REVIEW

Transversus abdominis plane block for analgesia after Cesarean delivery. A systematic review

P. FUSCO [1], P. SCIMIA [2], G. PALADINI [3], M. FIORENZI [2], E. PETRUCCI [2], T. POZONE [1], F. VACCA [1], A. BEHR [4], M. MICAGLIO [5], G. DANELLI [6], V. COFINI [7], S. NECOZIONE [7], G. CARTA [8], F. PETRINI [3], F. MARINANGELI [2]

[1]Unità Operativa Complessa di Anestesia e Rianimazione, Ospedale S. Salvatore, L'Aquila, Italia; [2]Cattedra di Anestesia e Rianimazione, Dipartimento di Medicina Clinica, Sanità Pubblica, Scienze della Vita e dell'Ambiente (MESVA), Università degli Studi di L'Aquila, L'Aquila, Italia; [3]Cattedra di Anestesia, Rianimazione e Terapia Intensiva, Università degli Studi "G. D'Annunzio" Chieti-Pescara, Chieti, Italia; [4]Unità Operativa Complessa Istituto di Anestesia e Rianimazione, Azienda Ospedaliera di Padova, Università degli Studi di Padova, Padova, Italia; [5]Dipartimento ad Attività Integrata Materno-Infantile dell'Azienda Ospedaliero Universitaria Careggi-Firenze, Firenze, Italia; [6]Dipartimento di Anestesia e Medicina Perioperatoria, Istituti Ospitalieri Di Cremona, Cremona, Italia; [7]Dipartimento di Medicina Interna e Sanità Pubblica, Università degli Studi di L'Aquila, L'Aquila, Italia; [8]Dipartimento di Ginecologia ed Ostetricia, Università degli Studi di L'Aquila, L'Aquila, Italia

ABSTRACT

Cesarean delivery is a major surgical procedure, after which a woman can experience substantial postoperative discomfort or pain. Inadequate postoperative analgesia is one of the most common reasons for poor patient satisfaction following cesarean delivery. Although spinal or systemic opioids are currently the gold standard to achieve effective analgesia, they are often associated with side effects. In the last few years there has been growing interest in abdominal plane blocks, with promising data on their efficacy. The transversus abdominis plane (TAP) block is a regional analgesic technique which is gaining acceptance in postoperative analgesia for lower abdominal surgeries. In this systematic review of articles published as of 31 December 2013, we searched the principal medical databases for randomized controlled trials that assessed the efficacy of ultrasound (US)-guided TAP block following cesarean delivery and reported on postoperative opioid consumption and pain score, opioid-related side-effects and patient satisfaction. Although controversy surrounds the utility of US-guided TAP block in cesarean section, evidence suggests that when correctly executed as part of a multimodal analgesic regimen, TAP block may reduce postoperative opioid consumption and opioid-related side effects, improving postoperative pain control and patient satisfaction. Further studies are necessary to explore this field of research. *(Minerva Anestesiol 2015;81:195-204)*

Key words: Caesarean section - Analgesics, opioids - Postoperative care.

Cesarean section is one of the most commonly performed surgical procedures in the world.[1-4] Cesarean delivery is a major surgical procedure, after which substantial postoperative discomfort and pain can be anticipated.[5] Significant discomfort can be expected afterwards: up to 79% of women experience pain at the incision site that can last for up to 2 months.[6] Inadequate postoperative analgesia is one of the most common reasons for poor patient satisfaction following cesarean delivery.[7-10] The provision of effective postoperative analgesia is key to facilitate early ambulation, infant care, and prevention of postoperative morbidity.[5] The optimum form of postoperative

analgesia is unknown, but many procedures are carried out under spinal anesthesia and patients typically receive spinal, systemic, or both opioids as a component of multimodal analgesia during the postoperative period. However, opioids, whether given *via* the spinal or systemic route, are frequently associated with adverse effects [11] such as nausea, vomiting, sedation and itching, and risk of delayed maternal respiratory depression, all of which reduce overall patient satisfaction.[5] Thus, knowledge about alternative (non-opioid) analgesia can help to replace or reduce opioid use and decrease opioid-related side effects.[8] The transversus abdominis plane (TAP) block is a regional anesthetic technique that blocks T6-L1 nerve roots and can provide analgesia for lower abdominal procedures.[12] Previous meta-analyses and recently published clinical trials have demonstrated promising results with this technique as part of multimodal postoperative pain treatment.[13-16] However, published data on TAP block efficacy in cesarean delivery are controversial.

The aim of this systematic review was to clarify whether ultrasound-guided TAP block improves postoperative analgesia in women undergoing cesarean delivery and allows to reduce opioid consumption and opioid-related side effects.

Methods

The present systematic review was conducted according to the guidelines of the Cochrane Collaboration [17] and Preferred Reporting Items for Systematic Reviews and Meta-analysis [18] (PRISMA).

