



Continuous wound infiltration of ropivacaine for reducing of postoperative pain after anterior lumbar fusion surgery: a clinical retrospective comparative study

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Background: Local anesthetic infiltration at the site of a surgical wound is commonly used to control postoperative pain. In this study, we examined the effectiveness of continuous local infiltration at an abdominal surgical site in patients undergoing anterior lumbar interbody fusion (ALIF) surgery.

Methods: Sixty-one patients who underwent ALIF surgery were enrolled. For thirty-one of them, a continuous local anesthetics infiltration system was used at the abdominal site. We collected data regarding the patients' sleep quality; satisfaction with pain control after surgery; abilities to perform physical tasks and the additional application of opioids in the postoperative 48 hours.

Results: The On-Q system group showed reduced visual analogue scale scores for pain at the surgical site during rest and movement at 0, 12, 24, and 48 hours; and more was satisfied with pain control management at the first postoperative day (7.0 ± 1.2 vs. 6.0 ± 1.4 ; $P = 0.003$) and week (8.1 ± 1.6 vs. 7.0 ± 1.8 ; $P = 0.010$) than the control group. The number of additional patient-controlled analgesia (PCA) bolus and pethidine injections was lower in the On-Q group (PCA: 3.67 ± 1.35 vs. 4.60 ± 1.88 ; $P = 0.049$ and pethidine: 2.09 ± 1.07 vs. 2.73 ± 1.38 ; $P = 0.032$). Patients who used the On-Q system performed more diverse activity and achieved earlier ambulation than those in the control group.

Conclusions: Continuous wound infiltration with ropivacaine using an On-Q system may be effective for controlling postoperative pain after ALIF surgery.

Key Words: Activities of Daily Living; Analgesia, Patient-Controlled; Anesthesia, Local; Anesthetics, Local; Pain Management; Pain, Postoperative; Ropivacaine; Spinal Fusion; Surgical Wound.

INTRODUCTION

Local anesthetic infiltration at the site of a surgical wound has become an increasingly common method for controlling postoperative pain [1]. The method is simple, safe, and may reduce the use of opioids, additional complications

during perioperative periods, the duration of hospitalization, and costs [2].

However, the effectiveness of local anesthesia infiltration for lumbar spine surgery has been a point of controversy. Kjærgaard et al. [3] reported in a review article that the clinical significance of this method for lumbar

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spine surgery was still questionable. In contrast, Perera [4] claimed, in a meta-analysis, that evidence supported the use of intramuscular local anesthetic infiltration to reduce the frequency of analgesics and the time to require first analgesics.

Recently, the number of transabdominal approaches to correct spinal vertebra and discs, such as anterior lumbar interbody fusion (ALIF) and oblique lumbar interbody fusion, has increased [5]. Many articles have reported the effectiveness of local anesthesia infiltration at the surgical site in abdominal surgeries such as colorectal surgery, cholecystectomy, hepatobiliary pancreatic surgery, and caesarean section [6-9]. However, the effectiveness of local anesthetic infiltration at the surgical site in transabdominal spinal surgery remains unknown.

In this study, we examined the effectiveness of local infiltration with ropivacaine at the abdominal surgical site in patients who underwent ALIF surgery.

MATERIALS AND METHODS

This is a retrospective case control study, which analyzes the effectiveness of continuous local anesthetics at an abdominal surgical site in patients undergoing ALIF. The study design was approved by the Institutional Review Board of Wooridul Spine Hospital (2019-08-WSH-006) in September 2019.

We retrospectively collected data on patients that had undergone ALIF and posterior pedicle screw fixation under three lumbar segmental levels, due to degenerative lumbar spine disease, who visited the hospital between January and June 2019. All the patients in our study had not responded to non-surgical treatments such as medication, physical therapy, and epidural steroid injection for at least 6 months. The exclusion criteria for this study patients include those who had undergone corrective surgery for deformity such as degenerative scoliosis and kyphosis; had cognitive or psychiatric disease; had known allergic reaction to local anesthetics; used opioids for more than 3 months; or had any contraindications for drugs used for pain control. Patients who met the inclusion criteria were divided into two groups: those who used the continuous local anesthetics infiltration system (On-Q system; Halyard Health, Alpharetta, GA) at the abdominal surgical site, and those who did not (control). We explained the On-Q system, including the benefits, risks, goal, and components to all patients undergoing ALIF surgery in our hospital. The patients that used the On-Q system decided to apply this system by themselves.

The On-Q system consists of an indwelling catheter and an elastomeric pump (Fig. 1). At the end of the ALIF pro-

cedure, the surgeon placed the multi-holed catheter between the abdominal muscle fascia and subcutaneous fat tissue. After the catheter was placed through the subcutaneous tissue, it was connected to the elastomeric pump filled with 40 mL of 2% ropivacaine and 60 mL of normal saline. The On-Q pump continuously infused 0.8% ropivacaine at a rate of 2 mL/hr through the indwelling catheter for 2 days. All ALIF surgeries and On-Q pump procedures were performed by one surgeon (HC Lee). After these procedures, the patients were turned to a prone position. If posterior decompression was necessary, the surgeon performed a laminotomy on both sides and posterior fixation with percutaneous pedicle screws at the fusion level. If not, the surgeon only performed percutaneous pedicle screw fixation immediately.

