Safety and efficacy of intravenous oxycodone in geriatric patients undergoing general anesthesia for ophthalmic surgeries:a randomized controlled trial

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Abstract

Background

The present study aimed to compare the safety and efficacy of intravenous oxycodone with fentanyl in geriatric patients undergoing general anesthesia for ophthalmic surgeries.

Methods

107 geriatric patients (age 65-79 years old) with the ASA physical status 1 or 2 undergoing general anesthesia for glaucoma or retina surgeries between May 2016 and November 2017 were divided into three groups: Group O1, Group O2, and Group F. After exclusion, 105 patients were included for the final analysis, with 35 patients in each group. Oxycodone (0.1 mg/kg in Group O1, or 0.2 mg/kg in Group O2) or fentanyl (2 mcg/kg in Group F) was administered intravenously during induction of general anesthesia. Patient demographics, surgical time and anesthesia time, perioperative hemodynamic parameters and requirement of vasoactive medication, postoperative pain and requirement of rescue analgesics, postoperative sedation level and recovery time, and perioperative complications were recorded.

Results

Patients in Group O1 experienced less clinically significant hypotension compared to either Group F or Group O2. Consistently, patients in Group O1 required less intraoperative vasoactive medication (ephedrine) than those in Group F. The postoperative pain on extubation was more severe and more patients required rescue analgesia in Group F compared to Group O2, but not Group O1. The recovery time was longer and sedation level was higher in Group O2 than Group F or O1. The incidence of hypoxia during postoperative recovery was higher in Group O2 than Group F or O1.

Conclusion

Oxycodone at 0.1mg/kg can be a safe and effective application for geriatric patients undergoing general anesthesia for ophthalmic surgeries, with adequate pain control and less side effects.

Background

Vision-impairment eye conditions are relatively common in geriatric patients [1]. The majority of eye surgeries can be successfully operated under local or regional anesthesia, with or without sedation [2]. However, geriatric patients may present more comorbidities that are not suitable for local or regional anesthesia [3]. In addition, general anesthesia is often indicated in some ophthalmic procedures that may require more intraoperative manipulation and longer operating time, such as glaucoma and retina surgeries [3, 4].

Oxycodone is a widely used opioid which exerts its analgesic effect through both μ- and κ-opioid receptors [5, 6]. In recent decades, intravenous oxycodone has been used for perioperative pain management [7]. Comparing to morphine or fentanyl, intravenous oxycodone provides better pain relief, especially for visceral pain [8–10]. During induction of general anesthesia, previous studies have shown that the attenuation effect of oxycodone on hemodynamic responses is comparable to fentanyl, and the complication rates are also similar between these two opioids [10, 11]. Other studies suggest that oxycodone may be associated with less sedation, less perioperative hemodynamic changes, and lower rate of hypoventilation when compared with morphine or fentanyl [8, 10, 12].

Geriatric patients with ophthalmic diseases are often presented with multiple systemic comorbidities, thus may be exposed to higher risk for perioperative complications [13, 14]. In addition, elder patients are especially sensitive to anesthetic agents, and vulnerable to hemodynamic changes during general anesthesia [15]. They usually require less opioids and are more susceptible to opioid-related complications [16]. The pharmacokinetic profile of intravenous oxycodone has been previously investigated [17, 18]. However, few clinical studies have examined the safety and efficacy of perioperative usage of intravenous oxycodone in geriatric patients with general anesthesia.

In this prospective double-blind randomized controlled study, we compared the effects of intravenous oxycodone at two different dosages with those of fentanyl in geriatric patients undergoing general anesthesia for ophthalmic surgeries.

Methods

Study Protocol

This prospective, double-blind, randomized controlled study was approved by the Institution Review Board of the Eye & ENT Hospital of Fudan University. Written informed consent were obtained from all participants. The trial was registered before patient enrollment at the Chinese Clinical Trial Registry (Clinical Trial Number: ChiCTR-IPR-16007927).

From May 2016 through November 2017, 109 patients undergoing glaucoma or retina (vitrectomy) surgeries were initially recruited in this study. Patients with the age between 65 and 79 years old who were classified as American Society of Anesthesiologists (ASA) Physical Status Class 1 or 2 were eligible to participate. Exclusion criteria included long-term chronic pain, long-term use of opioid analgesics, sedatives, or antidepressants, recent intake of opioid analgesics, sedatives, or antidepressants, current alcohol or other substance abuse, having allergy to study drugs, with liver or renal dysfunctions, or any medical conditions that were contradicted for laryngeal mask airway (LMA) anesthesia.

