]	Bilateral	Modified mid-axillary	Postoperative	NA	20 ml ropivacaine 0.375%	No	No	No	NA	TAP reduces the mean consumption of opioids in the first 24 h (8 mg vs. 48 mg; $p = 0.000$)

Table 3 (*Continued*)

Author, year	Type of block	Technique	Time	Needle	Anesthetic used by injection	Complications	Sensitive level of the block	Block duration	Additional analgesia	Conclusions
Albrecht et al., 2013[45]	Bilateral	Oblique subcostal	Preoperative	22 G 80 mm	30 ml bupivacaine 0.25% + adrenaline	No	No	No	Paracetamol 1 g Oxycodone 5–10 mg	There are no differences in the consumption of opioids between TAP and control in the first 24 postoperative hours (32.2 mg vs. 35.6 mg; $p = 0.41$)
Wu et al., 2013[46]	Bilateral	Oblique subcostal	Preoperative	ND	20 ml ropivacaine 0.375%	No	No	No	Morphine chloride	TAP is better than general anesthesia regarding the consumption of opioids in the first 24 h. Epidural is better than TAP regarding the consumption of opioids in the first 24 h
Elkassabany et al., 2013[47]	Bilateral	Mid-axillary	Postoperative	22 G	20 ml bupivacaine 0.5%	No	No	No	Morphine chloride	TAP reduces the mean consumption of opioids in the first 24 h (22.1 mg vs. 45.5 mg)

VAS, visual analog scale; ITM, intrathecal morphine; NA, not available; TAP, transverse abdominis plan.