The patient-controlled analgesia (PCA) system was filled with fentanyl 800 mg and nefopam hydrochloride 60 mg. Its total volume was 100 mL; it was set to infuse 2 mL/hr continuously, and deliver 0.5 mL per bolus dose, with a 15 minute lockout time (Accufuser plus[®]; Woo Young Medical, Jincheon, Korea). Tramadol 37.5 mg, acetaminophen 325 mg, and muscle relaxants were taken by all patients twice a day during hospitalization. They were also administered pethidine (25 mg) for severe pain (above 5 on the visual analogue scale [VAS]).

We collected data regarding pain intensity, as assessed before the operation, upon returning to the recovery room (H0), and at postoperative 12 hours, 24 hours, 48 hours, and 1 week, using a VAS score from 0 (no pain) to 10 (worst pain). We assessed the pain intensity at the abdominal and posterior lumbar surgical sites separately, at rest and during movement (coughing, turning, or walking). The sleep



Fig. 1. The components of On-Q system (indwelling catheter and elastic pump, Halyard Health, Alpharetta, GA).

Table 1. The demographic characters of the patients

Variable	On-Q (n = 31)	Control (n = 30)	P value
Age (yr)	66.7 ± 8.8	65.5 ± 9.8	0.595
Male	21 (67.7)	16 (53.3)	0.249
BMI (kg/m ²)	24.9 ± 2.9	25.4 ± 3.1	0.528
HTN	12 (38.7)	16 (53.3)	0.309
DM	16 (51.6)	14 (46.7)	0.999
Cardiovascular disease	2 (6.5)	3 (10.0)	0.671
Smoking	6 (19.4)	6 (20.0)	> 0.999
Preoperative pain severity			
Back pain	7.5 ± 1.3	7.3 ± 11.5	0.571
Leg pain	6.2 ± 1.9	6.8 ± 1.9	0.271
ASA class : I/II	9/22	5/25	0.251
Diagnosis			0.695
Central stenosis	3 (9.7)	1 (3.3)	
Foraminal stenosis	10 (32.3)	8 (26.7)	
Lytic spondylolisthesis	8 (25.8)	9 (30.0)	
Degenerative spondylolisthesis	10 (32.3)	12 (40.0)	
Fused level	1.5 ± 0.7	1.5 ± 0.8	0.808
Posterior decompression	19 (61.3)	22 (73.3)	0.316
Hospitalization (day)	18.2 ± 6.9	18.0 ± 5.1	0.877
Duration of anesthesia (min)	312.1 ± 135.5	309.7 ± 128.7	0.943
Duration of operation (min)	189.1 ± 167.6	252.3 ± 133.3	0.109
Crystalloids (mL)	1,537.1 ± 672.3	1,551.8 ± 679.0	0.932
Colloid (mL)	517.7 ± 106.9	605.0 ± 181.2	0.025
EBL (mL)	477.4 ± 279.2	494.3 ± 233.6	0.799
Transfusion	3 (9.7)	7 (23.3)	0.150
Complication of PCA	4 (12.9)	3 (10.0)	> 0.999

Values are presented as mean ± standard deviation or number (%).

BMI: body mass index, HTN: hypertension, DM: diabetes mellitus, ASA class: American Society of Anesthesiologist classification, EBL: estimated blood loss, PCA: patients controlled analgesia.

quality of the patients was estimated during the postoperative first and second nights and at 1 week using a numeric rating scale (NRS) from 0 (very poor, not sleeping for even a moment the previous night) to 10 (excellent, best sleep, as good as before the occurrence of pain), so as their satisfaction with the postoperative pain management on the first day, second day, and first week also using an NRS from 0 (no satisfaction) to 10 (excellent satisfaction in regards to pain).

We collected data regarding patients' ability to perform movement tasks with or without assistance, including turning in bed, sitting on the bed, getting out of bed, standing, using the restroom, walking with a walker, walking by themselves, and walking more than 100 meters before the operation and at H0, 12 hours, 24 hours, 48 hours, and 1 week. Assistance with postoperative actions was defined as the state of the patient's need for help from nurses or caregivers in performing their actions. We also recorded the numbers of bolus used with the PCA system and the administrations of pethidine in the postoperative 48 hours.

