BMC Gastroenterology

SYSTEMATIC REVIEW Open Access

Safety and efficacy of ciprofol versus propofol for gastrointestinal endoscopy: a meta-analysis

Xi Cheng[1,2†], Pengyu Zhang[1,2†], Dan Jiang[1,2], Baoxia Fang[1*] and Fuchao Chen[1,2*]

Abstract

Background The role of ciprofol as a novel anesthetic in gastrointestinal endoscopic surgery is unclear. We conducted a systematic review and meta-analysis to evaluate the efficacy and safety of ciprofol for gastrointestinal endoscopy in patients aged over 65 years and under 65 years, aiming to provide evidence-based information for clinical decision-making.

Methods We conducted a search for RCTs(randomized controlled trials) comparing ciprofol and propofol in gastrointestinal endoscopy on databases including PubMed, Embase, Cochrane Library, Web of Science, (China National Knowledge Infrastructure)CNKI, Wanfang, and Vipro Chinese Journal Service up to September 15, 2024. The required information was screened and extracted, and the quality of the included research literatures was assessed using the Cochrane Collaboration risk of bias assessment tool, and Meta-analysis of outcome metrics was performed using Revman 5.4 and Stata software.

Results A total of 17 RCTs involving 2800 patients were included, with 1,450 patients in the ciprofol group and 1350 patients in the propofol group. The results of the meta-analysis indicated that there was no statistically significant difference in the sedation success rate or recovery time between the two groups across all age categories. In patients under 65 years old, the induction time of the ciprofol group (MD = 0.41 min, 95%CI: 0.04 min ~ 0.78 min, $P = 0.03$) was longer than that in the propofol group. The incidences of hypotension (OR = 0.48, 95%CI: 0.32 ~ 0.72, $P = 0.004$), bradycardia (OR = 0.66, 95%CI: 0.49 ~ 0.87, $P = 0.004$), injection pain (OR = 0.08, 95%CI: 0.05 ~ 0.15, $P < 0.0001$), respiratory depression (OR = 0.21, 95%CI: 0.15 ~ 0.30, $P < 0.0001$), and hypoxemia (OR = 0.29, 95%CI: 0.20 ~ 0.43, $P < 0.0001$), in the ciprofol group were much lower than those in the propofol group.

Conclusion Meta-analysis results indicate that, across various age groups, ciprofol demonstrates a higher safety profile and effectively reduces the incidence of postoperative (ADRs)adverse reactions compared to propofol. However, there is no significant difference in the sedative effects of the two agents. This study categorized

†Xi Cheng and Pengyu Zhang contributed equally to this work and should be considered as equal first authors.

*Correspondence:
Baoxia Fang
fbx-811105@163.com
Fuchao Chen
dfyycfc@163.com

Full list of author information is available at the end of the article

elderly patients into subgroups, thereby providing a foundation for the application of ciprofol in gastrointestinal examinations of elderly patients. Consequently, we propose that ciprofol may serve as a safer alternative to intravenous anesthesia compared to propofol; However, this conclusion requires further validation through high-quality studies.

Keywords Propofol, Gastroscopy, Colonoscopy, Gastrointestinal Endos-copy, Ciprofol

Background

Gastrointestinal endoscopy is an important means to diagnose digestive tract diseases, which is of great significance for early detection and prevention of diseases [1]. Studies show that in most countries, about 1.2 out of 10.5 people are diagnosed with gastrointestinal cancer each year [2]. In addition, the incidence of gastrointestinal cancers is continuing to rise, with new cases and deaths projected to climb to 58% and 73%, respectively, by 2040 [3]. Their increasing disease burden makes early prevention particularly difficult as the pathogenesis is not yet fully understood [4]. As the incidence of gastrointestinal diseases continues to rise, the concepts of the importance of gastrointestinal endoscopy screening and comfort care have become increasingly popular [5]. Gastrointestinal endoscopy is a painless technology that provides a precise and accurate way of performing gastroenterology. The painless gastrointestinal endoscopy technique, facilitated by precise drug anesthesia, allows patients to experience minimal discomfort during gastrointestinal endoscopy and enteroscopy examinations. The implementation of this technique significantly enhances patient acceptance and the overall effectiveness of the examination [6]. Painless gastrointestinal endoscopy not only alleviates patients' pain and anxiety but also aids physicians in diagnosing conditions more accurately, thereby enabling more timely and effective treatment [7].

In current clinical practice, the anesthetic of choice for painless gastrointestinal endoscopy is propofol [8]. Propofol has become a "star" anesthetic in the field of painless gastrointestinal endoscopy by virtue of its rapid onset of action and rapid recovery after discontinuation of the drug [9]. However, propofol also has some side effects that should not be overlooked, such as respiratory depression and injection pain [10]. It has been used in combination with analgesic drugs and it has been shown that this combination can be effective in achieving certain goals. For example, although it is possible to achieve a similar sedation effect by reducing the amount of propofol when used in combination with analgesic drugs, this also increases the risk of cardiovascular events during sedation [11]. Therefore, there is an urgent need to explore a novel anesthetic drug that ensures low dosage and minimizes the risk of adverse events, thus providing a safer and more efficient option for painless gastrointestinal endoscopy.