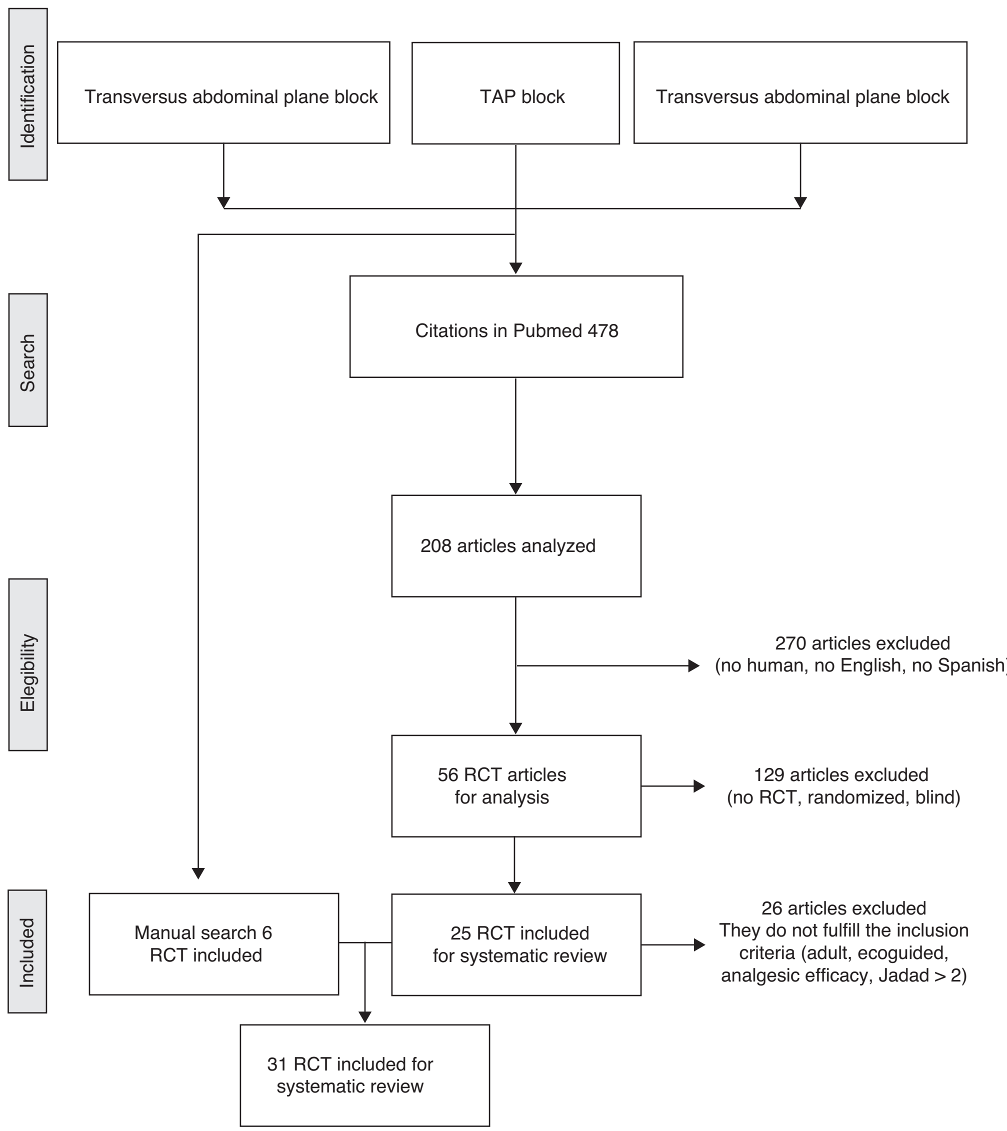

Figure 2 Flow diagram of the selection of the articles included.

epidural. In the second RCT,[18] a preoperative mid-axillary approach was performed and a reduction of 33% in the mean consumption of opioids was observed in the first 24 h (20 mg) ($p < 0.05$), mainly due to the infraumbilical surgery, although the consumption of opioids in the first 24 h in the supraumbilical-surgery subgroup also decreased. Decrease of PONV, sedation or itching was observed in none of the cases.

The ultrasound-guided TAP in cesarean was evaluated in 10 RCTs. Among those, cesarean with spinal anesthesia was evaluated in 8 RCTs[19–23,25,27]; of which 4[20,22,23,27] compared TAP vs. spinal morphine (ITM), 2 compared vs. placebo TAP,[19,21] and in one the addition of clonidine in TAP vs. TAP vs. placebo TAP,[26] and recently the analgesic effect TAP in cesarean with spinal anesthesia with ITM was evaluated.[28]

In 2 RCTs, TAP with cesarean was compared to general anesthesia.[24,26] In all cases, the block was carried out after the cesarean, through bilateral mid-axillary approach; in none there were complications associated with TAP nor the sensitive level neither the duration of the block were altered.[19–28]

Among the RCTs comparing TAP vs. ITM, in Costello et al.[19] there were no significant differences in VAS in pain at rest or in movement, or any significant reduction in time until the opioid rescue. Kanazi et al.[22] demonstrated that TAP prolonged 50% the time until the opioid rescue, and increased the early VAS at rest and in movement, and reduced PONV and itching in the TAP group. Similarly, the RCTs carried out by Loane et al.[23] demonstrated an increase in the consumption of opioids in the first 24 hours (h) (7.5 mg vs. 2.7 mg; $p = 0.03$), as well as an increase in the VAS both at rest and in early and late movement, whereas reduced the PONV and itching. Recently, Cánovas et al.[27] carried out a RCT in the 3 groups of patients undergoing cesarean where spinal anesthesia was administered: in the group A, 0.1 mg of morphine, in the group B, 10 mcg of fentanyl, and in the group C, 10 mcg of fentanyl and bilateral TAP block. The VAS at early/late rest was: group A, at 12 h 2.1 ± 1.2, and at 24 h 4.7 ± 1.6; in the group B, at 12 h 4.3 ± 2.9, and at 24 h 4.8 ± 2.0; and in the group C, at 12 h 1.9 ± 1.1, and at 24 h 2.3 ± 1.2 ($p < 0.05$). When in movement, the analgesia was better in the group C ($p \leq 0.02$). The time until the analgesic rescue was inferior in the group B: in the group A, 9.3 ± 4.9 ($p = 0.02$ in comparison to the group C); in the group B, 2 ± 1.8 ($p < 0.001$ in comparison to the group C); and in the group C, 13.2 ± 2.1 h. The consumption of opioids in the first 24 h was: in the group B 38 ± 5, in the group A, 10 ± 2 ($p < 0.05$), and in the group C, 5 ± 2 ($p < 0.001$). The incidence of nausea was superior in the group B (36.6%), and the itching was greater in group A (36.6%).