RESULTS

During the study period, 61 patients received ALIF surgery. Among them, 31 chose to use the continuous local infiltration system (On-Q group), while the others did not (n = 30, control group). The demographic characteristics of each groups are shown in **Table 1**. The preoperative diagnoses, fusion levels, and the trials of posterior decompression did not differ significantly between the groups. The severity of preoperative back pain and leg pain was not significantly different between the groups. Among perioperative parameters such as estimated blood loss, duration of operation and anesthesia, transfusion, and the total volume of colloid or crystalloid fluid, only the total volume of colloid was greater in the control group. The operative times of the control group were longer than those of the On-Q group, but the difference was not statistically significant (189.1 ± 167.6 vs. 252.3 ± 133.3; *P* = 0.109). Because of this, more colloid fluid was used in the control group (517.7 ± 106.9 vs. 605.0 ± 181.2; *P* = 0.025, **Table 1**).

The VAS scores for pain at the surgical site during resting and movement were lower in the ON-Q group at H0

Table 2. The presentation of pain

Severity of pain	On-Q (n = 31)	Control (n = 30)	P value
VAS (abdomen, resting)			
Pre OP	0	0	0.999
Post OP	3.7 ± 2.1	5.1 ± 1.9	0.010
Post 12 hr	3.4 ± 1.9	4.8 ± 1.9	0.004
Post 24 hr	2.4 ± 1.4	3.7 ± 1.6	0.001
Post 48 hr	1.7 ± 1.1	2.6 ± 1.2	0.005
Post 1 wk	1.3 ± 1.0	1.6 ± 1.0	0.148
VAS (abdomen, activation)			
Pre OP	0	0	0.999
Post OP	4.0 ± 2.0	5.4 ± 1.9	0.005
Post 12 hr	3.7 ± 1.5	5.3 ± 1.7	< 0.001
Post 24 hr	2.4 ± 1.2	3.7 ± 1.5	< 0.001
Post 48 hr	1.7 ± 1.0	3.0 ± 1.2	< 0.001
Post 1 wk	1.2 ± 0.9	1.6 ± 1.1	0.115
VAS (back pain, resting)			
Pre OP	6.2 ± 1.9	6.7 ± 1.9	0.271
Post OP	6.3 ± 1.7	7.1 ± 2.3	0.114
Post 12 hr	5.4 ± 1.6	5.1 ± 1.4	0.470
Post 24 hr	4.1 ± 1.2	4.3 ± 1.1	0.582
Post 48 hr	3.3 ± 1.4	3.4 ± 1.4	0.899
Post 1 wk	2.5 ± 0.8	2.6 ± 0.6	0.534
VAS (back pain, activation)			
Pre OP	6.7 ± 1.3	7.2 ± 1.4	0.252
Post OP	6.9 ± 1.6	7.1 ± 2.6	0.727
Post 12 hr	5.3 ± 1.4	5.5 ± 2.0	0.631
Post 24 hr	4.0 ± 1.0	4.5 ± 1.6	0.175
Post 48 hr	3.2 ± 1.0	3.4 ± 1.2	0.542
Post 1 wk	2.4 ± 0.8	2.7 ± 0.8	0.139
Quality of sleep			
Pre OP	4.5 ± 1.7	4.6 ± 2.7	0.838
Post 24 hr	5.8 ± 2.0	5.2 ± 0.6	0.255
Post 48 hr	6.1 ± 2.4	6.0 ± 1.0	0.838
Post 1 wk	6.8 ± 2.5	6.7 ± 1.2	0.783
Satisfaction of pain management			
Pre OP	1.7 ± 3.0	2.6 ± 2.2	0.220
Post 24 hr	7.0 ± 1.2	6.0 ± 1.4	0.003
Post 48 hr	7.2 ± 1.1	6.7 ± 1.5	0.092
Post 1 wk	8.1 ± 1.6	7.0 ± 1.8	0.010

Values are presented as mean ± standard deviation.

VAS: visual analogue scale, Pre: preoperative, Post: postoperative, OP: operation.

and at 12, 24, and 48 hours. Use of the On-Q system did not affect the intensity of pain at the abdominal lesion 1 week after the operation. The intensity of pain at posterior surgical sites (percutaneous pedicle screw or decompression) was also not affected by use of the On-Q system (Table 2, Fig. 2). Patients in the control group pushed the button on the PCA system for a bolus injection more frequently than those in the On-Q group (3.67 ± 1.35 vs. 4.60 ± 1.88 ; $P = 0.049$). The number of injections of pethidine in the On-Q group was lower than that in the control group (2.09 ± 1.07 vs. 2.73 ± 1.38 ; $P = 0.032$) (Table 3, Fig. 3). The complication

rates of the PCA system did not differ significantly between the two groups.

During 1 week of hospitalization, no differences in sleep quality were observed ($P = 0.838$ the first day, $P = 0.255$ the second night, and $P = 0.783$ at postoperative week 1). The patients using the On-Q system were more satisfied with their pain control management on the postoperative first day (7.0 ± 1.2 vs. 6.0 ± 1.4 ; $P = 0.003$) and at 1 week (8.1 ± 1.6 vs. 7.0 ± 1.8 ; $P = 0.010$). On the second postoperative day, patients in the On-Q group were more satisfied with their pain management than those in the control group (7.2 ± 1.1 vs. 6.7 ± 1.5), but the difference was not statistically significant ($P = 0.092$).