Ciprofol, as a γ -Aminobutyric Acid (GABA) receptor agonist, is a new intravenous anesthetic drug developed based on the activity of propofol. It has attracted widespread attention for its remarkable properties [12]. Ciprofol competitively binds to γ-aminobutyric acid type A (GABAA) receptors with t-butyl bicyclic ortho benzoate (TBOB) and t-butylbicyclic phosphate thioester, enhancing GABA-evoked chloride currents at lower concentrations. It binds to GABAA receptors at higher concentrations and mainly acts on the α1β2γ2 subtype [13]. Compared with propofol, ciprofol can enhance the ammonium ion current induced by GABA in cells. Moreover, by increasing the intracellular chloride ion concentration, it further activates GABA neurons and causes hyperpolarization of nerve cell membranes, thereby achieving the purpose of inhibiting the central nervous system and producing sedation and anesthesia. At the same time, ciprofol not only has the high-intensity effect and low dosage of a short-acting GABAA receptor agonist, but also has a relatively mild degree of inhibition on the respiratory and circulatory systems, effectively reducing adverse drug reactions such as the incidence of side effects including injection pain [14]. Moreover, studies have pointed out that the therapeutic index of ciprofol is about 1.5 times that of propofol and is significantly safer than propofol [15, 16].

In a systematic review comparing the effects of ciprofol and propofol on non-ICU sedation [17], 12 RCTs involving 1793 patients were included. The results showed that the effects of ciprofol and propofol on sedation and anesthesia induction were similar, while ciprofol had a lower risk of hypotension and pain at the time of injection. In another evaluation of the efficacy and safety of ciprofol in general anesthesia induction [18], 13 RCTs involving 1998 patients were included. It was found that ciprofol was as effective as propofol in inducing and maintaining general anesthesia. Compared with propofol, ciprofol is a better choice as a surgical sedative in surgeries such as fiberoptic bronchoscopy, gynecological surgery, and selective surgery, because it has smaller side effects. The most obvious advantage is that patients experience less pain during injection.

Previous relevant literature lacked comprehensive and systematic age-specific safety and efficacy data integration analysis of ciprofol in different age groups, especially in the elderly and non-elderly groups. This study fills this gap by searching multiple databases and including a large

number of RCTs for meta-analysis. It clearly presents for the first time the comprehensive properties of ciprofol when used for painless gastrointestinal sedation in all age groups, providing information for precise clinical medication.

Methods

Sources of information

We used PubMed, Embase, Cochrane Library, CNKI, WanFang database, and VIP database as search sources. The search terms included "ciprofol", "cyclopofol", "colonoscopy", "HSK3486", "gastroscopy", "propofol", "gastrointestinal endoscopy", and "gastroenteroscopy". These search terms were combined with free words and qualifiers like "RCTs" or "clinical trial". We screened the studies for the use of ciprofol and propofol in painless gastrointestinal endoscopy. The search was conducted from the time when the databases were established until September 15, 2024.

Inclusion of indicators

(1) RCT; (2) Interventions: In the test group, ciprofol was used, while in the control group, propofol was applied. Both drugs could be used either alone or in combination with opioid receptor agonists. Moreover, other interventions remained the same between the two groups; (3) Study subjects: ASA classification grade I - III, without severe cardiovascular and respiratory diseases, and without a history of intravenous anesthesia or general anesthesia (excluding local anesthesia) within the recent 3 months. Painless gastrointestinal endoscopy and gastrointestinal endoscopy patients requiring anesthesia, with no restrictions in terms of age, gender, or nationality; (4) Outcome indicators: sedation effectiveness, with sedation effectiveness defined as the successful completion of the gastrointestinal endoscopy examination without the need for additional sedation measures and with the use of additional sedation drugs ≤ 5 times within 15 min of the first administration; the incidence of major ADRs, such as hypotension(Systolic blood pressure SBP < 90 mmHg or SBP < 80% of the baseline value) bradycardia(Heart rate (HR) < 50 beats per minute) injection pain(The Visual Analogue Scale (VAS) score is above 3) respiratory depression(Respiratory rate is less than 8 breaths per minute and the duration is longer than 30 s) etc.; and anesthesia-related time indexes such as post-anesthesia induction time, it is defined as the time from the initial administration to when the MOAA/S score is ≤ 1 point.

Exclusion criteria

(1) duplicated literatures, case reports, literature reviews, trial protocols, animal experiments, basic research trials, and non-RCTs; (2) unpublished studies or literatures for which the full text was unavailable; (3) literatures that did not provide valid data for synthesis; (4) endpoint indicators that were not consistent with the requirements of this study; (5) Literature related to patients who were unable to communicate normally; (6) Some patients refused to give informed consent; (7) Cannot provide the study on the actual frequency of complications..

Literatures screening and data extraction

Two researchers independently searched the literature and extracted information using a standardized extraction form, which was then cross-checked, and any disagreements were resolved through discussion or with the assistance of a third researcher. The extracted information included authors of the literatures, year of publication, mode of operation, number of cases in the study population, age, interventions, and outcome indicators. During the literature research, screen and evaluate the composition of fund projects and the sources of published journals. The quality of the literatures was evaluated using a risk of bias assessment tool, which included random sequence generation, allocation concealment, whether subjects, operators and outcome evaluators were blinded, completeness of outcome data, selective reporting of findings and other biases, and the results were presented in three ways: low risk of bias, unclear risk of bias and high risk of bias.