Search

The following databases were searched from their earliest records through 31 December 2013: Medline, Embase, Cochrane Controlled Clinical Trial Register, Cochrane Database of Systematic Reviews, ISI Web of Knowledge, and SCOPUS. The databases were explored following a search algorithm using Boolean operators: ("TAP" OR "TAP block" OR "transversus abdominis" OR "transverse abdominis" OR "transversus abdominis plane block" OR "transversus abdominis block" OR "transverse abdominis plane block") AND ("Caesarean" OR "C section" OR "Caesarean delivery"). To be as inclusive as possible, no restrictions were applied with regard to publication year or language of the studies. The references of all selected full-text articles and related reviews were scanned.

Study selection

Screening was performed independently by two blinded reviewers. In case of disagreement over the inclusion or exclusion of studies, the issue was discussed with a third reviewer.

Eligibility criteria

The study selection was performed by two blinded reviewers in two steps. In the first, the studies were analyzed according to the following inclusion criteria (A): 1) randomized controlled trials (RCTs); 2) studies comparing TAP block with placebo in patients undergoing cesarean delivery under spinal anesthesia. Only studies that met all inclusion criteria in (A) progressed to the second step, which consisted in the analysis of the preselected studies according to the following exclusion criteria (B): 1) studies with no data reported; 2) inclusion of patients with pathological obesity, or who were assumed to be taking medications known to result in opioid intolerance; 3) patients suffering from chronic pain; 4) duplicate or ancillary studies; and 5) primary outcome of interest not analyzed.

Outcome variables

The primary outcomes were changes in postoperative opioid consumption. Secondary outcomes were changes on postoperative pain score, opioid-related side effects and patient satisfaction. We considered only side effects related to opioids and not overall side effects, because the focus of the review was to clarify whether US-guided TAP block improves postoperative analgesia in women undergoing cesarean section and reduces opioid consumption and opioid-related side effects. The majority of the studies did not report or assess any other effect.

Data extraction

Data were collected by two independent reviewers. The following data were extracted from the studies: year of publication, study design,

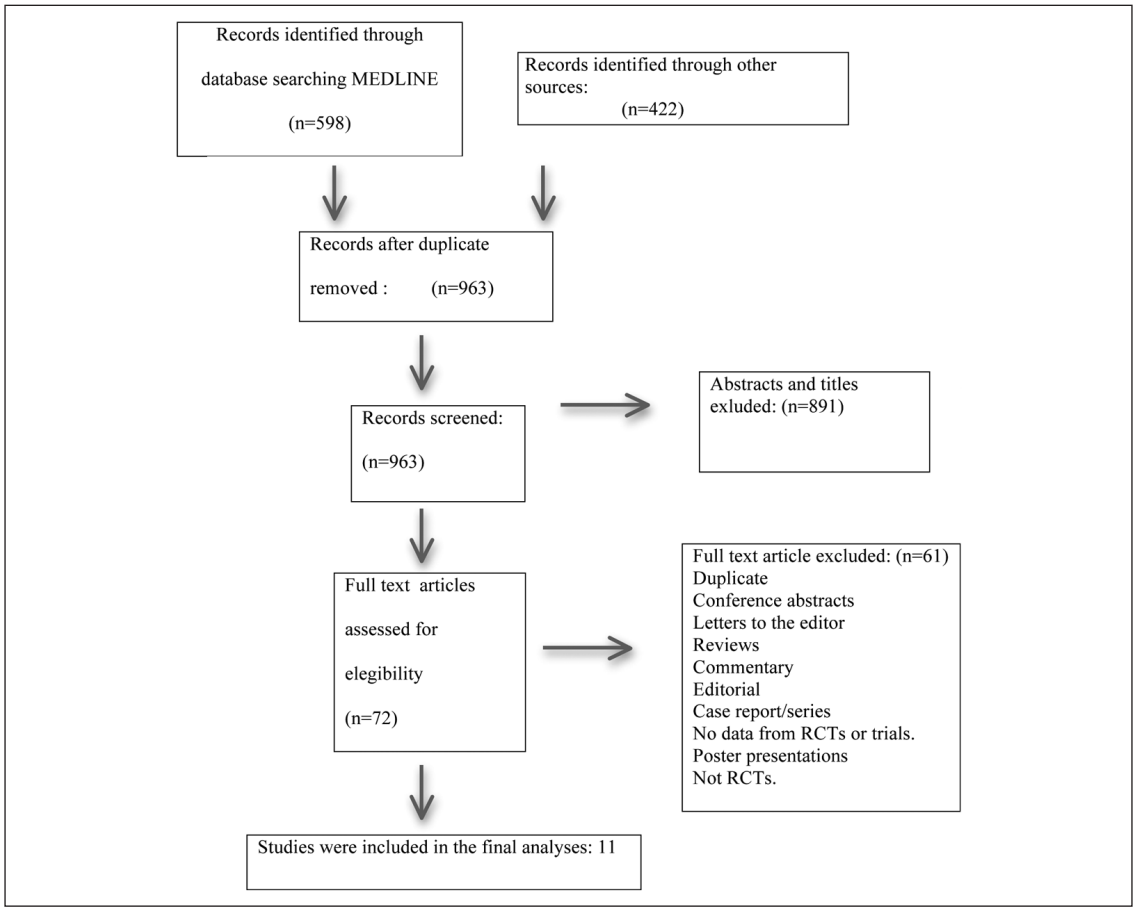

Figure 1.—Flowchart of study selection process.