The postoperative data regarding activity with assistance showed that patients using the On-Q system were more capable of turning in bed, sitting, standing, and using the restroom, and walked sooner than those in the control group. Patients in the On-Q group also performed the tasks above without assistance sooner than those in the control group (Tables 4, 5).

We reviewed all patients' medical records for 3 months after the operation. There were no reports of complications related to the On-Q system such as local fluid collection, infections, or skin redness at the insertion site.

DISCUSSION

We investigated the effectiveness of a continuous local infiltration system using ropivacaine at the surgical site in patients who underwent ALIF surgery. Our findings revealed that this system may potentially be used to control postoperative pain.

Relieving postoperative pain has become a major component in the care of patients who have undergone lumbosacral fusion [10]. A study by Hopf et al. [11] revealed that postoperative pain was exacerbated by increasing inflammatory factors in the surrounding tissue and the catecholamine level, resulting in insufficient wound perfusion and circulation. Wound infiltration with local anesthetics alleviates pain and promotes the wound-healing process by increasing perfusion and oxygenation at the surgical site [10].

Another hypothesis is that local continuous anesthesia infiltration reduces postoperative pain via modification of the central nervous system (CNS) [11]. Peripheral tissue damage triggered two types of CNS activation pathway. The first pathway, central sensitization, was activated by nociceptive afferent input due to operative tissue damage. This nociceptive stimulation lead to over-activation of spinal cord neurons. This hyper-activation results in an increase in the postoperative pain response. The other

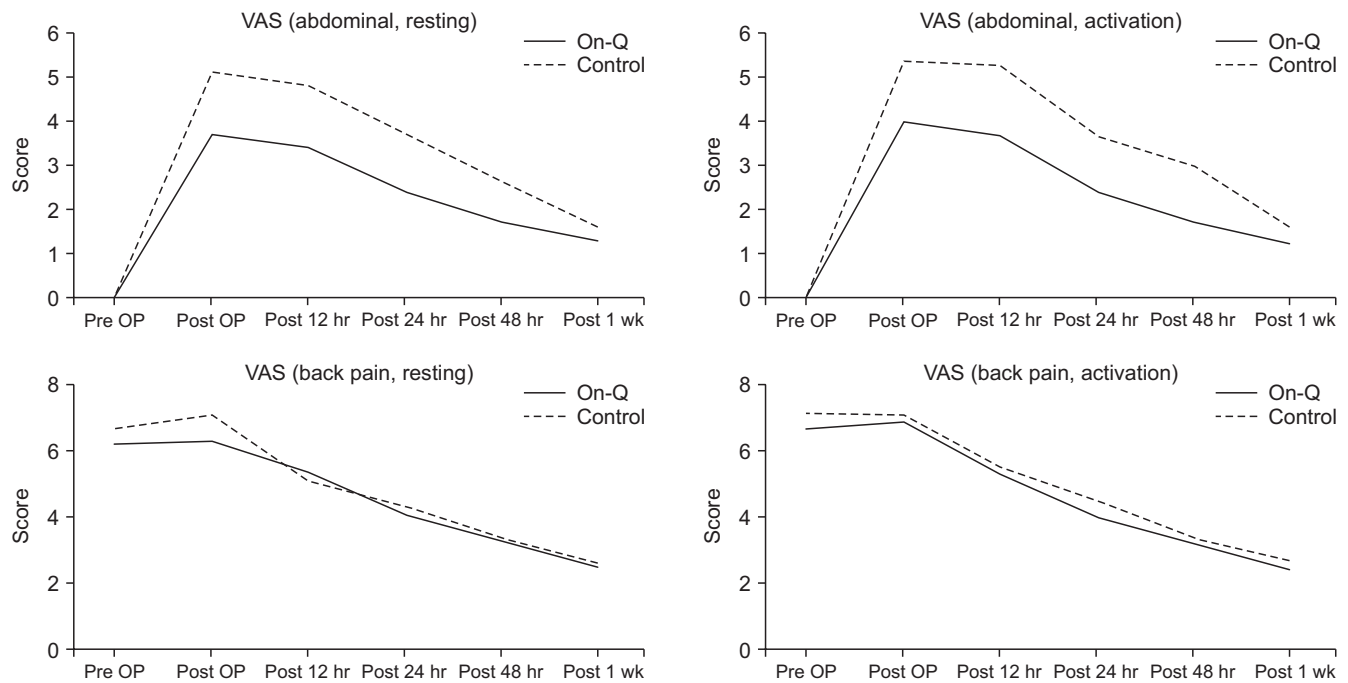


Fig. 2. Visual analogue scale (VAS) score for pain at the abdominal site and back lesion at postoperative 1 week.

