A Retrospective Comparative Study of Local Anesthesia Only and Local Anesthesia with Sedation for Percutaneous Endoscopic Lumbar Discectomy

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Abstract

The purpose of this study was to compare surgical experience and clinical outcomes of lumbar disk herniation (LDH) patients treated with percutaneous endoscopic lumbar discectomy (PELD) using local anesthesia only and local anesthesia with sedation. Ninety-two consecutive LDH patients were divided into four groups: control group (Con Group), dexmedetomidine group (Dex Group), oxycodone group (Oxy Group), and dexmedetomidine + oxycodone group (Dex + Oxy Group). Mean arterial pressure (MAP), heart rate (HR), Ramsay score and VAS score were compared before anesthesia (T1), working cannula establishment (T2), nucleus pulposus removal (T3), and immediately postoperative (T4). Surgical duration, hospitalization and MacNab criteria were evaluated. In control group, MAP and HR at T2 and T3 were higher than T1 ($P < 0.05$). In Dex, Oxy, and Dex + Oxy groups, MAP and HR at T2, T3, T4 were lower than T1, but Ramsay scores at T2, T3, T4 were higher than T1 ($P < 0.05$). VAS scores in all groups were improved postoperative ($p > 0.05$). The clinical outcomes have no significant differences among the four groups ($P > 0.05$). We concluded that the combination of dexmedetomidine and oxycodone under local anesthesia is an effective method to improve surgical experience and reduce anxiety in suitable LDH patients.

Introduction

Lumbar disk herniation (LDH) is a common disease in spinal surgery that often requires surgical treatment ^{1,2}. Lumbar discectomy can improve pain, function, and quality of life in properly selected patients ³. Typically, open lumbar surgery has been perceived as an effective intervention but carries postoperative back pain and long recovery time. Subsequently, minimally invasive surgery, such as PELD, has been published to facilitate lumbar discectomy ^{4,5}. The PELD has many advantages, such as preserving healthy tissue, shorter hospital stays, less blood loss and postoperative pain, and faster patient recovery ^{6,7}. Therefore, endoscopic techniques received increasing attention from spinal surgeons around the world.

Local and general anesthesia are commonly analgesic methods used in PELD ⁸⁻¹¹. General anesthesia can achieve an excellent surgical experience for patients ⁹⁻¹¹. However, it lacks intraoperative feedback during the operation, which indicates the unconscious patients cannot communicate with the surgeon if their nerve root or spinal cord is stimulated. In other words, general anesthesia may increase the surgical risk of PELD. Moreover, local anesthesia has the advantage of intraoperative feedback to improve surgical safety and seemed promising and feasible spinal surgery alternative ⁸. Nevertheless, it provides a poor surgical experience in some pain-sensitive patients, including anxiety and psychentonia. Furthermore, patients with local anesthesia are conscious and could hear the sound of surgical tools during an operation, ultimately lead to blood pressure increases, heart rate increases, even cardiovascular and cerebrovascular accidents ⁸. Thus, achieving effective pain relief, immediate feedback during operation, and satisfactory surgical experience simultaneously in PELD for patients with LDH remains a challenge.

Dexmedetomidine is a new alpha 2 adrenal receptor agonist with good sedative and analgesic effects, which has no inhibiting respiration and is easy to wake up after surgery ¹²⁻¹⁶. Moreover, oxycodone hydrochloride, as the only opioid and double receptor agonist, has an excellent inhibitory effect on mixed somatic and visceral pain ^{17,18}. We hypothesized that the combination of dexmedetomidine and oxycodone hydrochloride

under local anesthetics in PELD for LDH patients could achieve a good analgesic effect and improve the surgical experience. Therefore, this retrospective study aimed to compare the surgical experience, pain, and clinical outcomes of LDH patients with LDH treated with PELD using local anesthesia only and local anesthesia sedation.