Bollag et al.[25] studied the effect of the addition of clonidine and ropivacaine in the execution of the TAP in patients undergoing cesarean under spinal anesthesia with ITM to measure wound hyperalgesia. There were no differences between ITM, ITM with TAP and ITM with TAP and clonidine. No differences in the consumption of opioids or in VAS were found.

In the RCTs that compared TAP vs. placebo TAP in cesarean with spinal anesthesia without ITM, Belavy et al.[19] found a decrease in the consumption of opioids in the first 24 h (18 mg vs. 13.5 mg; $p < 0.05$) and in the time for the first opioid rescue (2 h vs. 3 h; $p = 0.019$). However, no significant differences in VAS at rest or movement were found, as well as for the incidence of secondary effects of opioids. Baaj et al.[21] demonstrated a significant reduction in the consumption of opioids in the first 24 h (25.89 mg vs. 62 mg; $p > 0.05$), as well as a lessening of 25% in the VAS at rest and in movement for the first 24 h, and a decrease in PONV. These results, however, were not significant.

Lee et al.[28] demonstrated that the execution of bilateral TAP in patients scheduled to cesarean with spinal anesthesia with ITM lessens significantly the pain score at rest or in movement within the first 2 h after the surgery (0.5 and 1.9 vs. 2.8 and 4.9; $p < 0.001$). It also decreases the consumption of analgesics (0 vs. 25%; $p = 0.01$). However, no significant differences were found in reducing the pain score in the first 24 h or in PONV.

In the RCT that compare TAP vs. placebo TAP in cesarean under general anesthesia, Tan et al.[24] concluded that the TAP reduces the mean consumption of opioids in the first 24 h (12.3 mg vs. 31.4 mg; $p < 0.01$). In addition, no significant differences were found in the VAS at rest or in movement or in the apparition of secondary effects of opioids. Eslamian et al.[26] demonstrated a decrease in the VAS at rest and in movement, a reduction in the consumption of opioids in the first 24 h (50 mg vs. 250 mg; $p = 0.001$) and an increase for the opioid rescue (210 min vs. 30 min; $p = 0.0001$); the incidence of secondary effects of opioids was not evaluated.

The ultrasound-guided bilateral TAP in laparoscopic cholecystectomy was studied in 5 RCTs,[29–33] among whose placebo was compared with in 3,[29,30] and no intervention in one[28]; and in 2 of the RCTs to the LA infiltration in laparoscopic wounds.[32,33] In all the cases, it was executed bilaterally and after the operation. In four cases,[29,32] a mid-axillary approach was used, and in one, subcostal.[33] In the RCT where TAP is compared to placebo TAP or no intervention,[29–31] El-Dawlatly et al.[29] compared the effect of the TAP in laparoscopic cholecystectomy vs. no intervention and demonstrated a lower consumption of intraoperative opioids (8.6 mcg vs. 23 mcg; $p < 0.01$), and of morphine in the first 24 h (10.5 mg vs. 22.8 mg; $p < 0.05$). Neither VAS nor secondary effects of opioids were evaluated. Ra et al.[30] compared TAP with bupivacaine 0.25% vs. TAP with bupivacaine 0.5% vs. placebo TAP, demonstrating that TAP, at both concentrations in comparison with placebo reduced the numeric verbal pain score in the first 24 h ($p < 0.001$), regardless the bupivacaine doses of 0.25% and 0.5%. The consumption of intraoperative opioids and analgesics in the postoperative period was lower in the groups with TAP with bupivacaine ($p < 0.001$), with no influence from different LA concentrations used. The control group presented higher sedation score in the postoperative period in comparison with the group of TAP plus bupivacaine 0.5%. Petersen et al.,[31] when comparing TAP vs. placebo TAP found a reduction for VAS in movement (calculated as an area under the curve) in the first 24 h (26 mm vs. 34 mm; $p = 0.04$); as well as a lower consumption of opioids in the first 2 postoperative hours (7.5 mg vs. 5 mg; $p < 0.001$). There were no differences in PONV or in sedation between the two groups. In the RCT that compare TAP vs. LA infiltration in laparoscopic wounds in the laparoscopic cholecystectomy,[31,32] Ortiz et al.[32] performed a mid-axillary approach and did not find differences in the VAS, in the consumption of analgesics in the first 24 h, and in PONV. However, recently Tolchard et al.,[33] from a subcostal approach, demonstrated that the TAP lowered the early VAS in movement (8 h; $p < 0.01$) as well as the consumption of opioids in the first 8 h (9.2 mg vs. 16.8 mg; $p < 0.01$). The secondary effects of opioids were not evaluated.

