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Original Article

# Can postoperative atelectasis be prevented by local bupivacaine infusion/infiltration after emergency upper midline laparotomy? Randomized clinical trial

Erol Kilic, Mustafa Ugur

Mustafa Kemal Universty, General Surgery, Faculty of Medicine, Hatay, Turkey



**Abstract**

**Aim:** To investigate the effectivity of conventional analgesia and transfascial local bupivacaine infusion used for postoperative pain management on the development of postoperative atelectasisin patients undergoing upper abdominal surgery by midline laparotomy.

**Materials and Methods:** The prospective study included patients that underwent emergency UAS by midline laparotomy and were administered conventional analgesia (CA) (nonsteroidal anti-inflammatory drugs [NSAIDs] + opioids) or transfascial bupivacaine infusion (TBI) (NSAIDs + bupivacaine) following extubating.

**Results:** The groups were similar with regard to age, preoperative ASA status, surgical indications, and operative time ($p>0.05$). Mean Visual Analogue Scale scores at 0-8, 08-24, and 24-48 h and the requirement of opioids were lower in the TBI group compared to the CA group ($p<0.05$). The median length of intensive care unit stay was significantly lower in the TBI group compared to the CA group (4 and 5 days, respectively) ($p<0.05$). The incidence of postoperative atelectasis and the requirement of noninvasive ventilation and reintubation were lower in the TBI group compared to the CA group ($p>0.05$).

**Conclusion:** Transfascial bupivacaine infusion/infiltration is effective not only in providing postoperative analgesia but also in the prevention of postoperative atelectasis.

**Keywords:** Transfascial bupivacaine infusion, postoperative atelectasis, postoperative analgesia.

## INTRODUCTION

Postoperative pulmonary complications (PPCs) are frequently seen following abdominal surgeries, leading to high morbidity and mortality (1,2). Most common PPCs include atelectasis, pneumonia, acute respiratory failure, tracheobronchitis, and prolonged mechanical ventilation. These complications mostly occur after surgical procedures involving a supra umbilical incision (2,3). Postoperative atelectasis (PA) is one of these complications whose incidence increases in association with various risk factors including age, smoking, malnutrition, and obesity. Additionally, operative time, type of surgical procedure, and anesthetic agents are also known to facilitate PA development (4). PA has been reported in 22% of the patients undergoing upper abdominal surgery (5). On the other hand, postoperative pain is known to cause respiratory muscle and diaphragmatic dysfunction, thereby resulting in PA (6,7).

The primary cause of PA is a mechanical restriction of motion in the diaphragm (i.e. the functional unit of the chest wall) and the anterior abdominal wall. The enlargement of the incision in the anterior abdominal wall with a retractor also facilitates the development of PA (3,8). Postoperative pain impairs respiratory function by restricting the movement of diaphragmatic and intercostal muscles (9). In particular, the reflex inhibition of the phrenic nerve during upper abdominal surgery leads to diaphragm dysfunction and PA development (10).

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**Corresponding Author:** Erol Kilic, Mustafa Kemal Universty, General Surgery, Faculty of Medicine, Hatay, Turkey
E-mail: ekkilic55@gmail.com

The mainstay treatment of PA is based on the prevention of its development. Common treatment options include pulmonary physiotherapy, mobilization, expansion maneuvers, incentive spirometry, postural drainage, bronchoscopy, pain management, high-flow oxygen therapy, cough assistance, and noninvasive ventilation (NIV) (11).

The present study aimed to investigate the effectivity of conventional analgesia and transfascial local bupivacaine infusion used for postoperative pain management on the development of PA in patients undergoing upper abdominal surgery by midline laparotomy.

## MATERIAL and METHODS

The study was conducted by the fund received from Mustafa Kemal University Scientific Projects Coordination Unit after obtaining an approval from the Local Clinical Research Ethics Board (Approval Date:05/24/2018). The double-blind randomized study included patients that underwent emergency upper abdominal surgery by midline laparotomy and were administered conventional analgesia (CA) (nonsteroidal anti-inflammatory drugs [NSAIDs] + opioids) or transfascial bupivacaine infusion (TBI) (NSAIDs + bupivacaine) following extubating between 2018 and 2019. The patients to be included in each group were determined by lot, using several computer programs, and were confirmed by a relevant expert. Eventually, a total of 80 patients were included in the study and were divided into two groups with 40 patients each. All the patients were followed up for a period of 30 days.