Methods

Subjects and groups

From January 2016 to June 2019, a total of 92 consecutive single-level LDH patients underwent PELD under local anesthesia only or local anesthesia sedative. Patients were divided into four groups: Con Group, Dex Group, Oxy Group, and Dex+Oxy Group.

All four groups were given local infiltration anesthesia with 1% lidocaine 30~40mL layer by layer on the skin, subcutaneous fascia, muscle, and articular process. In the Dex+Oxy Group, oxycodone hydrochloride (1 mL/10 mg) was slowly injected intravenously (0.05 mg/kg) (Duration: 1 min) at 10 min before operation; Dexmetomidine hydrochloride (2 mL/200 µg) (0.5 µg/kg) was infused continuously for 10 min, and then maintained at a rate of 0.4 µg/kg·h until the end of the operation. In the Dex Group, 0.3ml normal saline was slowly injected intravenously at 10 min before operation; Dexmetomidine hydrochloride (2 mL/200 µg) (0.5 µg/kg) was infused continuously for 10 min, and then maintained at a rate of 0.4 µg/kg·h until the end of the operation. In the Oxy Group, oxycodone hydrochloride (1 mL/10 mg) was slowly injected intravenously (0.05 mg/kg) (Duration: 1 min) at 10 min before operation; 0.3ml normal saline was infused continuously for 10 min, and then maintained at a rate of 0.4 µg/kg·h until the end of the operation. In the Con Group, 0.3ml normal saline was slowly injected intravenously at 10 min before operation; 0.3ml normal saline was infused continuously for 10 min and then maintained at a rate of 0.4 µg/kg·h until the end of the operation. Subsequently, all patients underwent PELD via the foraminal approach¹⁹.

Evaluation parameters

Parameters, including mean arterial pressure (MAP), heart rate (HR), SpO₂, and Ramsay score, were compared before anesthesia (T1), the establishment of working cannula (T2), the removal of the nucleus pulposus (T3), and immediately after surgery (T4). Moreover, the clinical outcomes, including the operation time, the hospitalization period, the visual analogue scale (VAS), the Short Form-36 health survey questionnaire (SF-36), the Oswestry disability index (ODI) score, and the modified MacNab criteria were evaluated. Lumbar radiological, CT, and MRI were performed during follow-up. Lumbar fluoroscopy, CT, and MRI were performed during the follow-up duration.

Statistical method

SPSS (version 26.0) was used for statistical analysis. The Chi-square test was used for counting data and analysis of variance (ANOVA) for measurement data. Before ANOVA, a homogeneity test of variance was performed. If $p > 0.05$, one-way ANOVA would be performed. If $p < 0.05$, Welch ANOVA would be used for statistical analysis. Least-Significant Difference (LSD) was used to test the differences between groups if the results of one-way ANOVA showed that $p < 0.05$, and the Games-Howell test was used to test the differences

between groups if the results of Welch ANOVA showed that $p < 0.05$. $P < 0.05$ is considered to be a statistical difference. For the inter-group comparison of multiple groups, the corrected P^* is used for comparison according to the number of pair comparisons (k), $P^* = P/k$.

Results

Patient characteristics

The demographic characteristics of all 92 patients were shown in **Table 1**. The gender and the segment of LDH among the four groups were tested by chi-square test, and the results showed that $p > 0.05$. Moreover, the homogeneity test of variance of the age of the four groups showed that $p > 0.05$. The one-way ANOVA compared the age of four groups, and the result showed that $p > 0.05$; thus, there was no statistical difference in the age of the four groups.

Evaluation parameters

The results of MAP, HR, SpO_2 , and Ramsay score at T1, T2, T3, and T4 in four groups were shown in **Fig. 1A-D**. First, a homogeneity test of variance was used, and the results were shown in **Table 2**. All p values of MAP, HR, and SpO_2 in four-time points and the p -value of Ramsay score in the T1 time were > 0.05 , so that one-way ANOVA could compare the differences of each group in the same time point. The Ramsay scores²⁰ at T2, T3, and T4 periods did not satisfy the homogeneity of variance ($p < 0.05$), and Welch ANOVA was used to compare Ramsay scores in each group at the time of T2, T3, and T4.

