

Continuous Wound Infiltration of Local Anesthetics in Postoperative Pain Management: Safety, Efficacy and Current Perspectives

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Abstract: Local infiltration and continuous infusion of surgical wound with anesthetics are parts of multimodal analgesia for postoperative pain control. The techniques, given the simplicity of execution that does not increase the timing of the intervention and does not require additional technical skills, are applied in several kinds of surgeries. The continuous wound infiltration can be used for days and a variety of continuous delivery methods can be chosen, including patient-controlled analgesia, continuous infusion or intermittent bolus. The purpose of this narrative review is to analyze the literature, in particular by researching the safety, efficacy and current perspectives of continuous wound infiltration for postoperative pain management in different surgical settings. We have identified 203 articles and 95 of these have been taken into consideration: 17 for the lower limb surgery; 7 for the upper limb surgery, 51 for the laparotomy/laparoscopic surgery of the abdominopelvic area, 13 studies regarding breast surgery and 7 for cardiothoracic surgery. The analysis of these studies reveals that the technique has a variable effectiveness based on the type of structure involved: it is better in structures rich in subcutaneous and connective tissue, while the effectiveness is limited in anatomic districts with a greater variability of innervation. However, regardless the heterogeneity of results, a general reduction in pain intensity and in opioid consumption has been observed with continuous wound infiltration: it is an excellent analgesic technique that can be included in the multimodal treatment of postoperative pain or represents a valid alternative when other options are contraindicated.

Keywords: continuous wound infiltration, postoperative analgesia, postoperative pain management, local anesthetics

Background

Postoperative pain, particularly if moderate or severe, can cause serious complications that compromise the patient's outcome and lead to the development of chronic postoperative pain.

Often the goal of achieving a compliant analgesia is disregarded, whereby combinations of techniques are required to provide complete multimodal analgesia.

Therefore, a good intraoperative analgesia that encourages the use of multimodal strategies, including regional techniques, reduces postoperative hyperalgesia and the onset of chronic pain.

Local infiltration (Local Infiltration Anesthesia, LIA) and continuous infusion of surgical wound (Continuous Wound Infiltration, CWI) with anesthetics are techniques that have recently been reintroduced as integral parts of multimodal analgesia schemes for postoperative pain control.

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Intuition to irrigate the surgical wound with local anesthetic solutions is due to the research conducted in the early 1900s by Ewald Fulde and Walter Capelle.¹

Subsequently, the two German surgeons focused attention on new methods that allowed both long-term pain control and early postoperative mobilization; developing, in 1930, the first CWI system.¹

Continuous wound infusion is an effective, proven and safe analgesic technique that is simple to perform compared to other analgesic techniques, such as peripheral nerve blocks or epidural analgesia.^{2,3} It consists of an infusion of local anesthetic (LA) into wound through a catheter directly placed by the surgeon at the end of the procedure.

The CWI can be used for several days and, thanks to the development of new pumps, a variety of continuous delivery methods can be chosen, including patient-controlled analgesia, continuous infusion, or intermittent bolus.³

Currently, more and more studies are showing that CWI is able to reduce postoperative pain scores, need for opioids, hospitalization and to improve rehabilitation.

The purpose of this narrative review is to analyze the literature of the last decade on safety, efficacy and current perspectives of CWI for postoperative pain management in different surgical settings.

Methods/Results

A literature search was carried out including the following databases: Medline via PubMed, EMBASE, Ovid and the Cochrane Library covering the period from 2009 until August 2019.

We have included systematic review, meta-analysis and randomized controlled trials (RCTs).

Publications in English, French, German and Spanish have been considered.

The search strategy has included the following key words: “postoperative analgesia,” “postoperative pain,” “local anesthetics,” “wound,” “continuous infiltration,” “continuous infusion,” and “catheters”. These key words and the corresponding MESH terms were combined with the Boolean operators “AND” and “OR.”

We have excluded studies on cadaver, animal or artificial models. We have also excluded letters, comments, editorials, practice guidelines, case reports, and other studies with insufficient data.

Among 203 retrieved articles, 17 eligible studies have been found for the lower limb surgery; 7 for the upper limb surgery, 51 studies for the laparotomy/laparoscopic

surgery of the abdominopelvic area, 13 studies regarding breast surgery and 7 for cardiothoracic surgery.