Statistical analysis

Quantitative analysis of the included data was performed using Review Manager 5.4. The mean difference (MD) of the measured data was used as the statistic for effect analysis, and the risk difference (RD) or odds ratio (OR) of the dichotomous variable was used as the effect size measure (combined with the corresponding 95% Confidence interval CI). Heterogeneity between included studies was assessed using the X^2 test and I^2 statistics. $P>0.1$ and $I^2<50\%$ indicate low heterogeneity. In this case, the fixed effects model is used. $P<0.1$ and $I^2>50\%$, indicating a high degree of heterogeneity, in which case a random effects model was used. This study included a sufficient number of studies ($n>10$), and therefore publication bias analysis was performed. If necessary, perform sensitivity analysis. $P<0.05$ indicates a statistically significant difference. To explore the possibility of publication bias, we performed a rigorous assessment using funnel plots and Eggers test. Eggers test was used when at least 10 studies were available, and all analyzes were performed at a significance level of $\alpha = 0.05$. By adopting these two methods, we aimed to comprehensively assess and determine whether there is any potential publication bias and ensure the robustness and reliability of the meta-analysis results.

Results

Results of the literatures search

Table 1 shows the general information on inclusion of randomized controlled clinical trials. A preliminary search of PubMed, Embase, Cochrane Library, CNKI, WanFang database, and VIP identified 1032 documents. After removing duplicate documents and reading titles and abstracts, which were obviously inconsistent, 22 documents remained. By reading the full text and excluding 2 uncontrolled studies and experimental protocols, 2 articles that did not meet the study population and standards, and 1 article that did not match the intervention measures, 17 trials with 2,800 patients were finally included in the study. The specific process is shown in Fig. 1.

Basic characteristics and quality assessment

Table 1 shows the general information on the inclusion of randomized controlled clinical trials. Risk of bias was assessed for the included studies, of which 17 studies [19–35] reported the generation of randomized sequences, among which 17 studies [19–35] described specific methods of allocation concealment, and 6 studies [19, 20, 23, 27, 29, 33] reported blinding of investigators and subjects. Regarding potential bias, all the studies were conducted in tertiary hospitals. Moreover, the source of fund projects was at the municipal level or above. Additionally, the published journals were from statistical sources or above.The results of the risk of bias assessment are shown in Figs. 2 and 3.

Meta-analysis results

Comparison of sedation efficacy rates

Among the included studies, (1) 9 literatures [21, 24, 26, 29–35] reported on the success rate of ciprofol versus propofol in sedation among patients. The test for heterogeneity ($P = 0.92$, $I^2 = 0\%$) suggested that there was no statistical heterogeneity among the studies, so the fixed effects model was used for analysis. The results showed that there was no statistically significant difference in sedation success rate between the ciprofol and propofol groups (OR = 1.37, 95%CI: 0.80–2.35, $P = 0.26$).

Subgroup analysis: (2) 4 documents [21, 24, 31, 33] reported the success rate of sedation between ciprofol and propofol in patients under 65 years old. The heterogeneity test ($P = 0.60$, $I^2 = 0\%$) showed that there was no statistical heterogeneity among the studies, so the fixed effects model was used for analysis. The results showed that among patients under 65 years old, there was no statistically significant difference in the sedation success rate between the ciprofol group and the propofol group (OR = 1.48, 95%CI: 0.72 ~ 3.03, $P = 0.28$); (3) 5 documents [26, 29, 30, 32] reported the success rate of sedation between ciprofol and propofol in patients over 65 years old. Heterogeneity test ($P = 0.87$, $I^2 = 0\%$) showed that there was no statistical heterogeneity among the studies, so the fixed effects model was used for analysis. In patients over 65 years old, there was no statistically significant difference in the sedation success rate between the ciprofol group and the propofol group (OR = 1.23, 95%CI: 0.54 ~ 2.81, $P = 0.63$), as shown in Fig. 4.

Table 1 Basic characteristics and quality evaluation of the included literatures

Trials(year)	Way	Ciprofol			Propofol			ASA	Outcomes
		Amount	Age	Measure	Amount	Age	Measure		
X Zhang2023	Gastroscope	50	70.5 ± 5.0	Sufentanil + C	50	70.4 ± 5.0	Sufentanil + P	I–III	3-6.9.21.23-25
JF Shi2024	Gastroscope	80	68.8 ± 2.8	Butorphanol + C	80	68.6 ± 2.7	Butorphanol + P	I–II	3.13.14.18.19.21
C Wang2023	Colonoscopy	49	76.6 ± 4.6	Afentanil + C	50	76.2 ± 3.5	Afentanil + P	I–III	3.5.7.19.23-25
ZW Gao2023	Gastroscope	61	68.0 ± 4.9	Nalbuphine + C	60	67.3 ± 3.0	Nalbuphine + P	I–II	3.5.8.13.14.18.19.21
M Xu2023	Colonoscopy	164	69.6 ± 3.6	Sufentanil + C	166	68.9 ± 3.3	Sufentanil + P	I–II	3.5.11.12.19.23-25
QL Yi2022	Gastroscope	79	69.6 ± 2.8	Sufentanil + C	80	70.1 ± 2.9	Sufentanil + P	I–II	3.5.9.19.21.24.25.29
CB Xing2023	Gastroscope	40	70.6 ± 5.2	Sufentanil + C	40	69.8 ± 4.4	Sufentanil + P	I–III	3-5.9.11-14.18.19.21.25
JX Li2022	Gastroscope	144	43.8 ± 11.8	Sufentanil + C	145	44.1 ± 11.3	Sufentanil + P	I–II	3-6.8.19.21.23-25
XQ Chen2022	Gastroscope	47	43.2 ± 12.3	Ciprofol	49	43.2 ± 12.3	Propofol	I–III	3-5.7-14.19
Y Teng2021	Colonoscopy	63	46.9 ± 14.1	Sufentanil + C	31	48.4 ± 13.7	Sufentanil + P	I–II	3–6
LN Chen2023	Gastroscope	105	48.4 ± 14.2	Sufentanil + C	44	43.6 ± 16.2	Sufentanil + P	I–III	3.7.11-14
XY Liu2023	Gastroscope	175	39.8 ± 5.3	Sufentanil + C	175	39.8 ± 5.2	Sufentanil + P	I–II	3.5.9.11–13.19.21.24.25
JW Zang2023	Gastroscope	52	62.0 ± 4.3	Remifentanil + C	52	61.2 ± 4.6	Remifentanil + P	I–II	3.6.8.13.14.18.19.21.24.25
EH Tang2024	Colonoscopy	56	45.3 ± 9.2	Sufentanil + C	56	45.7 ± 8.9	Sufentanil + P	I–II	3.5.6.8.9.13.14.18.21.23-25
L Xiang2023	Gastroscope	104	42.8 ± 10.7	Sufentanil + C	96	43.0 ± 11.5	Sufentanil + P	I–II	3-6.8.9.18.23.25.29
SH Gao2024	Gastroscope	82	54.0 ± 10.5	Ciprofol	82	54.0 ± 9.5	Propofol	I–II	19.21.24.25
XLJiang2024	Gastroscope	99	67.1 ± 3.4	Ciprofol	94	67.5 ± 3.3	Propofol	I–II	3-6.8.11.12.18.19.21.24