Table 3. The requirements of additional pain control management

	On-Q (n = 31)	Control (n = 30)	P value
PCA bolus required	3.67 ± 1.35	4.60 ± 1.88	0.049
Additional pethidine used	2.09 ± 1.07	2.73 ± 1.38	0.032

Values are presented as mean ± standard deviation.

PCA: patients controlled analgesia.

pathway passed through group C nerve fibers. The postoperative pain excited the dorsal horn of the spinal cord, and this response increased the severity of the pain. As a result, the wound infiltration of local anesthesia reduced the postoperative pain by increasing perfusions, elevating oxygenation and blocking the central nociceptive pathways along with peripheral C-fibers. The continuous wound infiltration system prolonged these effects for 2 days after surgery.

Ropivacaine is the propyl analogue of bupivacaine. It has a longer duration of action than bupivacaine and also inhibits the inflow of sodium in nerve fibers. Ropivacaine is less lipophilic than bupivacaine, so it has a lower tendency to penetrate large myelinated motor neuron fibers. As such, ropivacaine is used for differential sensory blockage and has fewer side effects involving the CNS and the heart [12].

Local anesthetic infiltration at the surgical wound has long been performed in many surgical fields, but the effects of this procedure on postoperative pain have been controversial. The first article regarding the effects of local

anesthetic infiltration over the wound edge was by Coppelle in 1935 [13]. Mullen and Cook first reported that local anesthetic infiltration at the surgical wound decreased the severity of postoperative pain in patients who underwent lumbar discectomy [6-17]. They thought that this reduction in postoperative pain was caused by lessening of the psychological effect of lumbar surgery [14]. Perera et al. [4] conducted a systemic review and meta-analysis of local anesthetic infiltration use in lumbar spine surgery. Their review, which included 11 articles, reported that the severity of pain differed significantly between those who used local anesthetic and those in the control group at postoperative hour 1, but not at 12 or 24 hours ($P = 0.001$, $P = 0.93$, and $P = 0.85$, respectively) [4]. The 11 articles included one by Perera et al. [4] that included only patients who underwent lumbar discectomy and laminectomy.

There were three articles on lumbosacral fusion surgery that examined the relationship between local anesthetic infiltration and the severity of postoperative pain [4]. Bianconi et al. [16] reported that continuous local anesthetic infiltration was an effective method for postoperative pain control after posterior spine stabilization surgery. Xu et al. [17] conducted a study on the effects of continuous wound infiltration after thoracolumbar surgery (including fusion surgery), and showed that continuous wound infiltration with ropivacaine achieved a reduction of postoperative pain similar to that of intravenous analgesics; moreover, fewer complications related to analgesics drugs such as nausea, vomiting, and chronic pain were reported. Contrary to these articles, Greze et al. [18] reported that

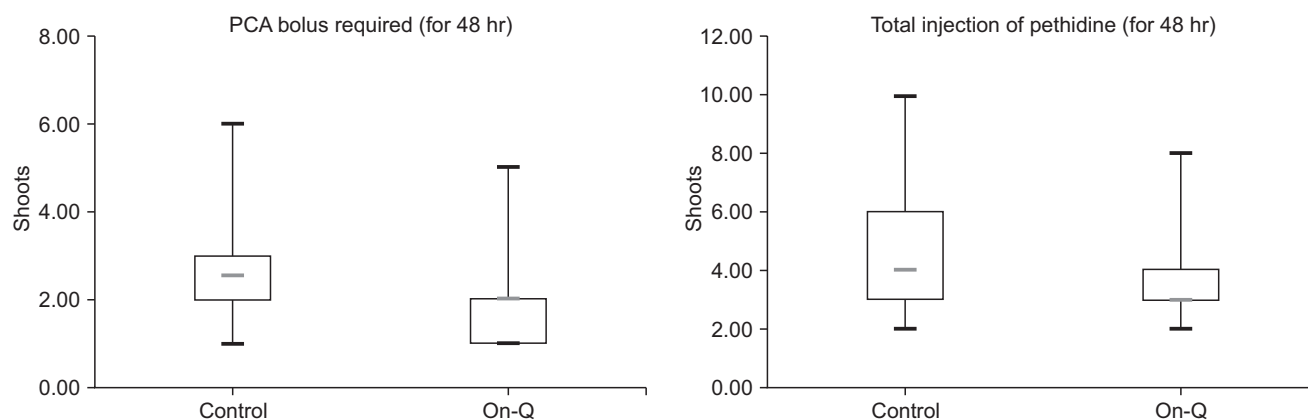


Fig. 3. Total postoperative patient-controlled analgesia (PCA) bolus and pethidine consumption in the postoperative 48 hours in the control ($n = 30$ patients) and On-Q ($n = 31$ patients) groups. Boxplots show the interquartile range (box). There were statistical differences between the two groups ($P = 0.049$, $P = 0.032$).

continuous wound infiltration of ropivacaine after spinal fusion surgery did not provide additional analgesic effects compared to baseline multimodal agents.