The TAP in gynecologic surgery was evaluated in four RCTs[34–37] in oncogynecological procedures via mid-laparotomy,[34] via laparoscopy in major outpatient surgery regime[36] and in total abdominal hysterectomy with Pfannenstiel[35] incision, and in laparoscopic hysterectomy.[37] In 3 of these, TAP vs. placebo TAP or no intervention is compared,[34,36,37] and in one, TAP vs. placebo TAP vs. infiltration is compared.[35] In all the cases, a bilateral mid-axillary approach was used; in 2, preoperatively,[35,36] and in 2, postoperatively.[34,37] Griffiths et al.,[34] in a heterogeneous group of patients that underwent oncogynecological procedures by mid-laparotomy, did not find differences in the consumption of opioids in the first 24 h (34 mg vs. 36.1 mg; $p = 0.76$), in the early EVA at rest or in movement or in the reduction of PONV. De Oliveira et al.[36] compared the use of TAP with ropivacaine 0.5% vs. ropivacaine 0.25% and placebo TAP in outpatient laparoscopic procedures, demonstrating that TAP improves the QoR-40 satisfaction score (average 16 ropivacaine 0.5%, and 17 ropivacaine 0.25% vs. saline; $p < 0.05$, mainly due to the component of pain and the consumption of opioids) and found no differences between ropivacaine 0.5% vs. ropivacaine 0.25%. The apparition of secondary effects of opioids was not evaluated, although there were no differences in the quantity of antiemetics used in the 3 groups compared. Atim et al.[35] demonstrated lower VAS at rest or in early or late movement in total abdominal hysterectomy with Pfannenstiel incision ($p < 0.0001$), the TAP and infiltration being higher than the infiltration with LA ($p < 0.001$). The consumption of opioids was significantly lower in the TAP group in the first 4 h ($p < 0.001$). There was no reduction in the secondary effects in the control group or in the group with LA infiltration. However, Kane et al.[37] did not find differences in the consumption of opioids in the

QoR-40 score in patients that underwent laparoscopic hysterectomy.

The use of ultrasound-guided TAP in inguinal herniorrhaphy with general anesthesia was studied in 3 RCT[38–40]; in the 3 it was performed in unilateral, mid-axillary, and preoperative. Aveline et al.[38] compared TAP vs. ilioinguinal/iliohypogastric block demonstrating, within a large series of 275 patients, that the TAP decreased the pain score at early (average 11 vs. 15; $p = 0.04$) and late (average 29 vs. 33; $p = 0.013$) rest, and the mean consumption of opioids in the first 24 h ($p = 0.03$). Recently López-González et al.[39] compared TAP vs. LA local infiltration finding no significant differences in VAS pain score at rest or in movement. Although the mean consumption of opioids decreased in the first 24 h (0.3 mg vs. 1.05 mg; $p < 0.05$), even without clinical relevance, the difference is lower and there were no differences in the secondary effects of opioids. Petersen et al.[40] compare the use of TAP vs. placebo TAP and vs. ilioinguinal block attended by a surgeon for the infiltration of surgical wound, demonstrating that the execution of TAP in inguinal herniorrhaphy brings no benefits to the analgesia obtained from paracetamol and ibuprofen.

Niraj et al.[41] demonstrated that the TAPs diminish the mean consumption of opioids in the first 24 h (28 mg vs. 50 mg; $p < 0.002$), the VAS at rest or in movement in the first 24 h and PONV when it is compared to intravenous analgesia in patients that underwent open appendectomy, and have not found complications associated with the TAP.[41]

Two RCTs compared TAP vs. placebo in donor nephrectomy.[42,43] In both RCTs a lower mean consumption of opioids in the first 24 h (12.4 mg vs. 21.6 mg; $p = 0.015$ in the first 6 h[42] and 103.8 ± 32.18 mg vs. 235.8 ± 47.5 mg in the first 24 h)[43] as well as a lower postoperative VAS was demonstrated. In none there were differences in PONV, sedation or itching.