Annotation: C = ciprofol; P = propofol; Outcome indicators: 3. awakening time, 4. insertion time, 5. induction time, 6. inspection time, 7. operating time, 8. recovery time, 9. Exit time, 11. SBP, 12. DBP, 13. HR, 14. SPO_2, 18. MAP, 19. injection pain, 21. respiratory depression, 23. hypoxemia, 24. bradycardia, 25. hypotension, 29. cough

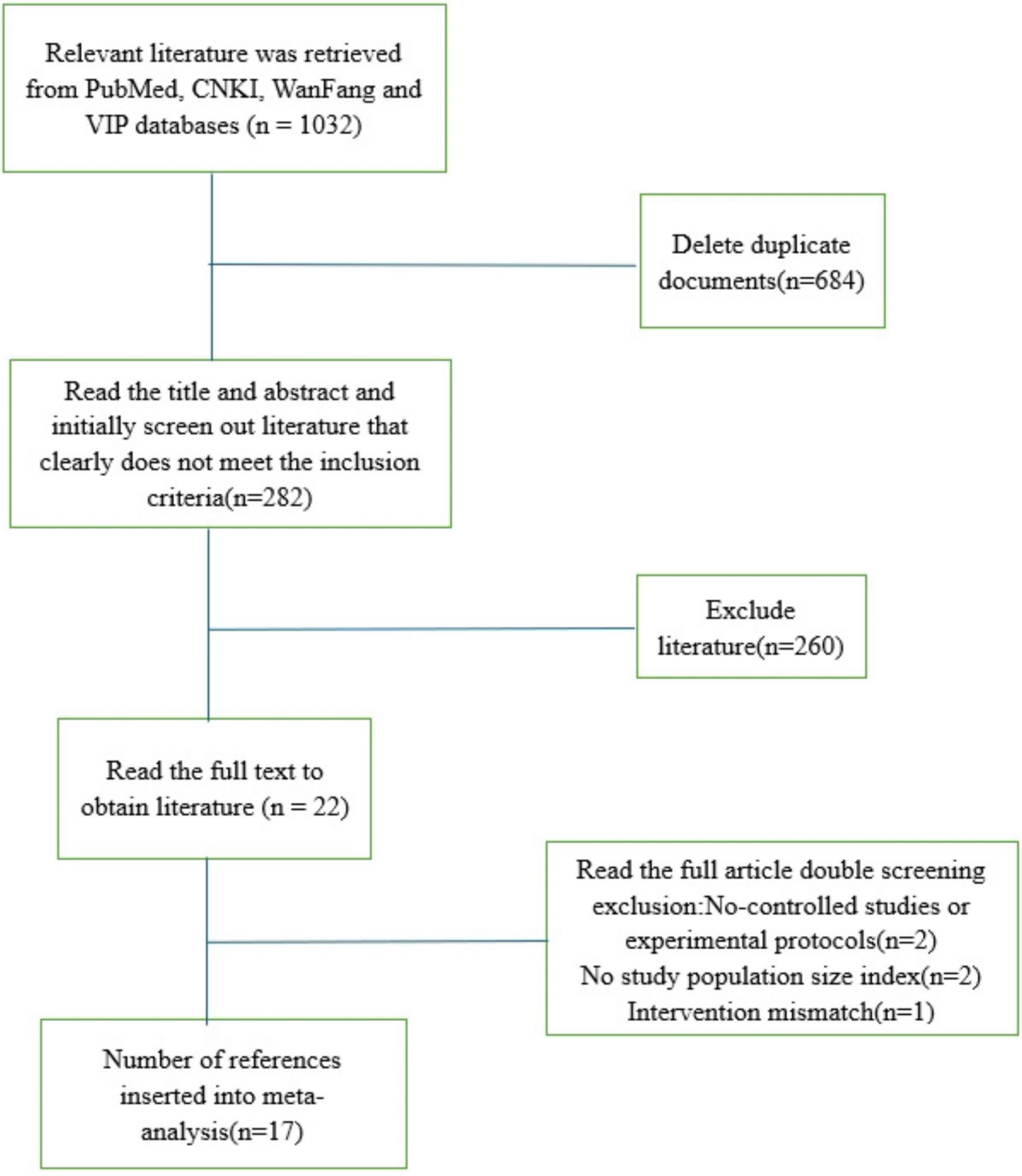

Fig. 1 Literature screening process

Comparison of anesthesia time correlation

Induction time: (1) 13 documents [20–30, 32, 34] reported the induction time of ciprofol versus propofol anesthesia. The heterogeneity test ($P<0.001$, $I^2=95\%$) showed that there was statistical heterogeneity among the studies, so a random effects model was used. The results showed that the anesthesia induction time in the ciprofol group was longer than that in the propofol group (MD = 0.13 min, 95%CI: 0.00 ~ 0.26 min, $P=0.04$).

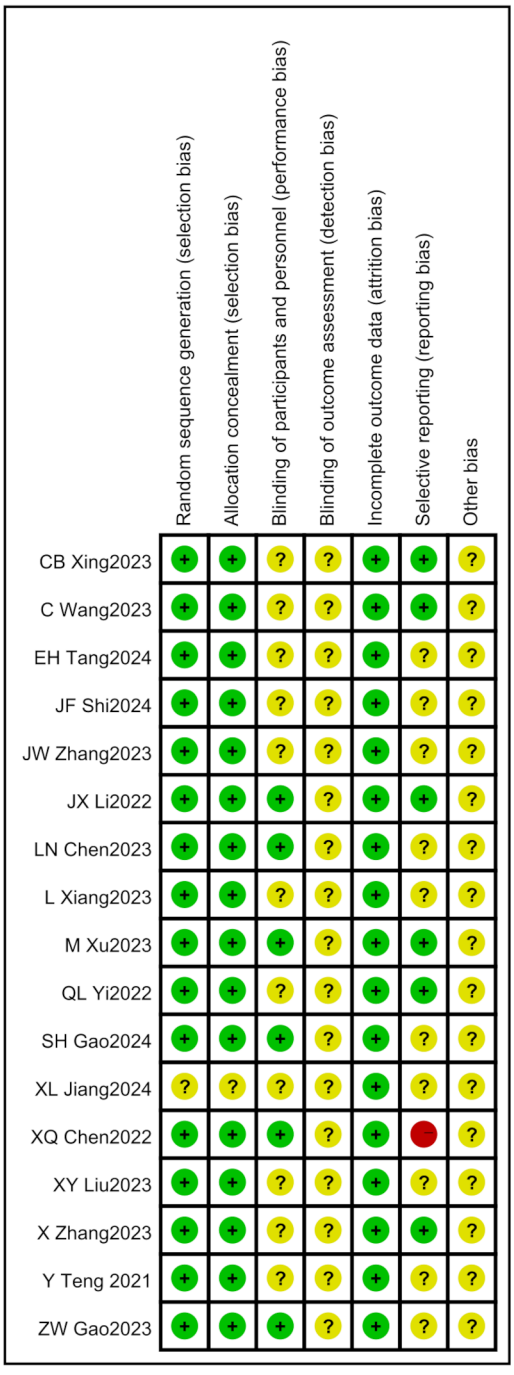

Fig. 2 Summary diagram of risk of bias in included literature

Subgroup analysis: (2) 6 documents [19, 21, 22, 24, 25, 27] reported the induction time of ciprofol and propofol in patients under 65 years old. The heterogeneity test ($P<0.0001$, $I^2=98\%$) showed that there was statistical heterogeneity among the studies, so the random effects model was used for analysis. The results showed that the induction time of the ciprofol group was longer than that of the propofol group (MD = 0.41 min, 95%CI: 0.04~0.78 min, $P=0.03$); (3) 7 documents [23, 26, 28–30, 32, 34] reported on the induction time of ciprofol and propofol in elderly patients over 65 years old. The heterogeneity test ($P=0.67$, $I^2=0\%$) showed that there was no statistical heterogeneity among the studies, so the fixed effects model was used for analysis. The results showed that there was no statistically significant difference in induction time between the ciprofol and propofol groups in patients over 65 years old (MD=-0.01 min, 95%CI: -0.05 ~ 0.02 min, $P=0.56$), as shown in Fig. 4.

Comparison of the incidence of ADRs

① Injection pain: (1) 12 documents [20, 21, 23, 24, 26, 28–31, 33–35] reported the number of ADRs of ciprofol versus propofol injection pain. The heterogeneity test ($P=0.006$, $I^2=58\%$) showed that there was statistical heterogeneity between studies, so a random effects model was used. The results showed that the incidence of injection pain in the ciprofol group was much lower than that in the propofol group (OR = 0.08, 95%CI: 0.05 ~ 0.15, $P<0.0001$).