Discussion

Lower Limb Surgery

Several surgical procedures have been analyzed, including Total Hip Arthroplasty (THA), Total Knee Arthroplasty (TKA), ankle and foot surgery, burn reconstructive surgery, lower limb revascularization or amputation.⁴⁻²⁰

Regarding THA, Fusco et al have conducted a double-blind, randomized, controlled study with 96 patients. The patients were randomized to receive either a local infiltration analgesia and continuous wound infusion of 0.2% levobupivacaine (experimental group) or a local infiltration analgesia and continuous wound infusion of saline solution. The results have shown a significant effect of CWI on the postoperative incident of pain and on resting pain with a lower analgesic consumption and lower pain scores during the rehabilitation period.¹²

On the other hand, Solovyova et al in their prospective, double-blind, placebo-controlled study on 105 patients underwent THA, have shown no significant differences in the administration of opioids or in the pain scores between the group treated with LIA alone and the group treated with LIA followed by continuous infusion of ropivacaine.¹⁷

Aguirre et al have investigated the impact of a continuous wound infusion with ropivacaine 0.3% on pain and morphine consumption after minimally invasive hip arthroplasty in 76 patients.⁴

When compared with placebo, the CWI has allowed a significant reduction in morphine consumption and a better postoperative analgesia. The beneficial effects of this technique were still present 3 months after surgery.⁴

No side effects have been reported in the above-mentioned trials.^{4,12,17}

CWI has been analyzed even in the context of knee arthroplasty giving heterogeneous results: when it has been compared to femoral nerve block, patient-controlled epidural analgesia (PCEA) or continuous epidural infusion of LA, it has provided a superior pain relief, an opioid-sparing effect and a better recovery.^{6,7,11} As stated by Duggal,¹¹ such benefits could lead to early mobilization/rehabilitation or to decrease length of stay in patients with complex comorbidities indicated by higher ASA class.

On the other hand, the systematic review and meta-analysis (10 RCTs; 735 patients underwent TKA) by Sun et al has indicated that there is no significant difference

in CWI or placebo treatment for pain at 48 hrs with rest and at 72 hrs with rest or mobilization.¹⁸

In addition, the most important finding of this study has been that CWI may also increase the rate of infection.¹⁸

Similar results have been obtained by Ali et al:

... continuous analgesia with ropivacaine after TKA has no relevant clinical effect on Visual Analogue Scale (VAS) pain and does not affect LOS, analgesic consumption, range of motion or leg-raising ability. There may, however, be a higher risk of wound-healing complications (including deep infections) during the first 3 months.⁵

Another side effect could be represented by knee chondrolysis when continuous intra-articular infusion of bupivacaine, with or without epinephrine, is set postoperatively.^{9,14}

As regards the use of CWI for arthroscopic procedures, there are insufficient or not validated data in Literature.

Finally, CWI has also been used in corrective hallux surgery with no difference in pain control compared to placebo^{8,15} and, outside of orthopedic surgery, in burn reconstructive surgery, lower limb revascularization or amputation allowing, in this case, an effective pain control and lower opioid consumption.^{13,16,19,20}

Laparotomy/Laparoscopic Surgery of the Abdominopelvic Area

Given the heterogeneity of the different procedures and the different surgical settings, in this paragraph, we have preferred to consider the use of CWI in two macro-areas: open abdominal surgery and laparoscopic surgery.

As regards the first macro-area (laparotomy), all the analyzed studies agree in demonstrating the superiority of CWI compared to single-shot nerve blocks or placebo in ensuring better pain relief, lower opioid consumption, lower opioid-related side effects; enhancing, at the same time, the postoperative recovery.²¹⁻²⁷

Unfortunately, the same conclusions cannot be drawn when CWI is compared to epidural analgesia (EA). In this field there is a high heterogeneity and, while some RCTs have shown a better or similar analgesic effect of CWI when compared to EA,²⁸⁻³⁵ others have claimed exactly the opposite;³⁶⁻³⁸ often in the face of a higher incidence of side effects (ie, treatment failure, vasopressor requirement, prolonged recovery time) and higher costs.^{31,34,35,38-40}

A meta-analysis of 2013 that included nine RCTs with a total of 505 patients has attempted to end this dilemma examining pain score at rest and on movement at 24 hrs and 48 hrs, with subgroup analysis according to incision

type and administration regimen (continuous versus bolus), opiate requirements, nausea and vomiting, urinary retention, catheter-related complications and treatment failure.³⁴