The ultrasound-guided TAP in laparoscopic bariatric surgery was evaluated in 2 RCTs.[44,45] Sinha et al.[44] demonstrated the utility of bilateral TAP vs. placebo by using a modification of the classical mid-axillary approach in the reduction of opioids consumption in the first 24 h (8 mg vs. 48 mg; $p = 0.000$), and in VAS at rest or movement in the first 24 h, as well as all for the secondary effects of opioids. However, Albrecht et al.[45], comparing TAP vs. no TAP in patients receiving LA infiltration, did not find any benefits in the execution of TAP by oblique subcostal approach.

Wu et al.[46] compared the preoperative oblique subcostal bilateral TAP in radical gastrectomy to thoracic epidural and no intervention (general anesthesia), finding that TAP is superior to the general anesthesia for the consumption of opioids in the first 24 h, but inferior to thoracic epidural in this consumption. TAP did not diminish VAS in comparison to general anesthesia, as well as the epidural did not diminish VAS in comparison to the TAP. Wu et al.[46] conclude that the epidural is superior to the TAP in radical gastrectomy.

Recently, the bilateral mid-axillary TAP[7] in retropubic radical prostatectomy has been used, demonstrating a diminution in the consumption of opioids in the first 24 h (22.1 mg vs. 45.5 mg; $p < 0.05$), as well as an increase in the time until the first opioid rescue ($p = 0.001$) and a lower early and late pain score ($p < 0.05$).

Approach and time for block execution

Twenty-eight RCTs were found where mid-axillary approach was carried out,[18–44,47] one subcostal,[17] and 2 RCTs in which the oblique subcostal approach was executed.[44,46]

The blockade was carried out preoperatively in 15,[18,21,28–32,34,35,37,38,40,43,44] and postoperatively in 16[17,19,20,22–27,34,37,40–43,47]; obtaining favorable results in 11 of the 15 RCTs carried out preoperatively,[18,21,29–31,33,35,36,38,39,42] and in 11 of the 16 RCTs in those carried out postoperatively.[19,24–27,40–43,47] However, none of the RCTs compared the preoperative vs. postoperative TAP or different approaches for the same intervention.

Drugs, volume and doses

Several LAs and their concentrations were used in TAP: bupivacaine in 10 (0.25% in 4[21,30,35,39]; 0.375% in 2[17,43]; and 5% in 4[26,29,30] and 1 mg kg^{-1} in one[33]) levobupivacaine in 5 (0.25% in one[24]; 0.375% in one[22]; 0.5% in 2[28,38] and 2 mg kg^{-1} in one)[18]; and ropivacaine in 15 (0.25% in 2[36,45]; 0.375% in 6[20,25,42–46]; 0.5% in 5[20,36,37,39–41]; 0.75% in one[28]; and 1 mg kg^{-1} in one[23]). Adrenaline was added in 3,[22,37,45] and clonidine in one.[25] Only in 2 there was a comparison for different concentrations of LA.[30,36] In none of them the use of different volumes or different LA for the same intervention were compared.

Sensitive level, duration of the block and complications

None of the RCTs reviewed analyzed the sensitive level of the block or its duration. In none of the cases complications were reported.[17–47]

Discussion

The execution of the ultrasound-guided TAP in colorectal surgery demonstrated its usefulness for surgeries with infraumbilical incision by mid-axillary approach.[18] Meanwhile, in surgery with supraumbilical incision, despite reducing the consumption of opioids in the first 24 h, it did not show the same performance significantly by mid-axillary approach when compared to placebo,[18] or by subcostal approach when it is compared to epidural anesthesia.[17] The epidural anesthesia will continue to be the ''gold standard'' or technique of election for this intervention until more evidence with TAP is available.