Subgroup analysis: (2) 5 documents [20, 21, 24, 31, 33] reported the number of cases of painful ADRs to ciprofol and propofol injections in patients under 65 years old. The heterogeneity test ($P<0.0001$, $I^2=83\%$) showed that there was statistical heterogeneity among the studies, so the random effects model was used for analysis. The results showed that among patients under 65 years old, the incidence of injection pain in the ciprofol group was much lower than that in the propofol group (OR = 0.05, 95%CI: 0.01 ~ 0.23, $P=0.0001$); (3) 7 documents [22, 23, 26, 28, 29, 34, 35] reported the number of painful ADRs to ciprofol and propofol injections in patients over 65 years old. The heterogeneity test ($P=0.84$, $I^2=0\%$) showed that there was no statistical heterogeneity among the studies, so the fixed effects model was used for analysis. The results showed that among patients over 65 years old, the incidence of injection pain in the ciprofol group was much lower than that in the propofol group (OR = 0.10, 95%CI: 0.06 ~ 0.15, $P<0.0001$), as shown in Fig. 5.

② Hypotension: (1) 11 documents [21, 23–33] reported the number of ADRs of hypotension after induction of anesthesia with ciprofol versus propofol. The heterogeneity test ($P=0.007$, $I^2=59\%$) showed that there was statistical heterogeneity among the studies, so a random effects model was used. The results showed that the incidence rate of hypotensive ADRs in the ciprofol group was less than that in the propofol group (OR = 0.48, 95%CI: 0.32 ~ 0.72, $P=0.0004$).

Subgroup analysis: (2) 6 documents [21, 24, 25, 27, 31, 33] reported the incidence of hypotensive ADRs of ciprofol and propofol in patients under 65 years old. The heterogeneity test ($P=0.05$, $I^2=55\%$) showed that there

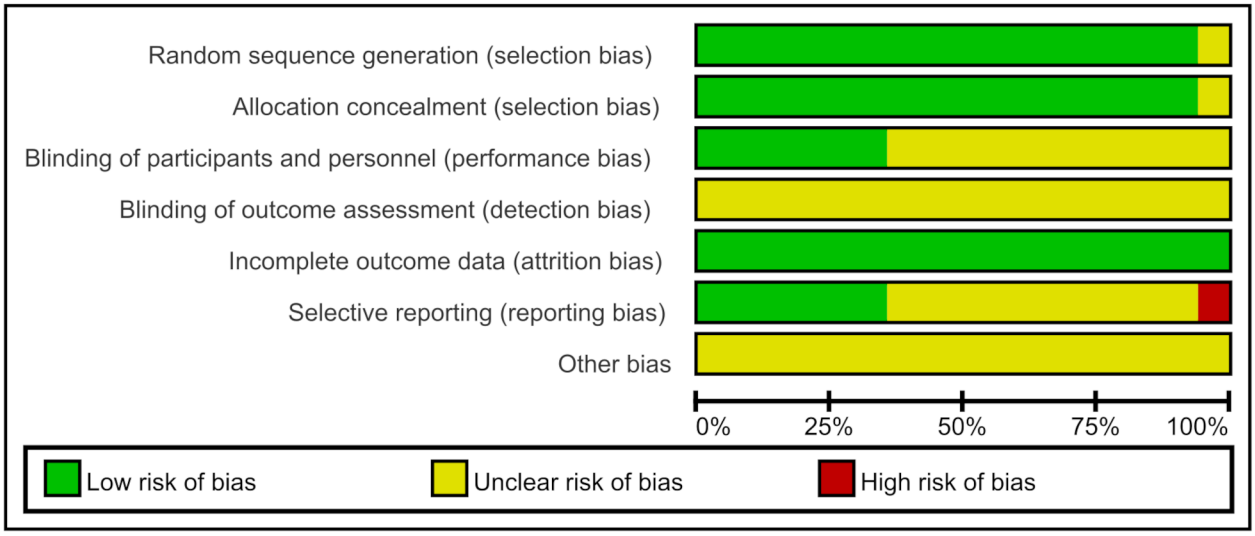

Fig. 3 Risk of bias percentage assessment chart of included literature

was statistical heterogeneity among the studies, so the random effects model was used for analysis. The results showed that among patients under 65 years old, there was no statistically significant difference in the incidence of hypotensive ADRs between the ciprofol group and the propofol group (OR = 0.61, 95%CI: 0.35 ~ 1.08, $P = 0.09$); (3) 5 documents [22, 26, 28, 29, 32] reported the number of ADRs of hypotension after induction of anesthesia with ciprofol and propofol in patients over 65 years old. The heterogeneity test ($P = 0.02$, $I^2 = 66\%$) showed that there was statistical heterogeneity among the studies, so the random effects model was used for analysis. The results showed that among patients over 65 years old, the incidence of hypotension in the ciprofol group was lower than that in the propofol group (OR = 0.35, 95%CI: 0.18 ~ 0.67, $P = 0.002$), as shown in Fig. 5.

③ Bradycardia: (1) 10 documents [20, 22, 24–26, 29, 31–34] reported the incidence of ADRs of bradycardia between ciprofol and propofol. The heterogeneity test ($P = 0.27$, $I^2 = 19\%$) showed that there was no statistical heterogeneity among the studies, so the fixed effects model was used. The results showed that the incidence of ADRs of bradycardia in the ciprofol group was less than that in the propofol group (OR = 0.66, 95%CI: 0.49 ~ 0.87, $P = 0.004$).