number and characteristics of participants, anesthesia technique, TAP block technique, local anesthetic used, primary study outcome, postoperative analgesia regimen, pain intensity scores at rest and movement, opioid consumption and side effects, patient satisfaction.

Assessment of risk of bias

The quality of the methodologies of the studies was analyzed independently by two blinded reviewers using the risk of bias table suggested by the Cochrane Collaboration.[17] After determining the score of each study, the overall plausible risk of bias was estimated for each study selected. Any discrepancies were resolved by discussion with the third reviewer.

Results

Search results

A total of 1020 articles were found through the electronic search in: Medline, Cochrane Database of Systematic Reviews, Cochrane Controlled Clinical Trial Register, in Embase, in Scopus, and in ISI Web of Knowledge. After removing duplicates, 963 articles qualified for screening, which resulted in the elimination of 891 studies *via* the Abstract and Title. Of the 72 articles evaluated for eligibility, 61 were excluded because they did not satisfy one or more inclusion and exclusion criteria. Finally, 11 studies [13,19-28] were included in the systematic review (Figure 1).

Table I.—*Characteristics of the included studies.*

Study	N. partecipants	TAP block technique	Anesthetic solution for TAP	Opioids in surgical analgesia
McDonnell *et al*. 2008 [22]	50 (25TAP *vs.* 25 control)	Landmark technique	Ropivacaine 0.75% (1.5 mg/kg) to a maximum of 150 mg per side	25 μg ITF
Belavy *et al*. 2009 [30]	47 (23 TAP *vs.* 24 control)	US-guided	Ropivacaine 0.5% 100 mg per side	15 μg ITF
Costello *et al*. 2009 [31]	96 (47 TAP *vs.* 49 control)	US-guided	Ropivacaine 0.375% 75 mg per side	10 μg ITF 100 μg ITM
Kanazi *et al*. 2010 [32]	57 (29TAP *vs.* 28 ITM)	US-guided	Bupivacaine 0.375% + epinephrine 5 mg/mL 75 mg per side	200 μg ITM
Baaj *et al*. 2010 [33]	40 (20TAP *vs.* 20 control)	US-guided	Bupivacaine 0.25% 50 mg per side	20 μg ITF
Mc Morrow *et al*. 2011 [34]	80 (20TAP *vs.* 20 control) (20TAP + ITM *vs.* 20 control+ ITM) (20TAP *vs.* 20 ITM)	Landmark technique	Bupivacaine 0.375% 1 mg/kg per side	10 μg ITF; 100 μg ITM
Loane *et al*. 2012 [35]	66 (33 TAP *vs.* 33 control)	US-guided	Ropivacaine 0.5% 100 mg per side	10 μg ITF 100 mcg ITM
Bollag *et al*. 2012 [36]	90 (30 Sal TAP, 30 Bup TAP; 30 Clo TAP)	US-guided	Bupivacaine 0.375% and bupivacaine 0.375% + 75 μg of clonidine in cloTAP per side	25 μg ITF+ 100 μg ITM
Canovas *et al*. 2013 [37]	90 (30 ITM 30 ITF 30 ITF + TAP)	US-guided	Levobupivacine 0.5% per side	100 ITM 10 μg ITF
Singh *et al*. 2013 [38]	60 (20 TAP high, 20 TAP low, 20 Sal TAP)	US-guided	Ropivacaine 0.5% 3 mg/kg to a maximum of 300 mg in TAP high and ropivacaine 0.25% 1.5 mg/kg to a maximum of 150 mg in TAP low	10 μg ITF+ 150 μg ITM
Lee *et al*. 2013 [39]	51 (26 TAP *vs.* 25 control)	US-guided	Ropivacaine 0.5% 100 mg per side	250 μg ITM+ 15 μg ITF

TAP: transversus abdominis plane block; ITM: intrathecal morphine; ITF: intrathecal fentanyl; Sal TAP: saline in TAP; Bup TAP: bupivacaine in TAP; Clo TAP: clonidine in TAP; I.V.: intravenous; PCA patient controlled analgesia; N.A.: not analyzed.