The ITM used in cesarean provides better analgesia than the TAP at the expense of higher adverse effects.[20,22,23] The use of TAP may be a good option for a regime of multimodal analgesia, since it reduces the VAS score at rest or in movement in the first 24 h, and the itching and PONV in those cases in which intrathecal morphine is not used. Cánovas et al.[27] demonstrated that the TAP improved the efficacy of intrathecal opioids reducing the pain in the first 24 h of the postoperative period, the consumption of opiates and the secondary effects, differently from the other RCTs[20,22,23,27] where the TAP did not have good results, probably due to the LA used (levobupivacaine 0.5% 20 ml vs. lower concentrations in other RCTs with ITM[20,22,23]) and the characteristics of the levobupivacaine. In the RCTs carried out by Canovas et al.[27] complications related to the TAP were not reported, although it is important to remember that gestation brings a higher vascularization that increases the risk to reach toxic concentrations of LA,[52] and the possibility of transference of the LA to the breast milk has to be taken into account.[53,54]

In case of cesarean with spinal anesthesia without ITM the execution of the TAP demonstrated up to 60% of reduction in the consumption of opioids.[21] However, a lower VAS or PONV, itching or sedation was not obtained, thereby the execution of the TAP could be indicated for those cases of hypersensitivity to opioid, history of PONV, or possibility of transference of opiate to breast milk.[55] In case of cesarean with general anesthesia, the execution of the bilateral TAP demonstrates reduction in the consumption of opioids[24,26]; although the reduction in VAS is not conclusive, it improved in one RCT,[24] and no differences were found in another[26]; it equally occurs with the apparition of secondary effects of opioids. In the RCT executed by Tan et al.[24] levobupivacaine 0.25% was used, and in that carried out by Eslamian et al.,[26] bupivacaine at 0.25%.

The execution of bilateral TAP is a valid alternative in patients undergoing cesarean without ITM, since it decreases the consumption of opioids and their secondary effects. These conclusions are not similar to those obtained in recent meta-analysis where ultrasound-guided TAP is not specified.[52,56] However, in those cesareans in which spinal anesthesia with ITM is carried out, it did not demonstrate to be beneficial,[40] considering the scarce clinical relevance of pain reduction only within the first 2 postoperative hours.

The execution of bilateral mid-axillary TAP for laparoscopic cholecystectomy demonstrated that it reduces the postoperative consumption of opioids,[30,31] the intraoperative consumption of opioids[30,31] and VAS[30–33] when it is compared to placebo TAP or no intervention. However, compared with LA infiltration, it obtains just the decreasing of the consumption of opioids and VAS when a subcostal approach is performed.[32,33] Ra et al.[30] demonstrated that in the execution of TAP there are no differences with bupivacaine 0.25% or bupivacaine 0.5%. The infiltration of laparoscopic wounds after cholecystectomy is an habitual practice, although it had good results with mid-axillary TAP when TAP vs. placebo TAP or no intervention are compared.[29–31] When it is compared to LA infiltration, results are not obtained,[32] so that the execution of TAP may be a valid option in case of impossibility of local LA infiltration, or as a way of reducing the consumption of intraoperative analgesics. With the subcostal approach, the VAS and the consumption of opioids are improved,[33] so that in case of execution of TAP in cholecystectomy, this approach should be elected. More RCTs are required in order to determine the optimal dose and volume in this intervention.

The studies carried out in gynecological procedures are very heterogeneous. The execution of preoperative mid-axillary TAP demonstrated to be useful and superior to the local LA infiltration in total abdominal hysterectomy with Pfannenstiel incision[35] and in outpatient gynecological procedures,[36] despite not having demonstrated to be effective in laparoscopic hysterectomy[37] or in a heterogeneous group of procedures with mid-laparotomy.[34] Given the heterogeneity of the RCTs in the gynecological interventions, new RCTs are needed, even though it has been demonstrated to be effective in total abdominal hysterectomy.[35]

The execution of TAP in inguinal herniorrhaphy is contradictory,[38–40] since that, although Aveline et al.[38] have demonstrated it was superior to the ilioinguinal/iliohypogastric block when compared to placebo, no benefits in the diminution in the pain score are found.[40] There is a grade of evidence IA, recommendation A for the execution of blocks of abdominal wall/local LA infiltration for inguinal herniorrhaphy.[57] Due to the scarse clinical relevance that it demonstrated when compared to the local LA infiltration,[39,40] currently it is not permitted to recommend its use for the intervention, the local LA infiltration being a technique of choice.