In our study, continuous wound infiltration with ropivacaine after anterior lumbar fusion surgery effectively reduced postoperative pain at the abdominal site. As ours was the first study on the effectiveness of continuous infiltration with local anesthesia after ALIF surgery, large and prospective randomized studies are needed to further verify the effectiveness of this analgesic method. Moreover, the consumption of opioids in the postoperative 48 hours was lower in the On-Q group than in the control group. However, it should be noted that the effects of postoperative opioid consumption have been controversial. In a systematic review by Kjærgaard et al. [3] about wound infiltration with local anesthesia after decompression or discectomy, control patients consumed more opioids than patients receiving local anesthetics. A study by Greze et al. [18], on the effect of continuous wound infiltration after posterior fusion surgery, showed that the consumption of opioids during the postoperative 48 hours did not differ significantly between the trial and control groups. In a study by Bianconi et al. [16], continuous wound infiltration with ropivacaine significantly decreased the number of requests for other analgesics during the 72 hours after fusion surgery. As described above, effects related to a decrease in opioid consumption after local anesthetics infiltration has been controversial, but we think that this analgesic method may decrease the need for additional analgesics. In the future, we plan to conduct a prospective double-blinded randomized study on the effects of opioid consumption after continuous local anesthetics infiltration with ropivacaine.

There were only two articles, by Greeze et al. [18] and Milligan et al. [19], that reported the effect of postoperative

wound infiltration with local analgesics. These articles showed no statistically significant differences between the trial and control groups regarding the time to the first mobilization after surgery. In contrast, our study reported that patients using the On-Q system were more active and performed activities such as sitting, standing, and walking sooner than those in the control group. We think that the On-Q system decreased postoperative pain at the abdominal site; this made it easier for patients to walk, sit, stand, etc.

Our study was the first to examine the effectiveness of continuous wound infiltration with ropivacaine after ALIF. There were some limitations. As this was a retrospective study, the enrolled patients had heterogeneous diseases, and the lengths of the surgical site differed among the patients. As such, a large-scale, prospective, randomized study is needed to evaluate the effectiveness of continuous wound infiltration with ropivacaine after ALIF surgery.

Our results revealed that continuous wound infiltration with ropivacaine using the On-Q system may be used to control postoperative pain after ALIF surgery. It may also lead to early mobilization, especially walking. Use of this method may prevent some of the potential side effects associated with reducing activities.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

FUNDING

No funding to declare.

Table 4. Performance state with assistance

	On-Q (n = 31)	Control (n = 30)	P value
Ability to turn on bed			
Pre OP	31 (100.0)	30 (100.0)	0.999
Post OP	10 (32.3)	8 (26.7)	0.632
Post 12 hr	24 (77.4)	24 (80.0)	0.806
Post 24 hr	25 (80.6)	24 (80.0)	0.949
Post 48 hr	30 (96.8)	25 (83.3)	0.104
Post 1 wk	31 (100.0)	30 (100.0)	0.999
Ability to sit			
Pre OP	27 (87.1)	29 (96.7)	0.173
Post OP	10 (32.3)	10 (33.3)	0.929
Post 12 hr	13 (41.9)	10 (33.3)	0.488
Post 24 hr	18 (58.1)	21 (70.0)	0.332
Post 48 hr	30 (96.8)	23 (76.7)	0.026
Post 1 wk	31 (100.0)	30 (100.0)	0.999
Ability to get out bed			
Pre OP	30 (96.8)	29 (96.7)	0.981
Post OP	9 (29.0)	10 (33.3)	0.717
Post 12 hr	10 (32.3)	12 (40.0)	0.529
Post 24 hr	17 (54.8)	21 (70.0)	0.222
Post 48 hr	30 (96.8)	22 (73.3)	0.006
Post 1 wk	30 (96.8)	30 (100.0)	0.999
Ability to stand			
Pre OP	30 (96.8)	29 (96.7)	0.981
Post OP	10 (32.3)	10 (33.3)	0.929
Post 12 hr	10 (32.3)	12 (40.0)	0.529
Post 24 hr	29 (93.5)	20 (66.7)	0.008
Post 48 hr	30 (96.8)	28 (93.3)	0.617
Post 1 wk	30 (96.8)	30 (100.0)	0.999
Ability to use restroom			
Pre OP	27 (87.1)	29 (96.7)	0.173
Post OP	1 (3.2)	0 (0.0)	0.305
Post 12 hr	1 (3.2)	0 (0.0)	0.305
Post 24 hr	20 (64.5)	13 (43.3)	0.097
Post 48 hr	31 (100.0)	24 (80.0)	0.011
Post 1 wk	31 (100.0)	28 (93.3)	0.238
Ability to walk with walker			
Pre OP	19 (61.3)	21 (70.0)	0.474
Post OP	0 (0.0)	0 (0.0)	0.999
Post 12 hr	6 (19.4)	5 (16.7)	0.785
Post 24 hr	22 (71.0)	16 (53.3)	0.155
Post 48 hr	30 (96.8)	23 (76.7)	0.020
Post 1 wk	30 (96.8)	29 (96.7)	0.981
Ability to walk by self			
Pre OP	19 (61.3)	21 (70.0)	0.474
Post OP	0 (0.0)	0 (0.0)	0.999
Post 12 hr	0 (0.0)	0 (0.0)	0.999
Post 24 hr	15 (48.4)	7 (23.3)	0.042
Post 48 hr	30 (96.8)	16 (53.3)	0.001
Post 1 wk	30 (96.8)	29 (96.7)	0.981
Ability to walk above 100 m			
Pre OP	12 (38.7)	11 (36.7)	0.869
Post OP	0 (0.0)	0 (0.0)	0.999
Post 12 hr	0 (0.0)	0 (0.0)	0.999
Post 24 hr	14 (45.2)	12 (40.0)	0.684
Post 48 hr	28 (90.3)	20 (66.7)	0.024
Post 1 wk	29 (93.5)	23 (76.7)	0.081