Description of studies

The characteristics of the studies are shown in Table I. In all eleven studies, TAP block was performed at the end of cesarean delivery. The TAP block was performed with an anatomical landmark technique in two [13, 23] out of the eleven studies and a US-guided technique was used in the remaining 9 studies.[19-22, 24-28] All RCTs compared the efficacy of TAP block with control in patients undergoing cesarean delivery under spinal anesthesia. The use of intrathecal opioids was found to be different. Three studies [13, 19, 22] reported the use of intrathecal fentanyl (ITF) alone in spinal anesthesia (doses range, from 25 to 10 μg). In one study [23] with ITF, patients were

Postoperative analgesia	Primary outcome	Time to first analgesic request	Patient satisfaction	Side effects
1 g/6 h of acetaminophen rectal diclofenac 100 mg/18 h and PCA with morphine	Consumption of morphine in 48 hour	Reported	N.A.	Reported
1 g/6 h of acetaminophen, ibuprofen 400 mg/8 h and PCA with morphine	Consumption of morphine in 24 hour	Reported	Reported	Reported
1 g/6 h of acetaminophen oral diclofenac 50 mg/8 h and morphine	Incident pain in 24 hour	-	Reported	N.A.
Rectal diclofenac 100 mg/12 h acetaminophen 1 g/6 h Tramadol 100 mg/8 h	Time to first analgesic request	Reported	N.A.	Reported
PCA with morphine	Consumption of morphine in 24 hour	-	Reported	Reported
Oral acetaminophen1 g/h; rectal diclofenac 100 mg/18 h and morphine with PCA	Incidence pain	-	Reported	Reported
Oral acetaminophene 1 g/6 h, oral or rectal naproxen 500 mg/12 h and oral hydromorphone 2-4 mg/4 h; morphine with PCA if pain control is inadequate	Morphine equivalents consumption at 24 h	-	N.A.	Reported
Acetaminophen 1 g/6 h, diclofenac 75 mg/8 h and oral tramadol 50 mg/8 h	Adjuvants extend Tap block duration	Reported	N.A.	Reported
Morphine with PCA	Time of first analgesic request and pain evaluation	Reported	Reported	Reported
Ketorolac 30 mg oral Acetaminophen 650 mg/6 h, codeine 30 mg or oxycodone 5-10 mg/4 h	Pain at 24 hours	Reported	Reported	Reported
Acetaminophen 1 g/6 h Ketorolac 30 mg or ibuprofen 800 mg/6 h IV morphine 2 mg/10 min as need Acetaminophen 300 mg/codeine 30 mg to times/6 h or oxycodone 5 mg/acetaminophen 325 mg 2 times/6 h	Pain at 24 hours	Reported	Reported	Reported

randomized to receive a combination of spinal morphine or saline with TAP block containing bupavacaine or saline. Four RCTs [20, 25, 27, 28] used ITF in addition to intrathecal morphine (ITM) with TAP block; in two of these studies [20, 28] local anesthetic with TAP was compared with saline solution. In another study,[27] the authors compared local low and high-dosage anesthetic with saline. Only one trial [26] compared the differences between ITM alone, ITF alone, and ITF added to TAP with levobupivacaine. Two studies [21, 24] used ITM in addition to TAP block with saline solution or local anesthetic. The anesthetic solution to achieve the TAP block was ropivacaine in six studies [13, 20, 21, 24, 27, 28] and only bupivacaine in two trials.[22, 23] One study [21] reported the use

Table II.—*The risk of bias of the included studies.*

Reference	Random sequence generation	Allocation concealment	Blinding of participants and researchers	Blinding of outcome assessment	Incomplete outcome data	Selective reporting
McDonnell *et al.* 2008 [22]	Low	Low	Low	Low	Low	Low
Belavy *et al.* 2009 [30]	Low	Not clear	Low	Low	Low	Low
Costello *et al.* 2009 [31]	Low	Not clear	Not clear	Low	Low	Low
Kanazi *et al.* 2010 [32]	Low	Low	Low	Low	Low	Low
Baaj *et al.* 2010 [33]	Not clear	Not clear	Low	Not clear	Low	Low
Mc Morrow *et al.* 2011 [34]	Not clear	Low	Low	Low	Low	Low
Loane *et al.* 2012 [35]	Low	Low	Low	Low	Low	Low
Bollag *et al.* 2012 [36]	Low	Low	Low	Not clear	Low	Low
Canovas *et al.* 2013 [37]	Low	Low	Not clear	Low	Low	Low
Singh *et al.* 2013 [38]	Low	Low	Low	Low	Low	Low
Lee *et al.* 2013 [39]	Low	Low	Low	Low	Low	Low

of bupivacaine added to epinephrine; another study [25] used bupivacaine added to clonidine, and only one RCT [26] used levobupivacaine.

Risk of bias in studies

The CONSORT-based quality analysis revealed that all eleven studies were at low risk of bias (Table II). The randomization methods were unclear in two studies,[22, 23] the use of blind participants and researchers was unclear in two studies,[20, 26] the blinding of outcome assessment was unclear in two studies,[22, 25] adequate allocation concealment was not satisfied in two studies.[19, 20, 22] Five studies [13, 21, 24, 27, 28] satisfied all of the quality analysis criteria.