The results of ANOVA were shown in **Table 3**. At the time of T1, all p values were more than 0.05. There was no significant difference in MAP, HR, SpO_2 , and Ramsay scores among the four groups before operation. At the time of T1, T2, T3, and T4, the results of one-way ANOVA of SpO_2 showed $p > 0.05$, indicating no statistical difference in SpO_2 among groups. The one-way ANOVA results of MAP, HR, and Welch ANOVA of Ramsay scores in T2, T3, and T4 showed all $p < 0.05$. There were statistical differences in MAP, HR, and Ramsay in T2, T3, and T4. LSD was used to compare MAP and HR among groups in T2, T3, and T4 time points to clarify the differences between groups, and the Games-Howell test was used to compare Ramsay scores among T2, T3, and T4 time points. The results are shown in **Table 4**.

According to **Fig. 1A** and **Table 4**, the MAP values at the time point of T2 were Con Group $>$ Oxy Group $>$ Dex Group $>$ Dex+Oxy Group, and the differences were statistically significant ($p < 0.05$). As can be seen from **Fig. 1B** and **Table 4**, the HR values at the time point of T2 were Con Group $>$ Oxy Group $>$ Dex Group/Dex+Oxy Group, and the differences were statistically significant ($p < 0.05$), there was no statistical difference between Dex Group and Dex+Oxy Group ($p > 0.05$). At the time of T2, both Dex Group and Dex+Oxy Group have significant higher Ramsay scores than Con Group and Oxy Group ($p < 0.05$), and no significant difference was found between Dex Group and Dex+Oxy Group ($p > 0.05$), Con Group and Oxy Group ($p > 0.05$) (**Fig. 1D** and **Table 4**).

According to **Fig. 1A** and **Table 4**, the MAP values at T3 from high to low were Con Group/Oxy Group, Dex Group, and Dex+Oxy Group, with significant statistically differences ($p < 0.05$), but no statistical difference was

found between Con Group and Oxy Group ($p>0.05$). As can be seen from **Fig. 1B** and **Table 4**, the HR values at the time of T3 from high to low were Con Group, Oxy Group, Dex Group/Dex+Oxy Group, with significant statistically differences ($p<0.05$), but there was no statistical difference between Dex Group and Dex+Oxy Group ($p>0.05$). As can be seen from **Fig. 1D** and **Table 4**, the Ramsay scores at the time of T3 from high to low were Dex Group/Dex+Oxy Group, Oxy Group/Con Group, with significant statistically difference ($p<0.05$), but there was no significant difference between Dex Group and Dex+Oxy Group ($p>0.05$), Con Group and Oxy Group ($p>0.05$).

According to **Fig. 1A** and **Table 4**, the MAP values at the time of T4 from high to low were Con Group, Oxy Group, Dex Group/Dex+Oxy Group, with significant statistically differences ($p<0.05$), but no statistical difference was found between Dex Group and Dex+Oxy Group ($p>0.05$). As can be seen from **Fig. 1B** and **Table 4**, the HR values at the time of T4 from high to low were Con Group, Oxy Group, Dex+Oxy Group, Dex Group, with significant statistically differences ($p<0.05$), but there was no statistical difference between Dex Group and Dex+Oxy Group ($p>0.05$), Group Dex and Group Oxy ($p>0.05$). As can be seen from **Fig. 1D** and **Table 4**, the Ramsay scores at the time of T4 from high to low were Dex Group/Dex+Oxy Group, Con Group/Oxy Group, and the difference was statistically significant ($p<0.05$), however, there was no significant difference between Dex Group and Dex+Oxy Group ($p>0.05$), Con Group and Oxy Group ($p>0.05$).