The mid-axillary TAP demonstrated to be useful when compared to placebo in patients undergoing laparoscopic bariatric surgery where local LA infiltration is not executed[44]. However, it is not the same for patients who receive infiltration of laparoscopic wounds[45] although promising oblique subcostal approach is used[8,14] that could be due to the preincisional execution of block in a full-length intervention, or to the lack of benefit for the addition of TAP to the local LA infiltration. The results of the TAP, when they are compared to the infiltration with LA, are not conclusive, demonstrating to be superior in some RCTs[33,35,39] and not in others[32] and having similar results to those of Albrecht et al[45] when TAP vs. no TAP is compared in patients that receive local LA infiltration.[58]

The unilateral mid-axillary TAP demonstrated to provide appropriate analgesia in patients submitted to open appendectomy.[40]

Recently, Hosgood et al.[42] and Parikh et al.[43] demonstrated the efficacy of the mid-axillary TAP in donor nephrectomy. Wu et al.[46] conclude that the epidural technique is superior to a single-dose TAP via oblique subcostal in radical gastrectomy; however, probably the use of catheters in TAP would improve the results, as Niraj et al.[17] suggest and in studies carried out in renal and hepatobiliary surgery, not finding differences between TAP with catheter and epidural anesthesia. Trials carried out with TAP attended by surgeon, in supraumbilical colorectal surgery[9] and ultrasound-guided[18], demonstrated its efficacy so that the debate about the appropriate approach for each intervention still remains, and the TAP could be a useful option if its efficacy was demonstrated in these interventions, mainly those in programs of accelerated recovery where epidural anesthesia, considered as the ''gold standard'' for this intervention, is avoided.[17]

Due to the fact that only in retropubic radical prostatectomy the TAP was evaluated,[47] despite the good results obtained, more RCTs are needed in order to confirm these results and their clinical benefits.

Limitations

The bibliographic research was limited to MEDLINE-Pubmed and to a manual driven one, aiming to comprise all the RCTs published, so that there may be published RCTs not evaluated.

The authors limited the research and the analysis to RCT that evaluated the ultrasound-guided TAP because of the decrease of complications and the greater variety of approaches that the ultrasound-guided technique permits, although the multiple RCTs executed with attended TAP or TAP based on references should be equally considered by the interest to the technique.

Conclusions

The execution of bilateral mid-axillary TAP is indicated in patients undergoing cesarean without ITM[19–21,24–26]; in cholecystectomy by subcostal TAP,[33] or mid-axillary where the infiltration is impossible, or as a way of reducing the consumption of postoperative opioids; in total abdominal hysterectomy by bilateral mid-axillary TAP[35]; in open appendectomy by unilateral mid-axillary TAP[40]; in donor nephrectomy, mid-axillary TAP.[42,43] However, there are controversies in the use of oblique subcostal TAP in radical gastrectomy,[17,46] in the use of bilateral mid-axillary in colorectal surgery[18] and in retropubic radical prostatectomy,[47] because of the limitation of the RCT analyzed.

It is not possible to recommend its use in inguinal herniorrhaphy.[40]

There is a considerable debate about the best approach for each type of intervention[59] since that despite the demonstration of metameric extension described by Lee et al.[14] and Carney et al.,[15] the data found in RCT are not conclusive or concordant. New well-designed RCTs with enough statistical power to solve the current questions and their consequences in the habitual clinical practice are required. The lack of RCTs that compare the pre- or postoperative execution of TAP in the same surgical intervention renders it impossible to recommend the appropriate time to the execution of the block. In comparing TAP with different concentrations,[30,36] it was demonstrated that there are no benefits in using a higher dose, and given the potential toxic effects of LA in the TAP and the possible overcoming of their toxic dose, as demonstrated by Griffiths et al.[60] with doses of ropivacaine habitually used, it is necessary to study the effective minimum doses to decrease the possible deleterious effects of the LA.

The use of catheters in the abdominal transverse plan could increase the analgesic efficacy of the block, as well as the use of new LA, like the recently approved liposomal bupivacaine (EXPAREL), which could increase the duration of the block, although there are no trials about the safety of this new drug in peripheral blocks. Ultimately, in the execution of new RCTs it would be convenient to determine the sensitive level of the block, as well as its duration and the plasmatic concentrations reached with different concentrations and volumes of LA, in order to determine the optimal dose of LA for each intervention.

Conflicts of interest

The authors declare no conflicts of interest.

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