Subgroup analysis: (2) 5 documents [21, 24, 25, 31, 33] reported the incidence of bradycardia ADRs of ciprofol and propofol in patients under 65 years old. The heterogeneity test ($P = 0.70$, $I^2 = 0\%$) showed that there was no statistical heterogeneity among the studies, so the fixed effects model was used for analysis. The results showed that among patients under 65 years old, the incidence of bradycardia in the ciprofol group was less than that in the propofol group (OR = 0.53, 95%CI: 0.32 ~ 0.88, $P = 0.01$); (3) 5 documents [22, 26, 29, 32, 34] reported the incidence of bradycardia ADRs of ciprofol and propofol in patients over 65 years old. The heterogeneity test ($P = 0.09$, $I^2 = 50\%$) showed that there was no statistical heterogeneity among the studies, so the fixed effects model was used for analysis. The results showed that among patients over 65 years old, there was no statistical significance in the incidence of ADRs of bradycardia in the ciprofol group and the propofol group (OR = 0.73, 95%CI: 0.51 ~ 1.02, $P = 0.07$), as shown in Fig. 5.

④ Respiratory depression: (1) 11 documents [21, 23–25, 28, 30–35] reported the incidence of ADRs of respiratory depression after induction of anesthesia with ciprofol versus propofol. The heterogeneity test ($P = 0.54$, $I^2 = 0\%$) showed that there was no statistical heterogeneity among the studies, so the fixed effects model was used. The results showed that the number of cardiorespiratory depression reactions in the ciprofol group was less than that in the propofol group (OR = 0.21, 95%CI: 0.15 ~ 0.30, $P<0.0001$).

Subgroup analysis: (2) 5 documents [21, 24, 25, 31, 33] reported the number of ADRs of respiratory depression after induction of anesthesia with ciprofol and propofol in patients under 65 years old. The heterogeneity test ($P = 0.40$, $I^2 = 1\%$) showed that there was no statistical heterogeneity among the studies, so the fixed effects model was used for analysis. The results showed that among patients under 65 years old, the incidence of respiratory depression after anesthesia induction in the ciprofol group was lower than that in the propofol group (OR = 0.25, 95%CI: 0.15 ~ 0.43, $P<0.0001$); (3) 6 documents [22, 23, 28, 32, 34, 35] reported the number of ADRs of respiratory depression after induction of anesthesia with ciprofol and propofol in patients over 65 years

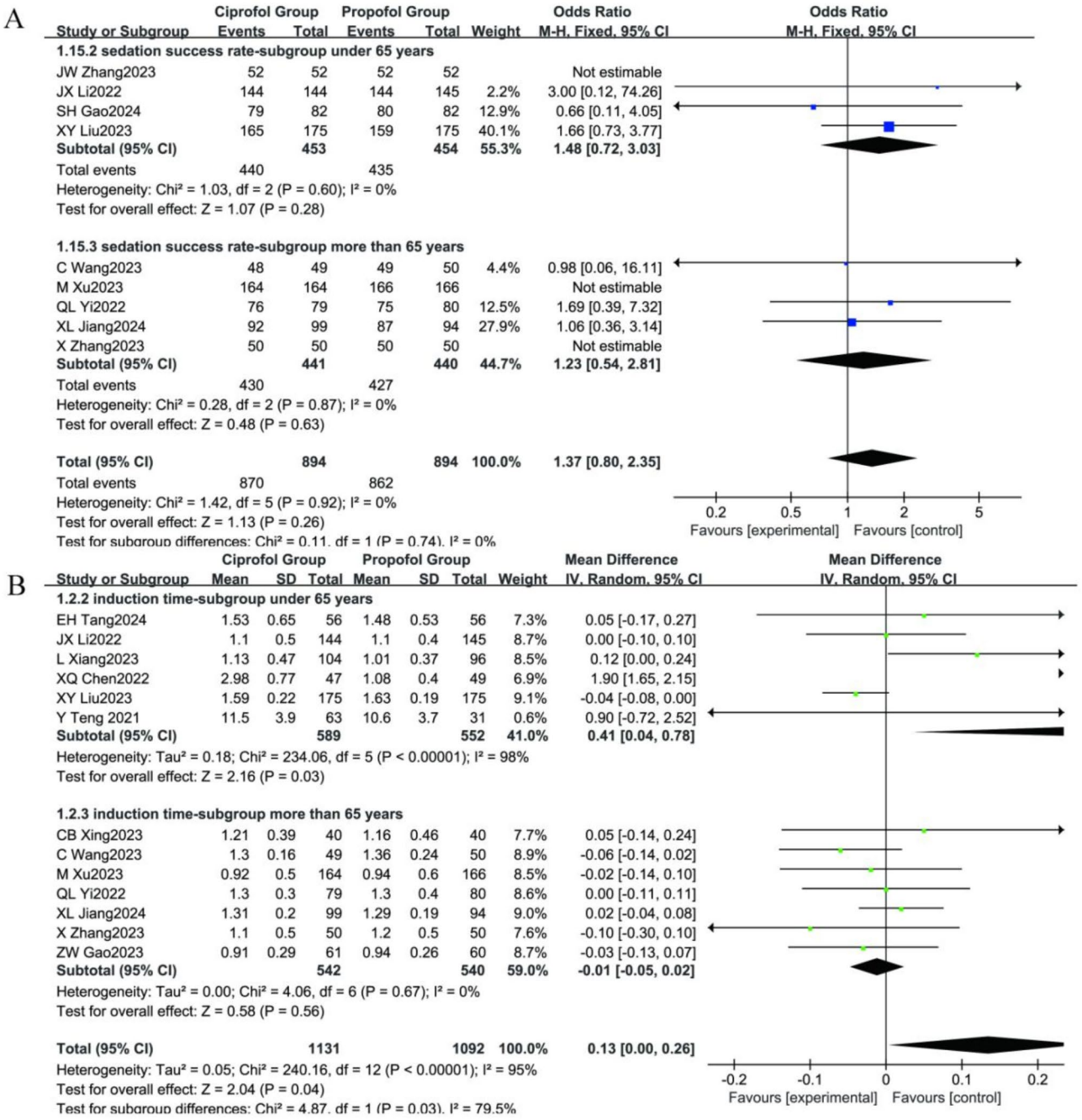

Fig. 4 The pooled results of **(A)**. sedation success rates **(B)**. induction time