Clinical outcomes

Operation time and hospitalization period

The results of operation time and hospitalization period were shown in **Fig. 2A-B** and **Table 5**. The results of the homogeneity test of variance were $p>0.05$, and the results of one-way ANOVA showed that there were differences in operation time ($p<0.001$) and no statistical differences in hospitalization period among different groups ($p>0.05$) (**Table 5**). LSD was used to compare the operation time between groups to clarify the difference of operation time between groups (**Fig. 2A**), and the results showed that the Con Group had the longest operation time, followed by Oxy Group, Dex Group, and Dex+Oxy Group, with significant statistically differences ($p<0.001$). In the control group, one patient suffered from intense pain accompanied by nervousness, which led to a significant prolongation of the operation time.

VAS Score

The VAS scores of the patients in the four groups before surgery, immediately postoperative (T4), 1 month, 3 months, 6 months, 12 months, and 24 months after the operation, were presented in **Fig. 3A**. Telephone follow-up was performed at 1 and 3 months after surgery, and patients were followed up at the hospital from 6 months to 24 months after surgery. There was no loss of follow-up 6 months after the operation, 3 patients lost follow-up 1 year after surgery, and 5 patients lost follow-up two years after surgery. The results of the homogeneity test of variance were $p>0.05$. At the time point of T4, the results of the VAS score were: Con Group > Dex Group > Oxy Group > Dex+Oxy Group, and all the differences were statistical. The one-way ANOVA results showed that at the other time point, there was no statistical difference among the 4 groups ($p>0.05$) (**Fig. 3A**). Therefore, we combine the data of each group at the same time point and compare the differences of VAS results between different time points to evaluate the therapeutic effect. The result of the homogeneity test of variance was $p<0.05$, and the result of Welch ANOVA was also $p<0.05$, so the Games-

Howell test was used to compare the difference between every two different time points. The results were shown in **Table 6** and **Fig. 3B**, and statistical differences existed between every two time points ($p < 0.001$), but no statistical differences were found between 12 months postoperatively and 24 months postoperatively ($p > 0.05$), indicating that pain improvement was stable 12 months postoperatively.

SF-36 (PCS+MCS) score and ODI score

The SF-36 Physical Component Summary (PCS), the SF-36 Mental Component Summary (MCS), and the ODI score in the four groups were showed in **Fig. 4A-C**. The results of variance homogeneity and one-way ANOVA among the four groups were shown in **Table 7**. The results show no statistical difference among the 4 groups at different times ($p > 0.05$). Therefore, we combined the data of each group at each same time point and compared the differences of SF-36 and ODI results between different time points to evaluate the clinical outcomes. The results showed in **Fig. 4D** and **Fig. 5**.

The modified MacNab criteria

The clinical outcomes were rated according to modified MacNab criteria as "Excellent" (patient symptom-free, able to resume normal life and work), "Good" (slight symptoms remain, activity slightly limited, no effect on life and work), "Fair" (some symptom relief, activity significantly limited, life and work affected) or "Poor" (post-operation symptoms the same or worse as preoperation symptoms) ²¹. The results of modified MacNab criteria at 24 months postoperation were shown in **Table 8**, Chi-square test was used for comparison among groups, and the p-value was more than 0.05. This result showed that local anesthesia with sedation and without sedation did not improve the clinical outcomes.

Discussion

The present findings indicated that local anesthesia sedation is a safe, effective, and reliable method to achieve satisfying pain control during PELD surgery. Moreover, an essential finding in the current study was that the combination of dexmedetomidine and oxycodone under local anesthesia could reduce anxiety, relieve pain, and improve the surgical experience in selected LDH patients who underwent PELD. Both local anesthesia and general anesthesia are effective methods for minimally invasive surgery in spinal surgery. Local anesthesia is inferior to general anesthesia in surgical experience for patients. However, local anesthesia may be superior to general anesthesia in information feedback. According to previous studies, simultaneous intraoperative feedback and good surgical experience remain challenging in LDH patients who underwent PELD ²². We hypothesized that using dexmedetomidine and oxycodone hydrochloride under local anesthetics in PELD could achieve a good analgesic effect and improve the surgical experience for LDH patients. Herein, we retrospectively studied 92 LDH patients to evaluate the surgical experience, pain control, and clinical outcomes of PELD under local anesthesia only and local anesthesia sedation.