Outcomes

Postoperative analgesic consumption

Postoperative analgesia was provided with patient-controlled analgesia (PCA) with morphine in two studies.[22, 26] A combination of acetaminophen, non-steroidal anti-inflammatory drugs (NSAIDs), and oral or intravenous opioids in combination with morphine in PCA was described in four studies.[13, 19, 23, 24] These drugs were used in the remaining studies, except for morphine.[20, 21, 25, 27, 28]

Opioid consumption was investigated in four trials.[13, 19, 22, 24] One evaluated 48-hour morphine consumption [13] and the remaining three trials examined 24-hour morphine consumption.[19, 22, 24] One trial showed a significant reduction in opioid consumption at 48 hours [13] and two trials demonstrated a reduction in opioid consumption at 24 hours in the TAP block group *vs.* the placebo group in patients who had received intrathecal opioids.[19, 22] Only one trial demonstrated that TAP block was associated with greater supplemental morphine requirements in comparison with intrathecal morphine alone.[24]

Time to first analgesia request was investigated in seven studies.[13, 19, 21, 25-28] Five showed that the time to the first analgesia request was shorter in the placebo group *vs.* the TAP block group in the women who had received intrathecal opioids.[13, 19, 25, 26, 28] One study demonstrated that the time to the first analgesia request was longer in the ITM group than in the TAP block group.[21] One study demonstrated no difference in time to first analgesia request between the ITM group and TAP block group at 24 h in the women who had received intrathecal opioids.[27]

TAP block was performed with the landmark techniques in two trials [13, 23] and with the US-guided technique in nine trials.[19-22, 24-28]

Postoperative pain score

All eleven studies evaluated postoperative pain score. Three trials showed that TAP block *vs.* intrathecal opioids did not improve pain relief.[21, 23, 24] Three other RCTs demonstrated that TAP block added to intrathecal opioids did not improve pain relief.[20, 25, 26] Four RCTs dem-

onstrated that TAP block added to intrathecal opioids, as compared with placebo, reduced pain intensity.[13, 19, 22, 28]

Opioid-related side effects

All eleven studies except one [20] analyzed opioid-related side effects. Ten trials investigated postoperative nausea and vomiting (PONV) and sedation [13, 19, 21-28] and showed a reduction in the occurrence of PONV but no significant difference in sedation. Seven studies investigated pruritus onset [19, 21, 23-27] and four demonstrated a reduction of this side-effect.[21, 23, 24, 26] Three trials examined all opioid-related side effects but found no difference in the occurrence or severity of PONV, sedation and pruritus between the patients who received TAP block in comparison with the control groups.[25, 27, 28]

Patient satisfaction

Patient satisfaction was evaluated in seven [19, 20, 22, 23, 26-28] of the eleven studies. Three reported higher satisfaction among patients who received TAP block together with intrathecal opioids in comparison with the placebo control group.[19, 22, 26] Four studies reported high satisfaction among TAP block group patients but that it was similar to that of the control groups.[20, 23, 27, 28]

Discussion

The TAP block was first described in 2001 in a letter by Rafi,[29] and was then further developed and tested by McDonnell *et al.*[12] It can be performed using anatomic landmarks or under ultrasound (US) guidance.[12, 30] The initial technique described the lumbar triangle of Petit as the landmark to access TAP.[12, 29] Although the TAP block "blind" technique is described as easy to perform,[12, 13] it is associated with the risk of complications such as liver injury and intraperitoneal injection.[31, 32] While US guidance has not been conclusively demonstrated to improve safety, it might reduce visceral and vascular injury resulting from the TAP block by offering the clinician the advantage of a direct visualization of the needle, allowing to confirm the proper spread of the local anesthetic in the neurovascular plane between the internal oblique and the transversus abdominis muscles.[31-34]

The analgesic efficacy of TAP block after cesarean delivery was assessed by analyzing the results of different studies. Some of the trials showed that TAP block alone does not improve postoperative analgesia in comparison with intrathecal opioids, but this was at the expense of an increased incidence of opioid-related side effects.[21, 23, 24] Kanazi *et al.*[21] concluded that, as part of a multimodal analgesic regimen, subarachnoid morphine provided superior analgesia and increased the time of first analgesic request when compared with ultrasound-guided TAP block after cesarean delivery, yet at the cost of increased side effects.[21] McMorrow *et al.*[23] compared the analgesic efficacy of the TAP block with and without spinal morphine after cesarean section and stated that, in the setting of multimodal analgesia, pain score and early morphine consumption were lower in the group receiving spinal morphine and was not improved by TAP block. Sedation score and patient satisfaction did not differ between the groups, but antiemetic use and itching were higher in patients receiving spinal morphine. Loane *et al.*[24] compared the efficacy and side effects of intrathecal morphine with US-guided TAP block and concluded that TAP block was associated with greater supplemental morphine requirements and higher pain scores than intrathecal morphine, but fewer opioid-related side effects.