The conventional analgesia (CA) group received 50 mg diclofenac sodium intramuscularly (IM) 3/24 h + pethidine hydrochloride 100 mg 2/24 h intravenously (IV) and the transfascial bupivacaine infusion (TBI) group received 50 mg diclofenac sodium IM 3/24 h + transfascial bupivacaine 12.5 mg/h for 48 h.

Bupivacaine was infused at a rate of 12.5 mg/h for 48 h using a transfascial catheter and an On-Q pain pump system (ON-Q Painbuster(R)). Patients with a Visual Analogue Scale (VAS) score of 4 or higher were additionally administered pethidine hydrochloride 1 mg/kg IV.

The ON-Q PainBuster® is an elastomeric pump comprising a 400-ml single-line reservoir and a multiport, silver-impregnated catheter delivering a local anesthetic at a preset flow rate of 5 mL/h. The catheter delivers the anesthetic by passing through the apparatus that contacts the skin and provides fluid thermoregulation. The reservoir was filled with 120 ml (600 mg) of bupivacaine and 120 ml of saline solution at a ratio of 1/1, and continuous infusion was performed at a rate of 5 ml/h for a total of 48 h.

All the surgical procedures were performed under general anesthesia. Anesthesia was induced with intravenous propofol (2 mg/kg), remifentanil (1 mcg/kg), and rocuronium (0.6 mg/kg). Anesthesia was maintained with sevoflurane and 50% nitrous oxide (N2O) in oxygen. At the end of the surgery, all the patients were administered pethidine hydrochloride 1 mg/kg IV and diclofenac sodium 100 mg IM for postoperative pain relief prior to extubating.

Inclusion criteria were as follows: age between 18-75 years, emergency abdominal surgery (within the first 48 h), general anesthesia, lung-protective ventilation continued throughout the surgical procedure (tidal volume <8 ml/kg with positive end-expiratory pressure ranging from 8 to 12 cmH2O), and immediate postoperative extubating.

Exclusion criteria were as follows: chronic or acute respiratory failure, body mass index >35 kg/m2, age over 75 years, active smoking, malnutrition, persistent hemodynamic instability, severe cardiac failure, use of immunosuppressive drugs within the last two months, requirement of postoperative mechanical ventilation, perioperative blood loss (20% of total blood volume), use of epidural analgesia, laparoscopic interventions, operations with non-upper-median cutting and prolonged postoperative intubation.

Postoperative atelectasis was diagnosed based on the detection of SpO2<% 90 and PaO2 <60 mmHg despite oxygen supplement, requirement of NIV, or the detection of atelectasis on unilateral or bilateral chest radiography (12). NIV or nasal continuous positive airway pressure was performed in patients with acute hypoxemic respiratory failure.

Age, gender, ASA (American Society of Anesthesiologists) status, surgical procedure, operative time, VAS score, requirement of analgesia, presence of PA requiring NIV, and the length of intensive care unit (ICU) stay were recorded for each patient.

### Statistical analysis

Data were analyzed using SPSS for Windows version 21.0 (Armonk, NY: IBM Corp.) Normal distributions of continuous variables was determined using Shapiro Wilk test and were compared using Student's t-test and Mann-Whitney U test. Categorical variables were compared using Chi-square test. A p value of <0.05 was considered significant.

## RESULTS

Table 1 presents the demographic and clinical characteristics of both groups. Each group included a total of 40 patients and the groups were similar with regard to age, gender, preoperative ASA status, surgical indications, and operative time (p>0.05). The median operative time was 86 min in the TBI group and 89 min in the CA group and no significant difference was found (p>0.05). The median length of ICU stay was significantly lower in the TBI group compared to the CA group (4 and 5 days, respectively) (p<0.05) (Table 1).