Traditional analgesics are opioids ²³⁻²⁶ and NSAIDs ²⁷⁻²⁹ commonly used in clinical. Opioids are mainly used to relieve pain by binding to the opioid receptors in the central and peripheral nervous systems ³⁰. However, it has several side effects, including nausea, vomiting, dizziness, itching, sedation, respiratory depression, uroschesis, constipation, euphoria, nausea, vomiting, respiratory depression, excessive sedation, and liver

dysfunction^{31–36}. Meanwhile, NSAIDs are predominantly applied to inhibit the synthesis of prostaglandins and the release of bradykinin in the process of inflammation to achieve pain relief^{37,38}. Nevertheless, NSAIDs occasionally lead to severe gastrointestinal reactions³⁸. Therefore, choosing analgesic agents with low side effects and good effects in PELD surgery is crucial.

Dexmedetomidine is a highly selective alpha 2 receptor agonist characterized by sedation, analgesia, anti-anxiety, easy arousal, and mild respiratory inhibition^{12,14,16}. Dexmedetomidine has a good analgesic effect in animal models of acute and chronic inflammatory pain, postoperative pain, and even in chronic pain patients for whom opioid analgesics are ineffective³⁹. In this study, we found that both Dex Group and Dex + Oxy Group have a lower MAP and HR than Con Group or Oxy Group at the time of T2, T3, and T4 ($p < 0.05$), indicating that dexmedetomidine plays a role in controlling blood pressure and heart rate in PELD under local anesthesia. Our results are consistent with those of Greenberg, R.G. et al.¹², who reported that dexmedetomidine could effectively alleviate stress response, maintain stable circulation, and reduce the number of anesthetic drugs intraoperatively.

Regarding the analgesic mechanism of dexmedetomidine, it activates alpha 2 receptors in the presynaptic membrane and inhibits neuronal excitation and norepinephrine release by negative feedback, thus stopping the transmission of pain signals^{12,14,16}. Dexmedetomidine can also stimulate 2 receptors in the postsynaptic membrane, inhibit sympathetic activity, cause slow heart rate, decrease blood pressure, and produce sedative and anti-anxiety effects^{13,14,16}. Moreover, it can also directly bind to 2 receptors in the intramedullary system, exerting analgesic and sedative effects. In our opinion, the stimulation of paravertebral soft tissue, spinal cord, and nerve root caused by PELD operation is the main risk factor leading to poor surgical experience. Thus, the pharmacological mechanism of dexmedetomidine might explain why Dex Group and Dex + Oxy Group have a better surgical experience than Con Group and Oxy Group at the time of T2, T3, and T4.

Oxycodone is a semisynthetic tetracyclic derivative of opioid alkaloids^{12–16,39}, which is characterized by easy to cross the blood-brain barrier, rapid action, long half-life, low affinity for receptors, mild respiratory inhibition, mild adverse reactions, little effect on hemodynamics, strong sedative effect, and good analgesic effect^{17,18}. In the current study, we detected that Oxy Group has a better analgesic effect than Con Group ($p < 0.05$), a similar analgesic effect to Dex Group ($p > 0.05$), and a worse analgesic effect than Dex + Oxy Group ($p < 0.05$). Our results were consistent with a previous study¹⁸. Han, L. et al.¹⁸ reported that oxycodone patient-controlled intravenous analgesia revealed better analgesic effects, lower incidence of adverse complications, and less analgesic drug consumption than sufentanil in pain management postoperatively. Thus, we believe that oxycodone is effective in suppressing pain but less effective in anti-anxiety.