The authors have shown not significant differences between CWI and EA related to pain score at rest after 48 hrs, or on movement at 24 and 48 hrs after surgery. Furthermore, CWI has allowed a reduced incidence of urinary retention in the postoperative period.³⁴

Another systematic review and meta-analysis by Mungrop et al has tried to explain these conflicting results by analyzing the impact that the different location of wound catheters (ie, preperitoneal vs subcutaneous) could have on outcome.⁴¹

The Authors have shown a superiority of preperitoneal placement compared to subcutaneous placement with an analgesic power of the former as effective as epidural analgesia.⁴¹

Perhaps, as stated by Rawal:

There is increasing evidence that less invasive regional analgesic techniques are as effective as epidural analgesia [...]. For routine postoperative analgesia, epidural analgesia may no longer be considered the gold standard.⁴²

Further studies are certainly needed to clarify this hypothesis.

Certainly, in some particular settings, such as pediatric surgery or cesarean section, CWI has widely demonstrated its advantages both with respect to neuraxial analgesia than other techniques, guaranteeing excellent outcomes in terms of postoperative pain control, opioid demand, ease of execution, side effects.⁴³⁻⁵⁸

Regarding laparoscopic surgery, among 13 articles retrieved⁵⁹⁻⁷¹ most were related to laparoscopic colorectal surgery (9 out of 13).^{59-61,63-65,67,69,71}

Similar to what has been demonstrated for open abdominal surgery, also in this case, CWI has demonstrated its effectiveness in the postoperative pain control, parental opioid consumption, rate of nausea/vomiting, early mobilization, bowel and pulmonary function; both when this technique has been compared with systemic or epidural analgesia.^{61,63,64,67,69,71}

Furthermore, it would appear that continuous wound infusion with LA could also affect stress response and immunomodulation.^{59,65} However, further studies are needed to elucidate this aspect.

As for other surgeries, Fassoulaki et al compared CWI with LA to CWI with saline solution in laparoscopic cholecystectomy.⁶² Pain at rest, pain during cough, and

analgesic consumption have been recorded in the post-anesthesia care unit and at 2, 4, 8, 24, and 48 hrs post-operatively. The authors have demonstrated good pain control up to 4 hrs postoperatively. On the other hand, they have reported no benefit regarding late and chronic pain.⁶²

In another study, Kong et al have assessed the efficacy of analgesia provided by continuous ropivacaine wound infiltration after gynecologic laparoscopy, comparing it with IV-PCA (fentanyl plus ketorolac).⁶⁶

Once again, CWI has shown to provide good analgesia with less opioid analgesic requirement and few adverse effects compared to IV-PCA, especially for PONV (The PONV scores at 12 and 24 hrs were, respectively, 0.28 and 0.27 in the CWI group, and 0.71 and 0.73 in the IV PCA group; $P=0.004$).⁶⁶

In laparoscopic gastric bypass, no benefits have been reported by the study of Medbery et al.⁶⁸

They have analyzed patient pain scores, postanesthesia care unit (PACU) times, postoperative narcotic and antiemetic requirements, postoperative complications, and hospital length of stay (LOS); but any difference has been found between patients with CWI and those without.⁶⁸

Finally, Panaro et al have compared CWI with ropivacaine to intravenous opioids in patients who underwent laparoscopic living donor nephrectomy.⁷⁰

They have observed a significant difference in terms of pain scores, use of morphine, hospital stay, and bowel recovery in favor of the CWI group. Unfortunately, one limitation of the study was the poor sample examined ($n=20$).⁷⁰

In conclusion, the use of the CWI for the surgery of abdominopelvic area, whether laparotomy or laparoscopy, offers numerous advantages in terms of analgesia, opioid consumption and early recovery, in accordance with ERAS (Enhanced Recovery After Surgery) protocols.⁷²

On the other hand, the analysis of the various articles shows a certain heterogeneity in the results, probably due to several concurrent factors (ie, delivery methods, catheter location, volume or concentration of local anesthetic).

Perhaps the standardization of the procedures could be helpful in overcoming these biases and this goal could be achieved through further meta-analysis, systematic reviews or the drafting of new international guidelines that require, of course, a multidisciplinary and broad-spectrum approach.