After a thorough explanation to eligible patients regarding the surgical procedure, general anesthesia, and the purpose of this study, informed consent was obtained from 107 patients. Patients were then randomized using a computer randomization program into one of the three groups: Group O1: oxycodone 0.1 mg/kg (Hamol Limited; Nottinghamshire, UK), Group O2: oxycodone 0.2 mg/kg, or Group F: fentanyl 2

mcg/kg (Yichangrenfu; Hubei, China). The designated drug for each patient was prepared into a 10-ml solution with normal saline, and labelled with the patient's name by a nurse. It was then delivered to the anesthesia team blindly right before the surgery.

Standard ASA and bispectral index (BIS) monitors were applied to patients upon their arrival to the operating room, without any pre-medication. After confirmation of each patient's baseline vital signs and adequate pre-oxygenation, general anesthesia was induced with intravenous propofol (2-2.5 mg/kg, AstraZeneca; Cambridge, UK), cisatracurium (0.15 mg/kg, Shanghai Pharma; Shanghai, China), and 10 ml of test drug. All patients were intubated with LMAs 3 minutes after induction of anesthesia. General anesthesia was maintained with sevoflurane and 50% air in oxygen with a constant fresh gas flow of 2 L/min to keep the BIS readings between 40 and 60. Intravenous ephedrine (3-5 mg) was administered for each event of hypotension (mean arterial pressure<65 mmHg).

After surgery completed, sevoflurane was turned off, and patients were transferred to the Post-Anesthesia Care Unit (PACU) for recovery. Patients were extubated at the PACU once criteria met. The severity of post-operative pain was evaluated using the Numeric Rating Scale (NRS: 0=no pain, 10=worst pain imaginable). When patients complained of moderate to severe pain (NRS>4), intravenous oxycodone (3 mg) or fentanyl (30 mcg) was administered as the rescue analgesic for Group O1/O2 or Group F patients respectively.

Data Collection

Age, sex, height, weight, ASA physical status classification, surgical time and anesthesia time were collected for each patient. Surgical time was defined as the duration between surgical incision and closure, and anesthesia time was defined as the duration between administration of induction agents and patient transport out of the operating room [19]. Heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) were documented and analyzed during the following time periods: baseline upon the arrival to the operating room; during induction (0-10 min after administration of induction agents); during the intraoperative period; and during PACU stay. Clinically significant hypotension was defined as either: MAP decrease of >40% and MAP<70 mmHg, or MAP<65 mmHg [15]. The recovery time of spontaneous breathing (the duration between discontinuation of anesthetics and returning of spontaneous breathing), the emergence time (the duration between discontinuation of anesthetics and extubation), and the PACU length of stay were recorded for each patient. The severity of postoperative pain was evaluated after extubation and at 0, 2, 6, 24 hours after discharge from PACU. The administration of rescue analgesics for each patient was recorded and analyzed. The Ramsay Sedation Scale (RSS) was used to evaluate the sedation level at PACU discharge (1=anxious, agitated, restless; 2=cooperative, oriented, tranquil; 3=responding to commands only; 4=brisk response to light glabellar tap or loud noise; 5=sluggish response to light glabellar tap or loud noise; and 6=no response). The incidents of perioperative complications including coughing during induction, postoperative nausea/vomiting, and hypoxia (pulse-oximetry reading below 90%) at PACU were also recorded for analysis.

Statistical Analysis

The main efficacy endpoint of our study was the PACU length of stay. Based on the data of our pilot study (33.4±8.12 min in Group F, 30.9±6.48 min in Group O1, 38.9±12.93 min in Group O2), the sample size of 28 patients in each group was calculated at $\alpha=0.05$, $\beta=0.2$ using the sample size software (NCSS-PASS, Kaysville, UT, USA). We aimed to recruit a total of 109 patients to allow for potential loss to follow-up.

We used the SPSS 23.0 software to perform data analysis. Continuous data with normal distribution was presented as mean±standard deviation. One-factor analysis of variance was used to analyze the baseline data among the groups, followed by SNK method for post hoc pairwise test. Analysis of variance of repeated measures was applied for hemodynamic data. Continuous data without normal distribution was presented as median (interquartile range). Kruskal Wallis test was used for analyzing the data among the groups, followed by Man-Whitney U test for post hoc pairwise test. Nominal data were presented as number of patients. Chi square test and Fisher exact test was applied for comparison of the data among the groups, followed by partitions of chi square test for post hoc pairwise test. The type-I error of multiple comparisons of continuous data without normal distribution and nominal data was corrected by Holm-Bonferroni method. $P<0.05$ was regarded as statistically significant.