In the present study, we found that VAS scores have no significant difference among groups at T1 ($p > 0.05$). However, VAS scores in Oxy Group and Dex + Oxy Group were lower than Con Group and Dex Group at T4. In our opinion, oxycodone has a good analgesic effect, and this view was supported by authors^{17,18}. Besides, oxycodone and dexmedetomidine can play a synergistic analgesic effect.

We found that HR and MAP in the control group were significantly higher than other groups during the operation steps of catheter insertion and nucleus removal. We believe that this is due to the anxiety caused by

surgical manipulations. In addition, we detected that HR and MAP in the Dex Group and Dex + Oxy Group were significantly lower than Con Group and Oxy Group during catheter insertion and nucleus removal. This result proves that dexmedetomidine could reduce sympathetic activity, control heart rate and blood pressure, and reduce myocardial oxygen consumption, which is beneficial to prevent cardiovascular and cerebrovascular events. We attribute this excellent result to the sedative, analgesic, and anti-anxiety functions of dexmedetomidine, and this view is consistent with that of Yang et al.¹⁵, who found that dexmedetomidine therapy seems to be an effective treatment for pain control in patients undergoing total knee arthroplasty or total hip arthroplasty. Moreover, it alleviates the intraoperative tension and anxiety of patients by the sedative effect.

Scholars believe that pain is produced by coordinating the central and peripheral nerve conduction systems^{24,40}. Thus, the combined application of multiple analgesic strategies for pain management has been developed^{41–44}. However, there are still many side effects in combined analgesic strategies, including nausea, vomiting, pruritus, and even excessive sedation. In our study, dexmedetomidine and oxycodone hydrochloride combined can provide prolonged local analgesia and had lower side effects than the control group. This viewpoint was also consistent with previous studies^{45,46}. Moreover, the intraoperative blood oxygen saturation in the Dex + Oxy Group had little change compared with that before operation ($P > 0.05$), indicating that the combination of dexmedetomidine and oxycodone did not increase the risk of intraoperative respiratory depression and oxygen saturation reduction.

The Dex Group, Oxy Group, and Dex + Oxy Group had a shorter operative time than the Con Group ($p < 0.05$). We believe that the result is directly related to the patient's cooperation with the surgeon during the operation. However, ODI score, MacNab score, SF-36 score were no significant differences among groups during the follow-up visit ($p > 0.05$). Thus, we believe that the local anesthetic combined with sedatives in a PELD for LDH cannot facilitate the surgical effect but might improve the patient's surgical experience.

In the control group, a patient was very nervous, anxious, and even shouting intraoperatively, which seriously affected the surgeon's operation and significantly prolonged the operation. Besides, severe bleeding causes blurred endoscopic vision during surgery and eventually leads to a dural tear in this patient. However, no neurological deterioration or infection was found postoperatively. In all groups, no other surgical complications, such as vascular injury, nerve injury, visceral injury, infection, nonunion of incisions, or relapsed LDH, were found during 2 years of follow-up.

Positive clinical results were achieved in this study. However, certain limitations still deserve our attention. In the present study, there was no pharmacodynamics and pharmacokinetics evaluation of the combined therapy. Thus, pharmacodynamics and pharmacokinetics for the evaluation combination of oxycodone and dexmedetomidine in PELD could be further studied.

Conclusions

The combination of dexmedetomidine and oxycodone under local anesthesia is a safe, effective, and reliable analgesic-sedative method to reduce anxiety, relieve pain, and improve the surgical experience in suitable patients with LDH who underwent PELD.