Mean VAS scores at 0-8, 08-24, and 24-48 h were lower in the TBI group compared to the CA group (p<0.05) (Table 1).

The indications for laparotomy were similar in both groups, among which perforated peptic ulcer, acute cholecystitis, and acute cholangitis were the most common indications, respectively.

Although no statistical significant difference was found between the TBI and CA groups with regard to PA, NIV requirement, and requirement of reintubation, These complications are less found in TBI group (p>0.05) (Table 2). Postoperative opioid requirement at 0-8, 08-24, and 24-48 h were significantly lower in the TBI group compared to the CA group (p<0.05) (Table 2).

Postoperative opioid requirement at 0-8, 08-24, and 24-48 h were significantly lower in the TBI group compared to the CA group (p<0.05) (Table 2).

**Table 1. Demographic and clinical characteristics of groups**

| | TBI (NSAID + bupivacaine) | | | CA (NSAID + opioid) | | | p |
|---|---|---|---|---|---|---|---|
| | Mean ± SD | Median | Min -Max | Mean ± SD | Median | Min -Max | |
| **Age (years)** | 61.05 ± 8.66 | 63.00 | 38 - 75 | 60.73 ± 6.46 | 62.50 | 47 - 72 | 0.850* |
| **Operative Time/ (Min)** | 96.15 ± 27.86 | 86.00 | 61 - 154 | 92.65 ± 20.62 | 89.00 | 61 - 134 | 0.525* |
| **ICU stay (days)** | 3.75 ± 0.54 | 4.00 | 3 - 5 | 4.63 ± 0.98 | 5.00 | 3 - 7 | 0.001* |
| **VAS Score (0-10) (0-8 h)** | 5.9 ± 0.84 | 6.00 | 4 - 7 | 6.63 ± 0.95 | 6.00 | 5 - 9 | 0.002** |
| **(8-24 h)** | 3.23 ± 0.92 | 3.00 | 2 - 5 | 4.63 ± 0.95 | 5.00 | 2 - 6 | 0.001** |
| **(24-48 h)** | 0.95 ± 0.64 | 1.00 | 0 - 3 | 2.1 ± 0.84 | 2.00 | 0 - 4 | 0.001** |

TBI: Transfascial Bupivacaine Infusion, CA: Conventional Analgesia, Min: Minute, ICU: Intensive Care Unit, VAS: Visual Analogue Scale, h: Hour. * : Student's t-test, **: Mann Whitney U Test. SD: Standard Deviation

**Table 2. ASA status, surgical indications, postoperative atelectasis, NIV requirement, reintubation and opioid requirement of groups**

| | | Groups | | p |
|---|---|---|---|---|
| | | TBI(%) | CA (%) | |
| **Gender (%)** | | | | |
| Female | | 42.5 | 47.5 | >0.05 |
| Male | | 57.5 | 52.5 | |
| **ASA Status (1.2.3)** | | | | |
| 1 | | 3 (7.5) | 4 (10) | |
| 2 | | 19 (47.5) | 17 (42.5) | |
| 3 | | 18 (45) | 19 (47.5) | |
| **Indications** | | | | |
| PPU | | 19 (47.5) | 21 (52.5) | |
| Acute Cholecystitis | | 13 (32.5) | 11 (27.5) | |
| Acute Cholangitis | | 8 (20) | 8 (20) | >0.05 |
| **Atelectasis** | **No** | | | |
| | **Yes** | 30 (75) | 27 (67.5) | |
| **NIV requirement** | **No** | 10 (25) | 13 (32.5) | |
| | **Yes** | 34 (82.5) | 30 (75) | |
| **Reintubation** | **No** | 7 (17.5) | 10 (25) | |
| | **Yes** | 37 (92.5) | 35 (87.5) | |
| | | 3 (7.5) | 5 (12.5) | |
| **Opioid requirement** | | | | **<0.05** |
| 0-8h | | 11 (27.5) | 20 (50) | **<0.05** |
| 8-24h | | 5 (12.5) | 12 (30) | **<0.05** |
| 24-48h | | 2 (4) | 6 (12) | |