Values are presented as number (%).

Pre: preoperative, Post: postoperative, OP: operation.

Table 5. Performance state by self

	On-Q (n = 31)	Control (n = 30)	P value
Ability to turn on bed			
Pre OP	29 (93.5)	29 (96.7)	0.573
Post OP	3 (9.7)	2 (6.7)	0.668
Post 12 hr	14 (45.2)	10 (33.3)	0.344
Post 24 hr	25 (80.6)	17 (56.7)	0.043
Post 48 hr	30 (96.8)	19 (63.3)	0.001
Post 1 wk	30 (96.8)	29 (96.7)	0.981
Ability to sit			
Pre OP	27 (87.1)	29 (96.7)	0.173
Post OP	0 (0.0)	0 (0.0)	0.999
Post 12 hr	0 (0.0)	0 (0.0)	0.999
Post 24 hr	5 (16.1)	9 (30.0)	0.198
Post 48 hr	27 (87.1)	19 (63.3)	0.031
Post 1 wk	30 (96.8)	29 (96.7)	0.981
Ability to get out bed			
Pre OP	23 (74.2)	28 (93.3)	0.044
Post OP	0 (0.0)	0 (0.0)	0.999
Post 12 hr	0 (0.0)	0 (0.0)	0.999
Post 24 hr	9 (29.0)	7 (23.3)	0.613
Post 48 hr	29 (93.5)	19 (63.3)	0.004
Post 1 wk	30 (96.8)	30 (100.0)	0.999
Ability to stand			
Pre OP	17 (54.8)	28 (93.3)	0.001
Post OP	0 (0.0)	0 (0.0)	0.999
Post 12 hr	1 (3.2)	0 (0.0)	0.321
Post 24 hr	13 (41.9)	10 (33.3)	0.488
Post 48 hr	30 (96.8)	26 (86.7)	0.195
Post 1 wk	30 (96.8)	24 (80.0)	0.178
Ability to use restroom			
Pre OP	18 (58.1)	28 (93.3)	0.001
Post OP	1 (3.3)	0 (0.0)	0.305
Post 12 hr	0 (0.0)	0 (0.0)	0.999
Post 24 hr	8 (25.8)	9 (30.0)	0.715
Post 48 hr	31 (100.0)	22 (73.3)	0.002
Post 1 wk	29 (93.5)	27 (90.0)	0.614
Ability to walk with walker			
Pre OP	16 (51.6)	19 (63.3)	0.355
Post OP	0 (0.0)	2 (6.7)	0.144
Post 12 hr	0 (0.0)	0 (0.0)	0.999
Post 24 hr	8 (25.8)	12 (40.0)	0.238
Post 48 hr	30 (96.8)	22 (73.3)	0.002
Post 1 wk	29 (93.5)	28 (93.3)	0.973
Ability to walk by self			
Pre OP	16 (51.6)	16 (53.3)	0.893
Post OP	0 (0.0)	0 (0.0)	0.999
Post 12 hr	0 (0.0)	0 (0.0)	0.999
Post 24 hr	9 (29.0)	3 (10.0)	0.062
Post 48 hr	29 (93.5)	13 (43.3)	< 0.001
Post 1 wk	27 (87.1)	24 (80.0)	0.679
Ability to walk above 100 m			
Pre OP	8 (25.8)	6 (20.0)	0.590
Post OP	0 (0.0)	0 (0.0)	0.999
Post 12 hr	0 (0.0)	0 (0.0)	0.999
Post 24 hr	9 (29.0)	9 (30.0)	0.934
Post 48 hr	28 (90.3)	18 (60.0)	0.006
Post 1 wk	21 (67.7)	21 (70.0)	0.849

Values are presented as number (%).

Pre: preoperative, Post: postoperative, OP: operation.