Abbreviations

lumbar disk herniation (LDH), percutaneous endoscopic lumbar discectomy (PELD), dexmedetomidine group (Dex), oxycodone group (Oxy), visual analogue scale (VAS), mean arterial pressure (MAP), heart rate (HR), short form-36 health survey questionnaire (SF-36), Oswestry disability index (ODI), computed tomography (CT), magnetic resonance imaging (MRI)

Declarations

Authors contributions

LTY and YL participated in the study design and surgery; YL and CZ participated in surgery and radiographic outcome assessment. DXG collected all data. Data analysis was performed by DX under supervision of XZ. All authors contributed in reviewal and interpretation of data. The manuscript was drafted by LY and XZ, reviewed by all authors and revised with contributions from all authors under supervision and final revision of XZ. XZ was responsible for the integrity of the work from inception to finished article. All authors read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

Ethical approval and consent to participate

This study was based on the principles outlined in the Helsinki Declaration, which the Ethics Committee approved of Zhengzhou Orthopaedic Hospital (No.2021014). All volunteers who participated in the study signed written informed consent.

Consent for publication

Not applicable.

Data availability

The datasets used during the current study are available from the corresponding author on reasonable request.

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Tables

Table 1 Basic features of the 92 patients in four groups.

Basic characteristics	Group Con	Group Dex	Group Oxy	Group Dex + Oxy	χ^2 / F	<i>P</i>
Male Gender (%)	10 (43.5)	11 (47.8)	13 (56.5)	12 (52.2)	0.870	0.833
Age (mean $\pm$ SD)	47.5 $\pm$ 7.2	46.6 $\pm$ 7.1	45.2 $\pm$ 5.9	46.5 $\pm$ 4.6	0.523	0.668
Treatment level					2.031	0.917
L3-4	5 (21.7)	4 (17.4)	4 (17.4)	3 (14.3)		
L4-5	10 (43.5)	9 (39.1)	7 (30.4)	7 (33.3)		
L5-S1	8 (34.8)	10 (43.5)	12 (52.2)	11 (52.4)		

Table 2 *P* values of homogeneity test of variance for MAP, HR, SpO₂ and Ramsay at four time points

Time Point	MAP	HR	SpO ₂	Ramsay
T1	0.289	0.530	0.574	0.255
T2	0.338	0.767	0.390	0.006*
T3	0.311	0.516	0.970	0.001*
T4	0.210	0.740	0.685	0.001*

* indicates the difference is statistically significant.

Table 3 *P* values of ANOVA for MAP, HR, SpO₂ and Ramsay at four time points

Items	MAP	HR	SpO2	Ramsay	
Time Point	One-way ANOVA			One-way ANOVA	Welch ANOVA
T1	0.301	0.457	0.623	0.769	/
T2	0.001*	0.001*	0.196	/	0.001*
T3	0.001*	0.001*	0.937	/	0.001*
T4	0.001*	0.001*	0.974	/	0.001*

* indicates the difference is statistically significant.

Table 4 *P* values of LSD and Games-Howell test for MAP, HR and Ramsay at the time points of T2-T4

Items	MAP			HR			Ramsay		
Group	Group Dex	Group Oxy	Group Dex+Oxy	Group Dex	Group Oxy	Group Dex+Oxy	Group Dex	Group Oxy	Group Dex+Oxy
T2									
Group Con	0.001*	0.001*	0.001*	0.001*	0.001*	0.001*	0.001*	0.139	0.001*
Group Dex	/	0.001*	0.001*	/	0.001*	0.23	/	0.003*	0.788
Group Oxy	0.001*	/	0.001*	0.001*	/	0.001*	0.003*	/	0.001*
Group Dex+Oxy	0.001*	0.001*	/	0.23	0.001*	/	0.788	0.001*	/
T3									
Group Con	0.001*	0.103	0.001*	0.001*	0.013*	0.001*	0.001*	0.248	0.001*
Group Dex	/	0.042*	0.012*	/	0.001*	0.083	/	0.001*	1.000
Group Oxy	0.042*	/	0.001*	0.001*	/	0.001*	0.001*	/	0.001*
Group Dex+Oxy	0.012*	0.001*	/	0.083	0.001*	/	1.000	0.001*	/
T4									
Group Con	0.001*	0.033*	0.001*	0.001*	0.001*	0.001*	0.015*	0.730	0.001*
Group Dex	/	0.036*	0.190	/	0.266	0.075	/	0.005*	0.160
Group Oxy	0.036*	/	0.001*	0.266	/	0.004*	0.005*	/	0.001*
Group Dex+Oxy	0.190	0.001*	/	0.075	0.004*	/	0.160	0.001*	/