Results

One hundred and nine patients were initially recruited in the study and 2 subjects were excluded because that they were declined to participate. Hence, 107 patients were enrolled and randomly allocated into three groups: Group O1: oxycodone 0.1 mg/kg, Group O2: oxycodone 0.2 mg/kg, or Group F: fentanyl 2 mcg/kg. 2 patients (1 from Group O1 and 1 from Group F) were excluded for analysis because of incomplete data collection. Baseline patient characteristics, including age, gender, body mass index (BMI), and ASA physical status classification distribution of all three groups were comparable (Table 1). In addition, there was no significant difference among these three groups in either surgical time or anesthesia time (Table 1).

As displayed in Table 2a, 2 of 35 patients (5.71%) in Group O1 experienced clinically significant hypotension during the induction period. The incidence of clinically significant hypotension during induction was 11/35 (31.43%) in Group O2 and 13/35 (37.14%) in Group F, respectively. There was significant difference when comparing Groups O1 to Group O2 or F ($p<0.05$), but not between Groups F and O2. However, we did not find significant difference in the incidence of hypotension among three groups during either the intraoperative period or PACU stay. We observed consistent findings for the intraoperative requirement of vasoactive medication: less ephedrine was administered in Group O1 than F ($p<0.05$, Table 2b). There was no significant difference in the administration of ephedrine between Groups O1 and O2 or between Groups F and O2. As for the HR change from baseline, there was no significant difference among these three groups during any of the above time periods examined (Table 2c).

When evaluating for postoperative pain, NRS on extubation was significantly higher for patients in Group F comparing to Group O2 ($p<0.05$). No difference in NRS on extubation was observed between Group F and Group O1. Similarly, more patients required postoperative rescue analgesics in Group F than Group O2 ($p<0.05$), whereas there was no difference between Group F and Group O1 (Table 3). However, there was no significant difference in NRS at 0, 2, 6, 24 hours after discharge from PACU among these three groups (Table 3).

The recovery time of spontaneous breathing, the emergence time and PACU length of stay in Group O2 were all longer comparing to either Group O1 or F ($p<0.05$). Upon discharge from PACU, the RSS in Group O2 was significantly higher than Group O1 or F ($p<0.05$, Table 4).

With regard to perioperative adverse effects, the incidence of hypoxia events in PACU was significantly higher in Group O2 than either Group O1 or F ($p<0.05$). There was no significant difference among these three groups in coughing during induction or postoperative nausea/vomiting (Table 5).

Discussion

As the elderly comprises a substantial and rapidly-growing portion of the ophthalmology surgical patient population, their specific requirement for perioperative analgesics ought to be carefully considered [2-4]. Intravenous fentanyl has been one of the most commonly used opioids for general anesthesia in ophthalmology procedures. When using the standard dose of fentanyl (2 mcg/kg), we found that over a third of geriatric patients experienced significant hypotension during induction of general anesthesia. However, 0.1 mg/kg oxycodone provided much more stable hemodynamic responses during induction in this population. This effect was not observed for the higher dose of oxycodone (0.2 mg/kg). Similarly, patients in Group O1 (0.1 mg/kg oxycodone) required significantly less intraoperative pharmacological intervention (ephedrine) for hypotension comparing to Group F (2 mcg/kg fentanyl). Previous studies have suggested that senior age was a risk factor associated with hypotension during induction [15], and dosage requirement for fentanyl decreased by 50% in the elderly population [20]. Clinicians were recommended to consider reducing opioid doses by up to 50% for geriatric patients [21]. It is conceivable that many elderly patients might be much more sensitive to standard dose of opioids, thus may experience more significant hypotension during induction and require more pharmacological intervention. 0.1 mg/kg oxycodone provided relatively more desirable hemodynamic effects, and may be considered as a safer alternative to fentanyl during induction of general anesthesia for geriatric patients.

Previous studies supported that oxycodone may offer advantages over fentanyl for pain control [9,10]. Recent data demonstrated that a lower dose of oxycodone was sufficient to control acute post-operative pain [22,23]. Our results confirmed similar findings in geriatric patients: comparing to fentanyl (2 mcg/kg), equivalent dose of oxycodone (0.2 mg/kg) achieved better postoperative pain control and required less rescue analgesics, while lower dose of oxycodone (0.1 mg/kg) yielded similar analgesic effects. This could be explained by either the better therapeutic effect of oxycodone on visceral pain through kappa opioid receptors [8], or the relative shorter duration of action from fentanyl [24].