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REFERENCES

- Ozyilmaz K, Ayoglu H, Okyay RD, Yurtlu S, Koksall B, Hanci V, et al. Postoperative analgesic effects of wound infiltration with tramadol and levobupivacaine in lumbar disk surgeries. *J Neurosurg Anesthesiol* 2012; 24: 331-5.
- Johansson B, Glise H, Hallerbäck B, Dalman P, Kristoffersson A. Preoperative local infiltration with ropivacaine for postoperative pain relief after cholecystectomy. *Anesth Analg* 1994; 78: 210-4.
- Kjærgaard M, Møiniche S, Olsen KS. Wound infiltration with local anesthetics for post-operative pain relief in lumbar spine surgery: a systematic review. *Acta Anaesthesiol Scand* 2012; 56: 282-90.
- Perera AP, Chari A, Kostusiak M, Khan AA, Luoma AM, Casey ATH. Intramuscular local anesthetic infiltration at closure for postoperative analgesia in lumbar spine surgery: a systematic review and meta-analysis. *Spine (Phila Pa 1976)* 2017; 42: 1088-95.
- Phan K, Maharaj M, Assem Y, Mobbs RJ. Review of early clinical results and complications associated with oblique lumbar interbody fusion (OLIF). *J Clin Neurosci* 2016; 31: 23-9.
- Beaussier M, Parc Y, Guechot J, Cachanado M, Rousseau A, Lescot T; CATCH Study Investigators. Ropivacaine preperitoneal wound infusion for pain relief and prevention of incisional hyperalgesia after laparoscopic colorectal surgery: a randomized, triple-arm, double-blind controlled evaluation vs intravenous lidocaine infusion, the CATCH study. *Colorectal Dis* 2018; 20: 509-19.
- Fassoulaki A, Vassi E, Korkolis D, Zotou M. Perioperative continuous ropivacaine wound infusion in laparoscopic cholecystectomy: a randomized controlled double-blind trial. *Surg Laparosc Endosc Percutan Tech* 2016; 26: 25-30.
- Mungroop TH, Veelo DP, Busch OR, van Dieren S, van Gulik TM, Karsten TM, et al. Continuous wound infiltration versus epidural analgesia after hepato-pancreato-biliary surgery (POP-UP): a randomised controlled, open-label, non-inferiority trial. *Lancet Gastroenterol Hepatol* 2016; 1: 105-13.
- Reinikainen M, Syväoja S, Hara K. Continuous wound infiltration with ropivacaine for analgesia after caesarean section: a randomised, placebo-controlled trial. *Acta Anaesthesiol Scand* 2014; 58: 973-9.
- Mitra S, Purohit S, Sharma M. Postoperative analgesia after wound infiltration with tramadol and dexmedetomidine as an adjuvant to ropivacaine for lumbar discectomies: a randomized-controlled clinical trial. *J Neurosurg Anesthesiol* 2017; 29: 433-8.
- Hopf HW, Hunt TK, West JM, Blomquist P, Goodson WH 3rd, Jensen JA, et al. Wound tissue oxygen tension predicts the risk of wound infection in surgical patients. *Arch Surg* 1997; 132: 997-1004.
- Woolf CJ, Chong MS. Preemptive analgesia--treating postoperative pain by preventing the establishment of central sensitization. *Anesth Analg* 1993; 77: 362-79.
- Knudsen K, Beckman Suurküla M, Blomberg S, Sjövall J, Edvardsson N. Central nervous and cardiovascular effects of i.v. infusions of ropivacaine, bupivacaine and placebo in volunteers. *Br J Anaesth* 1997; 78: 507-14.
- Ford GT, Guenter CA. Toward prevention of postoperative pulmonary complications. *Am Rev Respir Dis* 1984; 130: 4-5.
- Mullen JB, Cook WA Jr. Reduction of postoperative lumbar hemilaminectomy pain with Marcaine. Technical note. *J Neurosurg* 1979; 51: 126-7.
- Bianconi M, Ferraro L, Ricci R, Zanoli G, Antonelli T, Giulia B, et al. The pharmacokinetics and efficacy of ropivacaine continuous wound instillation after spine fusion surgery. *Anesth Analg* 2004; 98: 166-72.
- Xu B, Ren L, Tu W, Wu Z, Ai F, Zhou D, et al. Continuous wound infusion of ropivacaine for the control of pain after thoracolumbar spinal surgery: a randomized clinical trial. *Eur Spine J* 2017; 26: 825-31.
- Greze J, Vighetti A, Incagnoli P, Quesada JL, Albaladejo P, Palombi O, et al. Does continuous wound infiltration enhance baseline intravenous multimodal analgesia after posterior spinal fusion surgery? A randomized, double-blinded, placebo-controlled study. *Eur Spine J* 2017; 26: 832-9.
- Milligan KR, Macafee AL, Fogarty DJ, Wallace RG, Ramsey P. Intraoperative bupivacaine diminishes pain after lumbar discectomy. A randomised double-blind study. *J Bone Joint Surg Br* 1993; 75: 769-71.