* indicates the difference is statistically significant.

Table 5 *P* values of homogeneity test of variance and One-way ANOVA for operation time and hospitalization period

	Operation time	Hospitalization period
Homogeneity test of variance	0.147	0.098
One-way ANOVA	0.001*	0.478

Table 6 *P* values of VAS score between every two time points by Games-Howell test

Time point	pre-op	1 mon post-op	3 mon post-op	6 mon post-op	12 mon post-op	24 mon post-op
1 mon post-op	0.001*	/	0.878	0.719	0.518	0.338
3 mon post-op	0.001*	0.878	/	1.000	0.986	0.941
6 mon post-op	0.001*	0.719	1.000	/	0.999	0.990
12 mon post-op	0.001*	0.518	0.986	0.999	/	1.000
24 mon post-op	0.001*	0.338	0.941	0.990	1.000	/

pre-op is preoperative, mon represents month or months, and post-op indicates postoperative.

Table 7 *P* values of homogeneity test of variance and One-way ANOVA for SF-36 score and ODI score among groups at different time points

Time Point	PCS	MCS	ODI
Homogeneity test of variance			
preoperatively	0.948	0.969	0.814
6 months postoperatively	0.647	0.736	0.395
12 months postoperatively	0.295	0.417	0.848
24 months postoperatively	0.138	0.732	0.263
One-way ANOVA			
preoperatively	0.947	0.864	0.881
6 months postoperatively	0.519	0.560	0.122
12 months postoperatively	0.881	0.564	0.974
24 months postoperatively	0.720	0.773	0.110

PCS: Physical Component Summary, MCS: Mental Component Summary, ODI: Oswestry Disability Index.

Table 8 The results of modified MacNab criteria at 24 months postoperation

Group	Poor/total	Fair/ total	Good/ total	Excellent/ total	χ^2	<i>P</i>
Group Con	0/22	0/22	4/22	18/22	0.770	0.857
Group Dex	0/22	0/22	3/22	19/22		
Group Oxy	0/21	0/21	3/21	18/21		
Group Dex+Oxy	0/22	0/22	2/22	20/22		

Con: control, Dex: dexmedetomidine, Oxy: oxycodone.

Figures

Figure 1

The results of MAP (A) HR (B), SpO₂ (C), and Ramsay score (D) at T1-T4 in Con Group, Dex Group, Oxy Group, and Dex+Oxy Group. "@", "#", "&", "*" represent the difference was statistical when compared with Con Group, Dex Group, Oxy Group, and Dex+Oxy Group, respectively.

Figure 2

The results of operation time (A) and hospitalization period (B) in different groups. "@", "#", "&", "*" represent the difference was statistical when compared with Group Con, Group Dex, Group Oxy, and Group Dex+Oxy, respectively.

Figure 3

The results of the VAS score at different times of the four groups (A). VAS results in follow-up duration (B). "©" represents the differences were all statistical when compared with the other groups. "£" represents differences

were all statistical when compared with the other time points. "®" represents differences was statistical only when compared with the time point of preoperation.

Figure 4

The clinical outcomes of PCS (A), MCS (B), ODI (C) were showed in different groups. "£" represents differences were all statistical when compared with the other time points.

Figure 5

Processing flow and follow-up results of SF-36 and ODI.