TBI: Transfascial Bupivacaine Infusion, CA: Conventional Analgesia, ASA: American Society of Anesthesiologists, PPU: Perphorated Peptic Ulcer, NIV: Noninvasive Ventilation. *: Chi-square Test

## DISCUSSION

Unless well managed, postoperative pain may inhibit respiratory function and cough reflex, leading to increased secretion and atelectasis (13). A well-planned postoperative pain management with adequate ventilation and deep breathing and cough exercises reduces the risk of atelectasis and pneumonia and also leads to increased mobilization, thereby resulting in reduced risk of postoperative thrombophlebitis and embolism (14,15). Moreover, the incidence of atelectasis may be reduced by a better postoperative analgesia with a lower risk of respiratory depression (16).

Effective postoperative pain management is of paramount importance in patients undergoing surgery. Opioids are commonly and effectively used for postoperative pain management. However, these agents have been shown to have several disadvantages such as respiratory depression, postoperative nausea and vomiting, pruritus, difficulty in voiding, ileus, and prolonged hospital stay (17,18). On the other hand, some other techniques such as epidural catheterization, patient-controlled analgesia, and local infiltrative analgesia are also used for postoperative pain management (19).

The pain experienced after abdominal surgery is of two types: (i) visceral pain which responds well to opioids and (ii) somatic pain which is induced by cough and movement and shows a weak response to opioids. Isolated opioid use results in weak somatic pain treatment, thereby leading to an increased risk of PA (20-22).

In our study, postoperative pain severity and opioid requirement at 0-8, 08-24, and 24-48 h were significantly

lower in the TBI group compared to the CA group, which could be attributed to the greater suppression of the severity of somatic pain by local infiltration analgesia. Additionally, it could also be attributed to the effectiveness of the somatic pain treatment administered in the same group, which could have reduced the risk of respiratory depression, thereby leading to a lower risk of PA.

Local infiltrative analgesia is an effective technique used in postoperative pain management and also reduces postoperative opioid requirement and prevents opioid-induced respiratory depression and complications such as nausea and vomiting (23,24).

The mainstay treatment of PA involves the prevention of its development. Common therapeutic and preventive treatment options include pulmonary physiotherapy, mobilization, expansion maneuvers, incentive spirometry, postural drainage, bronchoscopy, pain management, high-flow oxygen therapy, cough assistance, and NIV (11). NIV is the delivery of mechanical ventilation via a face mask in hemodynamically stable, cooperative patients with intact airway reflexes, with no need for intubation and no complications associated with invasive mechanical ventilation (25). Administration of NIV reduces the risk of infection and leads to shorter ICU stay and reduced requirement of reintubation (26). The PA patients that remain uncooperative or have inadequate oxygenation, impaired consciousness, and hemodynamic instability despite NIV therapy may require reintubation.

In our study, the requirement of NIV and reintubation was lower in the TBI group compared to the CA group due to the lower incidence of PA in the former. We consider that, the administration of an effective somatic pain treatment in the same group prevented respiratory depression and thereby inhibited the development and severity of PA.

Somatic pain, also known as parietal pain, is a sudden-onset, sharp, well-localized pain caused by the irritation of peripheral nerve endings in skin, muscles, and joints, which is aggravated by movement and cough. Pain arising from nociceptors in the skin is known as superficial somatic pain and the pain originating from nociceptors in skeletal muscles, joints, tendons, or fascia is called deep somatic pain. The irritation of the nociceptors in the parietal peritoneum is another cause of somatic pain.

## CONCLUSION

The results indicated that local infiltrative analgesia is a more effective and safe technique compared to conventional analgesia for the prevention of postoperative atelectasis following upper abdominal surgery. It was also revealed that this technique exerts its effect by controlling somatic pain. Although PA cannot be completely prevented by TBI, it is less developed thanks to effective somatic pain inhibition. Therefore, it is thought that the development of PA can be prevented by TBI.

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*ErolKilic ORCID: 0000-0002-0229-2911*
*Mustafa UgurORCID: 0000-0002-5922-2367*

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