Other studies evaluated a multimodal analgesic regimen including IT opioids added to TAP block to investigate whether this approach might improve outcomes such as pain control, opioid consumption, patient satisfaction, and adverse effects.[13, 19, 22, 26-28] McDonnell *et al.*[13] evaluated analgesic efficacy of TAP block in conjunction with ITF over the first 48 postoperative hours after cesarean delivery. In this study, the TAP block with ropivacaine, as compared with placebo, reduced postoperative pain score and total morphine requirements in the first 48 postoperative hours, as was the 12-h interval morphine consumption up to 36 h postoperatively, reducing

the incidence of PONV and sedation. Belavy *et al*.[19] demonstrated in patients undergoing cesarean delivery that, as compared with the placebo group, US-TAP block added to ITF had opioid-sparing effects reducing 24-h morphine use, improved satisfaction with pain relief, and reduced antiemetic use. Costello *et al*.[20] evaluated the efficacy of the TAP block for post-cesarean section as part of a multimodal regimen inclusive of ITM, and concluded that the technique does not improve the quality of post-cesarean analgesia. The trial found no difference in pain score or supplemental opioid consumption between the group that received TAP block with ropivacaine 0.375% and the placebo group. Baaj *et al*. [22] demonstrated that US-guided TAP block for post-cesarean delivery patients inclusive of ITM improved postoperative analgesia and patient satisfaction, reducing morphine consumption and the incidence of PONV. Canovas *et al*. [26] showed that US-guided TAP block improves spinal opioid analgesia, with a decrease in VAS scores during the first 24 hours, and that it reduces opioid requirement and secondary effects after C-section.[26] Singh *et al*.[27] compared the analgesic efficacy of two doses of local anesthetic for TAP block after cesarean delivery and concluded that, as compared with a placebo TAP block, neither high nor low dose TAP block as part of a multimodal analgesia including ITM improved pain score with movement at 24 h after cesarean delivery. High dose TAP blocks improved pain score up to 12 hours after cesarean delivery. Lee *et al*.[28] demonstrated that TAP block in conjunction with intrathecal opioids provided superior early postcesarean analgesia to ITM alone. At 24 hours there was no difference in pain score and analgesic consumption.

In our systematic review, we investigated whether US-guided TAP block improves postoperative analgesia in women undergoing cesarean delivery and allows to reduce opioid consumption and opioid-related side effects. Currently, findings on the utility of US-TAP block in cesarean section are contradictory. The discrepancies between studies may be attributed to the fact that the authors did not test for alterations in skin sensation that would have indicated a successful block and they did not demonstrate if the block was correctly executed.[35] There is currently no evidence that the TAP block is of benefit when ITM has been administered.[36] However, Abdallah *et al*. (2012) suggest that TAP block may be an effective analgesic option for postoperative analgesia after caesarean section performed under spinal anaesthesia when spinal morphine is not used.[36]

Conclusions

Pain following cesarean section is multifactorial in origin, with a somatic component arising from the abdominal wound and a visceral component resulting from visceral and uterine manipulation.[10, 37] Since ITM affects both somatic and visceral afferents,[38] postoperative analgesia was improved with ITM as compared with TAP block alone; this was at the expense of an increased incidence of opioid-related side effects, however.[39] The role of TAP block added to ITM is less clear.[39] Our systematic review highlights a certain heterogeneity of the trials; therefore, large studies with adequate power are needed to explore whether the use of TAP block offers any benefits in patients who receive intrathecal opioids. It is interesting to observe that the recent literature suggests that US-guided TAP block failure might be due to deposition of local anesthetic in the wrong location, that is, above, and not below the fascial plane between the internal oblique and the transversus abdominis (muscles.[35] When correctly executed, US-guided TAP block, as part of a multimodal analgesic regimen including intrathecal opioids, may reduce postoperative opioid consumption and opioid-related side effects, improving postoperative pain control and patient satisfaction. Further studies are necessary to explore this field of research.[35, 39] Moreover, future areas of focus [33] may be a retrospective cohort study to demonstrate whether the occurrence of chronic pain after cesarean section is frequent and responsible for impaired quality of life.[40] Further investigation is needed to evaluate the effect of TAP block on the development of persistent pain in this patient population.[39, 40]

Key messages

— US-guided TAP-block is a regional analgesic technique which has an evolving role in postoperative analgesia for lower abdominal surgeries, including C-section.

— US-guided TAP block alone does not improve postoperative analgesia in comparison with intrathecal opioid, but at the expense of an increased incidence of opioid-related side effects.

— US-guided TAP block may offer a valid alternative to improve postoperative analgesia in women undergoing cesarean section performed under spinal anesthesia who did not receive IT opioids, although there is currently no evidence that this technique is of benefit when ITM has been administered.