Upper Limb Surgery

Traditionally, brachial plexus block is effectively used for the upper limb surgery, but local wound infiltration has

been investigated; particularly in two settings: small ambulatory surgery (eg nerve decompression) and shoulder surgery.

A study of Fontana et al compared the analgesic efficacy of intraarticular injection, subacromial injection, interscalene block and intraarticular plus subacromial injection, associated with general anesthesia, for arthroscopic shoulder surgery. The analysis of this work shows that the interscalenic block is the technique that allows a better analgesia, with a lower VAS score and a lower demand for rescue analgesic drugs. However, the combination of intra-articular and subacromial infiltration allowed a valid level of analgesia with a lower analgesic consumption compared to the control group (intravenous analgesia) and the groups in which the techniques were used individually. Moreover, at 18 and 24 hrs postoperative follow-up the level of VAS pain and the detected Mean Satisfaction Score were similar between the interscalenic group and the intra-articular-subacromial infiltration group. Therefore, the authors conclude that the technique represents a valid alternative to the interscalenic block.⁷³

Another study by Koltka et al analyzed postoperative analgesia after continuous interscalenic block versus continuous infusion analgesia with catheter in the subacromial space.⁷⁴

Patients had the possibility of administering a bolus of local anesthetic using a PCI pump and could receive systemic analgesia rescue. Need for intravenous analgesia and consumption of local anesthetic were significantly lower in the interscalenic group. Even in this study, the authors underline the superiority of the interscalenic block and recommend its use up to contraindications.⁷⁴

Merivirta et al compared subacromial LA infusion with placebo. The authors reported a moderate reduction of pain score, but, on the other hand, they underline the high consumption of analgesics and the risk of LA-mediated chondrotoxicity, although there is not much evidence in this regard.^{75,76} Another study of Schwartzberg et al compared the analgesic efficacy of the subacromial local anesthetic infusion with placebo. The author did not find any difference in pain scores or analgesic consumption between subacromial infiltration and placebo.⁷⁷

Probably, the limited effectiveness of this technique in the pain control is linked to the complex and rich innervation of the shoulder which is difficult to control through the infusion at the site of the surgical wound compared to what happens through the interscalenic infusion of the brachial plexus.

As regards upper-extremity nerve decompression, Nabhan et al compared local anesthesia with intravenous regional anesthesia for endoscopic carpal tunnel release and reported no differences in pain scores but a longer tourniquet inflation time for the latter group.⁷⁸ A systematic review about nerve decompression under local anesthesia confirmed the effectiveness of LA injection into the carpal tunnel, particularly when associated with anesthesia of subcutaneous plane.⁷⁹ Although the authors did not find any evidence that long-acting LAs provide any advantages over short-acting LAs, they recommend the use of long-acting anesthetics since several studies underline its effectiveness in controlling postoperative pain.⁸⁰ The use of epinephrine added to LAs is not recommended by the authors of the review.⁷⁹

Interestingly, the comparison of local wound infiltration (LWI) with peripheral nerve block in hand lacerations did not find any difference in terms of pain and satisfaction scores, but reported a shorter anesthesia onset time for LWI, that makes this technique, easier to perform compared to nerve block, particularly attractive in the emergency department.⁸¹

Breast Surgery

In this section, we have analyzed the results from 10 recent randomized trials reporting 927 cases of different breast surgery, including mastectomy with or without Immediate Tissue Expander Reconstruction, radical mastectomy, axillary node dissection, breast lump excision, wide local excision and reduction mammoplasty.

Pre-emptive local anesthesia, used at the surgical incision site in a patient undergoing mastectomy (with or without removal of the sentinel lymph node) compared with placebo, is associated with a lower mean pain score and a lower opioids consumption both in the intraoperative and postoperative phases with a relative reduction in cost and treatment.^{82–84}

In the same way, continuous LA infusion through surgically placed wound catheters can conveniently prolong the pain control with reduced side effects including sedation, nausea and vomiting.^{85,86} Furthermore, the placement of continuous infusion catheters did not require additional surgical skills and the infusion pump or infusion catheter did not hinder patients during the postoperative stay.⁸⁵

Compared to other local anesthesia techniques, Bouman et al did not find any difference in pain scores between continuous paravertebral block and continuous LA infusion after oncological breast surgery, pointing out that the latter may be preferable due to the lower incidence of associated complications.⁸⁷