On the other hand, when we examined the post-operative adverse effects of oxycodone, we found that equivalent dose of oxycodone, comparing to fentanyl, was associated with more drowsiness, longer PACU stay, delayed recovery of spontaneous respiration, and more incidence of postoperative hypoxia in geriatric patients. The lower dose of oxycodone demonstrated comparable safety profile to fentanyl. For equivalent doses, oxycodone exerts longer duration of effects than fentanyl, thus is likely associated with prolonged sedation and PACU stay. Therefore, lower dose of oxycodone should be considered for perioperative pain management. This concept was confirmed by other studies. Xie et al. showed that patients receiving higher dose of oxycodone exhibited more delayed awakening and more drowsiness (higher RSS score) comparing to fentanyl [25]. However, different from our results, they found higher incidence of intraoperative respiratory depression and hypoxia in the fentanyl group [25]. Their study was conducted on patients under general anesthesia with natural airway, while patients in our study had more controlled airway and ventilation. Thus, we could not observe significant intraoperative respirator depression from fentanyl. Instead, we found that equivalent dose of intravenous oxycodone to fentanyl was associated with more delayed respiration depression and hypoxia in PACU, likely due to its longer duration of action. Therefore, lower dose of oxycodone might be more appropriate for geriatric patients: it provided similar analgesia and demonstrated comparable sedative/respiratory suppression effects as fentanyl.

As for other adverse effects, such as nausea/vomiting or coughing on induction, we did not find any significant difference among fentanyl and oxycodone groups. Kim et al. reported oxycodone was associated with higher incidence of side effects, such as nausea or vomiting, dizziness, and drowsiness, in the setting of postoperative intravenous patient-controlled analgesia [23]. It is likely that a single dose of oxycodone in our study resulted in less accumulation in the body, and thus less adverse effects.

Limitations

This study has several limitations. One limitation was that we did not include patients with higher score of ASA physical status (3 and above) or extreme age (over 80 years old). Chung et al. reported that healthier and younger patients were more likely to experience severe postoperative pain after ambulatory surgeries [26]. Therefore, it is prudent to consider even lower dose of perioperative opioids for older and sicker patients. Secondly, patients in our study are all Chinese. Racial and ethnic differences in pain perception and opioid sensitivity have been well documented [27]. Further studies are warranted to confirm our findings in different racial and ethnic populations.

Conclusions

In this prospective, double-blind, randomized controlled trial, we found that 0.1 mg/kg intravenous oxycodone provided relatively more stable hemodynamic response and less perioperative adverse effects comparing to 0.2 mg/kg dosage or 2 mcg/kg fentanyl in geriatric patients during general anesthesia for ophthalmic surgeries.

Lower dose of oxycodone can be a safe and effective application during ophthalmic surgeries in geriatric patients.

Declarations

Ethics approval and consent to participate

The protocol was approved by the Institution Review Board of the Eye & ENT Hospital, FuDan University on 2 February 2016 (Number: 2015024-1). The trial was also registered before patient enrollment at Chinese Clinical Trial Registry (Clinical Trial Number: ChiCTR-IPR-16007927).

Consent for publication

Written informed consent were obtained from all participants.

Availability of data and materials

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

Competing interests

The authors declare that they have no competing interests.

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None.

Authors' contributions

SL: This author helped with writing the manuscript, data collection, analysis and presentation, edited and approved the final version of the manuscript. DY: This author helped with writing the manuscript, data collection, analysis and presentation, edited and approved the final version of the manuscript. XH: This author helped with data collection, analysis and presentation, edited and approved the final version of the manuscript. WL: This author helped with writing the manuscript, edited and approved the final version of the manuscript. FT: This author helped with writing the manuscript, data collection, edited and approved the final version of the manuscript.

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Abbreviations

ASA: American Society of Anesthesiologists; LMA: Laryngeal mask airway; BIS: Bispectral index; PACU: Post-Anesthesia Care Unit; NRS: Numeric Rating Scale; HR: Heart rate; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; MAP: Mean arterial pressure; RSS: Ramsay Sedation Scale; BMI: Body mass index

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Tables

Table 1. Patients' demographic characteristics, surgical and anesthesia time.