— Primary US-guided TAP block failure, rather than lack of its clinical efficacy, may explain why this technique, when used as part of a multimodal analgesic regimen including intrathecal morphine, doesn't improve the quality of post-cesarean analgesia.

— When correctly executed, US-guided TAP block, as part of a multimodal analgesic regimen including intrathecal opioids, may reduce postoperative opioid consumption and opioid-related side effects, improving postoperative pain control and patient satisfaction, but further studies are necessary to explore this field of research.

— Studies are also needed to investigate the optimum US-guided TAP block approach for analgesia following cesarean section, as well as to examine continuous catheter techniques for TAP block, in order to evaluate the efficacy of this technique in postsurgical chronic pain.

References

1. Betran AP, Merialdi M, Lauer JA, Bing-Shun W, Thomas J, Van Look P *et al*. Rates of Caesarean section: analysis of global, regional and national estimates. Paediatr Perinat Epidemiol 2007;21:98-113.
2. Bragg F, Cromwell DA, Edozien LC, Gurol-Urganci I, Mahmood TA, Templeton A *et al*. Variation in rates of caesarean section among English NHS trusts after accounting for maternal and clinical risk: cross sectional study. Br Med J 2010;341:c5065.
3. Mathai M, Hofmeyr GJ. Abdominal surgical incisions for caesarean section. Cochrane Database Syst Rev 2007: CD004453.
4. National Hospital Service. NHS Maternity Statistics, 2008-09. [cited 2014 December 23]. Available from: http://www.ic.nhs.uk Farragher RA, Laffey JG. Postoperative pain management following cesarean section. In: Shorten G, Carr D, Harmon D *et al.*, editors. Postoperative pain management. An evidence-based guide to practice. 1st ed. Philadelphia, PA: Saunders Elsevier; 2006. p. 225-38.
5. Deelereq F, Cunningham DK, Johnson C, Sakata C. Mothers' reports of postpartum pain associated with vaginal and cesarean deliveries: results of a national survey. Birth 2008;35:16-24.
6. McKelly S, Malhotra RK. Ultrasound-guided transversus abdominis plane blocks for analgesia post cesarean section. Comparative Effectiveness Research 2011;1:35-8.
7. Pan PH. Post cesarean delivery pain management: multimodal approach. Int J Obstet Anesth 2006;15:185-8.
8. Kuczkovski KM. Postoperative pain control in the parturient: new challenges in the new millennium. J Matern Fetal Neonatal Med 2011;24:301-4.
9. McDonnell NJ, Keating ML, Muchatuta NA, Pavy TJ, Paech MJ. Analgesia after cesarean delivery. Anaesth Intensive Care 2009;37:539-51.
10. Madadi P, Ross CJ, Hayden MR, Carleton BC, Gaedigk A, Leeder JS *et al*. Pharmacogenetics of neonatal opioid toxicity following maternal use of codeine during breastfeeding: a case-control study. Clin Pharmacol Ther 2009;85:31-5.
11. McDonnell JG, O'Donnell B, Curley G, Heffernan A, Power C, Laffey JG. The analgesic efficacy of transversus abdominis plane block after abdominal surgery: a prospective randomized controlled Trial. Anesth Analg 2007;104:193-7.
12. McDonnell JG, Curley G, Carney J, Benton A, Costello J, Maharaj CH *et al*. The analgesic efficacy of transversus abdominis plane block after cesarean delivery: a randomized controlled trial. Anesth Analg 2008;106:186-91
13. Petersen PL, Mathiesen O, Torup H, Dahl JB. The transversus abdominis plane block: a valuable option for postoperative analgesia? A topical review. Acta Anaesthesiol Scand 2010;54:529-35
14. Charlton S, Cyna AM, Middleton P, Griffiths JD. Perioperative transversus abdominis plane (TAP) blocks for analgesia after abdominal surgery. Cochrane database Syst Rev 2010;8:CD007705.
15. Siddiqui MR, Sajid MS, Uncles DR, Cheek L, Baig MK. A meta-analysis on the clinical effectiveness of transversus abdominis plane block. J Clin Anesth 2011;23:7-14.
16. Higgins JPT, Green S. Cochrane handbook for systematic reviews of interventions, Version 5.1. The Cochrane Collaboration, 2009. [cited 2014 December 23]. Available from: http://www.cochrane-handbook.org
17. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Ann Intern Med 2009;151:264-9.
18. Belavy D, Cowlishaw PJ, Howes M, Philips F. Ultrasound-guided transversus abdominis plane block for analgesia after Caesarean delivery. Br J Anaesth 2009;103:726-30.
19. Costello JF, Moore AR, Wieczorek PM, Macarthur AJ, Balki M, Carvalho JC. The transversus abdominis plane block, when used as part of a multimodal regimen inclusive of intrathecal morphine, does not improve analgesia after cesarean delivery. Reg Anesth Pain Med 2009;34:586-9.
20. Kanazi GE, Aouad MT, Abdallah FW, Khatib MI, Adham AM, Harfoush DW *et al*. The analgesic efficacy of subarachnoid morphine in comparison with ultrasound-guided trans-