Even delivering LAs through the surgical drain may have some advantages.^{88,89}

Jonnvithula et al compared the instillation of 0.25% bupivacaine 40 mL (20 mL through each of the drain) with placebo. The drains were clamped for a period of 10 min after the drug administration. The technique was simple and effective in reducing postoperative pain and no technique-related complications were found.⁸⁸

As regards the development of chronic postoperative pain, a qualitative systematic review that included 10 trials and 699 patients and a meta-analysis that analyzed 13 trials with 1150 patients confirm that continuous wound infiltration has an analgesic effect only in the first hours after surgery.^{90,91}

Similar results were shown by the multicenter study of Albi-Feldzer et al, who evaluated the efficacy in postoperative pain control, the incidence of chronic postoperative pain and its consequences on quality of life and mood comparing the efficacy of preoperative infiltration of the wound at second and third intercostal spaces and at the humeral insertion of major pectoralis with placebo in 236 patients. The authors believe that the technique allows an effective pain control in the immediate postoperative period, especially in the first 90 mins, but – on the other hand – it does not bring benefits in persistent and chronic pain at 3, 6 and 12 months.⁹²

An important study by Chiu et al compared paravertebral blockade with wound infusion (145 patients) in terms of persistent postoperative pain at 1 year after surgery. The authors reported a chronic postoperative pain incidence of only 8% in the sample of patients analyzed, much lower than the percentage reported in the literature of 25–60%.⁹³

However, the study included both radical mastectomies and conservative surgeries; perhaps this may have influenced in reducing the incidence of persistent postoperative pain, as reported by the authors of the article.

Anyway, the regional techniques and the wound infiltration have shown to be effective in reducing the acute postoperative pain, which is one of the predisposing factors for the development of persistent pain.^{86,94,95}

However, such results need to be confirmed by larger and well-designed randomized trials.

Cardiothoracic Surgery

Cardiothoracic surgery includes procedures ranging from thoracoscopy to thoracotomy-sternotomy: epidural or paravertebral block are effective analgesic techniques but can be associated with serious complications and requires more skills compared to LWI; moreover, the anticoagulation

therapy often required after cardiac surgery can be a contraindication to neuraxial block.⁹⁶

Both in thoracotomy and thoracoscopic surgery, LWI has shown a lower pain score, lower analgesic consumption, shorter postoperative hospital stays, higher patient satisfaction scores, earlier bowel canalization and ambulation when compared to no infiltration or placebo.^{97,98}

On the other hand, Karnik et al, who compared local infiltration and systemic opioids in video-assisted thoracoscopic surgery decortication in pediatric empyema patients, affirmed that LWI is not as effective as epidural block in the reduction of postoperative pain.⁹⁹

Similarly, Abo-zeid et al compared single-shot paravertebral block with local anesthetic infiltration in thoracoscopic surgery: the authors highlighted a considerable analgesic superiority of the para-neuraxial technique compared to the infiltration of the surgical site in terms of postoperative pain reduction, leading to a better respiratory function (FEV1).¹⁰⁰

As regards to sternotomy, several authors suggested the continuous sternal infusion of LA for postoperative pain management, but data from published studies are conflicting: a study comparing continuous wound infusion versus placebo after sternotomy in 49 children did not find any difference in morphine consumption, pain score values, or nausea and vomiting.¹⁰¹ Conversely, a similar study on 40 adults reported a reduced pain score, reduced morphine consumption and improved rehabilitation but no differences in respiratory outcome associated with continuous LWI.¹⁰²

The same authors confirmed the analgesic effect of CWI in a subsequent study, but did not find any difference in respiratory outcome or ICU length of stay.¹⁰³

Conclusion

CWI is a simple technique, burdened with minimal incidence of complications, that can be applied to several kinds of surgeries. The technique does not require additional anesthetic or surgical skills and does not involve significant increases in the time of the procedure.

However, the type of surgery and the innervation of the structures involved can affect the effectiveness of the technique: the best results have probably been obtained in the treatment of cutaneous, subcutaneous and connective tissue structures, while the treatment of complex structures such as articulation and areas with multiple innervations has given lower results when compared to the reference regional techniques.

At the same time, regardless of this heterogeneity of results, a general reduction in pain intensity and in opioid consumption has been observed.

We believe that CWI is an excellent analgesic technique that can be included in the multimodal treatment of postoperative pain or represents a valid alternative when the other options are contraindicated.

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Disclosure

The authors report no conflicts of interest in this work.

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