	Group O1 (n=35)	Group O2 (n=35)	Group F (n=35)
Age (years)	71.74±4.42	70.63±4.96	72.46±3.83
Male/female (n)	17/18	18/17	15/20
BMI (kg/m^2)	23.45±3.24	22.3±2.79	22.9±2.98
ASA physical status classification, □/□ (n)	4/31	11/24	6/29
Surgical time (min)	48.46±17.89	50.54±28.81	48.54±24.23
Anesthesia time (min)	61.40±18.60	63.72±29.72	62.43±24.02

Values are expressed as mean±standard deviation or number.

BMI = body mass index, ASA = American Society of Anesthesiologists.

Table 2a. The incidence of clinically significant hypotension during induction, the intraoperative period, and PACU stay.

	Group O1 (n=35)	Group O2 (n=35)	Group F (n=35)
Induction, n (%)	2 (5.71%)[a,b]	11 (31.43%)	13 (37.14%)
Intraoperative, n (%)	3 (8.57%)	7 (20.00%)	10 (28.57%)
PACU, n (%)	0 (0%)	0 (0%)	0 (0%)

Values are expressed as number (%).

PACU=postoperative anesthesia care unit.

a: significant difference between Groups O1 and O2, P<0.05.

b: significant difference between Groups O1 and F, P<0.05.

Table 2b. The requirement of intraoperative vasoactive medication (ephedrine) for hypotension.

	Group O1 (n=35)	Group O2 (n=35)	Group F (n=35)
Ephedrine administered (mg)	3.09±3.21[a]	5.00±4.72	5.66±3.96

Values are expressed as mean±standard deviation.

a: significant difference between Groups O1 and F, P<0.05.

Table 2c. Heart rate changes from baseline during induction, the intraoperative period, and PACU stay.

	Group O1 (n=35)	Group O2 (n=35)	Group F (n=35)	P
Induction	8.81±9.06	13.52±11.10	13.96±13.57	0.122
Intraoperative	3.62±9.44	13.79±11.85	13.41±11.68	0.989
PACU	4.31±9.53	4.85±9.52	1.64±11.29	0.371

Values are expressed as mean±standard deviation.

PACU=postoperative anesthesia care unit.

Table 3. Postoperative pain control.

	Group O1 (n=35)	Group O2 (n=35)	Group F (n=35)
NRS on extubation	2 (0, 4)	0 (0, 3)[a]	2 (0, 6)
Rescue analgesics, n (%)	2 (5.71%)	0 (0%)[a]	7 (20%)
NRS on PACU discharge	0 (0, 2)	0 (0, 2)	1 (0, 2)
NRS at 2h after discharge	0 (0, 2)	0 (0, 2)	0 (0, 2)
NRS at 6h after discharge	0 (0, 0)	0 (0, 0)	0 (0, 0)
NRS at 24h after discharge	0 (0, 0)	0 (0, 0)	0 (0, 0)

Values are expressed as number (%) or median (ranges).

NRS=Numeric rating scale, PACU=postoperative anesthesia care unit.

a: significant difference between Groups O2 and F, P<0.05.

Table 4. Recovery time and sedation level during PACU stay.

	Group O1 (n=35)	Group O2 (n=35)	Group F (n=35)
Recovery time of spontaneous breathing (min)	13.03±5.10	18.66±5.47[a,b]	12.51±8.28
Emergence time (min)	17.09±4.29	25.77±10.07[a,b]	18.29±7.27
PACU length of stay (min)	32.94±6.43	42.80±11.64[a,b]	35.09±8.75
RSS on PACU discharge	2 (2, 2)	3 (2, 3)[a,b]	2 (2, 2)

Values are expressed as mean±standard deviation or median (ranges).

PACU= postoperative anesthesia care unit, RSS=Ramsay sedation score.

a: significant difference between Group O2 and Group O1, P<0.05.

b: significant difference between Group O2 and Group F, P<0.05.

Table 5. The incidence of perioperative adverse events.

	Group O1 (n=35)	Group O2 (n=35)	Group F (n=35)
Hypoxia in PACU, n (%)	2 (5.71%)	9 (25.71%)[a,b]	2 (5.71%)
Coughing during induction, n (%)	1 (2.86%)	2 (5.71%)	2 (5.71%)
Nausea or vomiting, n (%)	0 (0%)	4 (11.43%)	0 (0%)

Values are expressed as number (%).

PACU= postoperative anesthesia care unit.

a: significant difference between Group O2 and Group O1, P<0.05.

b: significant difference between Group O2 and Group F, P<0.05.

Supplementary Files

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