versus abdominis plane block after cesarean delivery: a randomized controlled trial. Anesth Analg 2010;111:475-81.
21. Baaj JM, Alsatli RA, Majaj HA, Babay ZA, Thallaj AK. Efficacy of ultrasound-guided transversus abdominis plane (TAP) block for postcesarean section delivery analgesia - A double-blind, placebo-controlled, randomized study. Middle East J Anesthesiol 2010;20:821-6.
22. McMorrow RCN, Ni Mhuircheartaigh RJ, Ahmed KA, Aslani A, Ng SC, Conrick-Martin I *et al*. Comparison of transversus abdominis plane block vs spinal morphine for pain relief after Caesarean section. Br J Anaesth 2011;106:706-12.
23. Loane H, Preston R, Douglas MJ, Massey S, Papsdorf M, Tyler J. A randomized controlled trial comparing intrathecal morphine with transversus abdominis plane block for post-cesarean delivery analgesia. Int J Obstet Anesth 2012;21:112-8
24. Bollag L, Richebe P, Siaulys M, Ortner CM, Gofeld M, Landau R. Effect of transversus abdominis plane block with and without clonidine on post-cesarean delivery wound hyperalgesia and pain. Reg Anesth Pain Med 2012;37:508-14.
25. Cánovas L, López C, Castro M, Rodríguez AB, Pérez L. Contribution to post-caesarean analgesia of ultrasound-guided transversus abdominis plane block. Rev Esp Anestesiol Reanim 2013;60:124-8.
26. Singh S, Dhir S, Marmai K, Rehou S, Silva M, Bradbury C. Efficacy of ultrasound-guided transversus abdominis plane blocks for post-cesarean delivery analgesia: a double-blind, dose-comparison, placebo-controlled randomized trial. Int J Obstet Anesth 2013;22:188-93.
27. Lee AJ, Palte HD, Chehade JM, Arheart KL, Ranasinghe JS, Penning DH. US-guided bilateral transversus abdominis plane blocks in conjunction with intrathecal morphine for postcesarean analgesia. J Clin Anesth 2013;25:475-82.
28. Rafi AN. Abdominal field block: a new approach via the lumbar triangle. Anaesthesia 2001;56:1024-29.
29. Hebbard P, Fujiwara Y, Shibata Y, Royse C. Ultrasound-guided transverses abdominis plane (TAP) block. Anaesth Intensive Care 2007;35:616-7.
30. Farooq M, Carey M. A case of liver trauma with a blunt regional anesthesia needle while performing transversus abdominis plane block. Reg Anesth Pain Med 2008;33:274-5.
31. Chin JK, Chan V. Ultrasound-guided peripheral nerve blockade. Curr Opin Anaesthesiol 2008;21:624-31.
32. Jankovic Z, Ahmad N, Ravishankar N, Archer F. Transversus abdominis plane block: how safe is it? Anesth Analg 2008;107:1758-9.
33. Lancaster P, Chadwick M. Liver trauma secondary to ultrasound-guided transversus abdominis plane block. Br J Anaesth 2010;104:509-10.
34. Factor D, Chin KJ. Transversus abdominis plane block in lower segment cesarean section: a question of block failure or lack of efficacy? Reg Anesth Pain Med 2010;35:404-5.
35. Abdallah FW, Halpern SH, Margarido CB. Transversus abdominis plane block for postoperative analgesia after Caesarean delivery performed under spinal anaesthesia? A systematic review and meta-analysis. Br J Anaesth 2012;109:679-87.
36. Lavand Homme P. Postcesarean analgesia: effective strategies and association with chronic pain. Curr Opin Anaesthesiol 2006;19:244-8.
37. Tong C, Conklin D, Eisenach JC. A pain model after gynecologic surgery: the effect of intrathecal and systemic morphine. Anesth Analg 2006;103:1288-93.
38. Mishriky BM, George RB, Habib AS. Transversus abdominis plane block for analgesia after Cesarean delivery: a systematic review and meta-analysis. Can J Anaesth 2012;59:766-78.
39. Nardi N, Campillo-Gimenez B, Pong S, Branchu P, Ecoffey C, Wodey E. Chronic pain after cesarean: Impact and risk factors associated. Ann Fr Anesth Reanim 2013;32:772-8.

Acknowledgements.—The authors would like to thank Dr. Ambra Petrucci for the valuable help and support during this work.

Conflicts of interest.—The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Received on July 31, 2013. - Accepted for publication on April 15, 2014. - E-pub ahead of print on April 16, 2014.

Corresponding author: P. Fusco, Unità Operativa Complessa di Anestesia e Rianimazione, Ospedale S. Salvatore, Via Vetoio 1, 67100 L'Aquila, Italia. E-mail: p.frankfu@alice.it