old. The heterogeneity test ($P = 0.54$, $I^2 = 0\%$) showed that there was no statistical heterogeneity among the studies, so the fixed effects model was used for analysis. The results showed that among patients over 65 years old, the incidence of respiratory depression ADRs after anesthesia induction in the ciprofol group was lower than that in the propofol group (OR = 0.18, 95%CI: 0.12 ~ 0.29, $P<0.0001$), as shown in Fig. 6.

⑤ Hypoxemia: (1) 7 documents [21, 25–29, 32] reported the number of ADRs of hypoxemia after anesthesia induction. The heterogeneity test ($P = 0.34$, $I^2 = 12\%$) showed that there was no statistical heterogeneity among the studies, so the fixed effects model was used. The results showed that the incidence of ADRs of hypoxemia after anesthesia induction was statistically significant between the ciprofol group and the propofol group (OR = 0.29, 95%CI: 0.20 ~ 0.43, $P<0.0001$), with the number of ADRs in the ciprofol group being less than that in the propofol group.

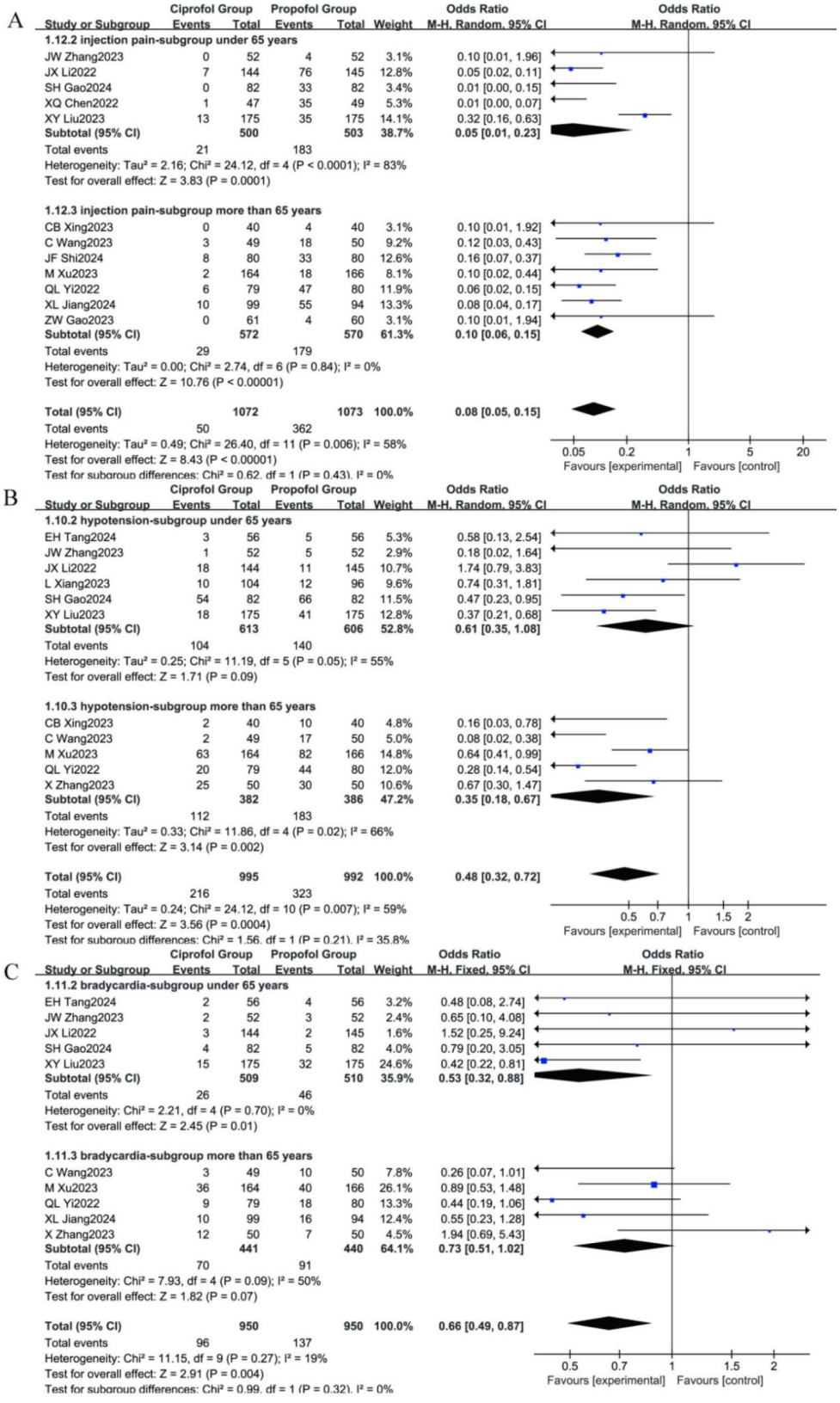

Fig. 5 The pooled results of **(A)**. injection pain **(B)**. hypotension **(C)**. bradycardia

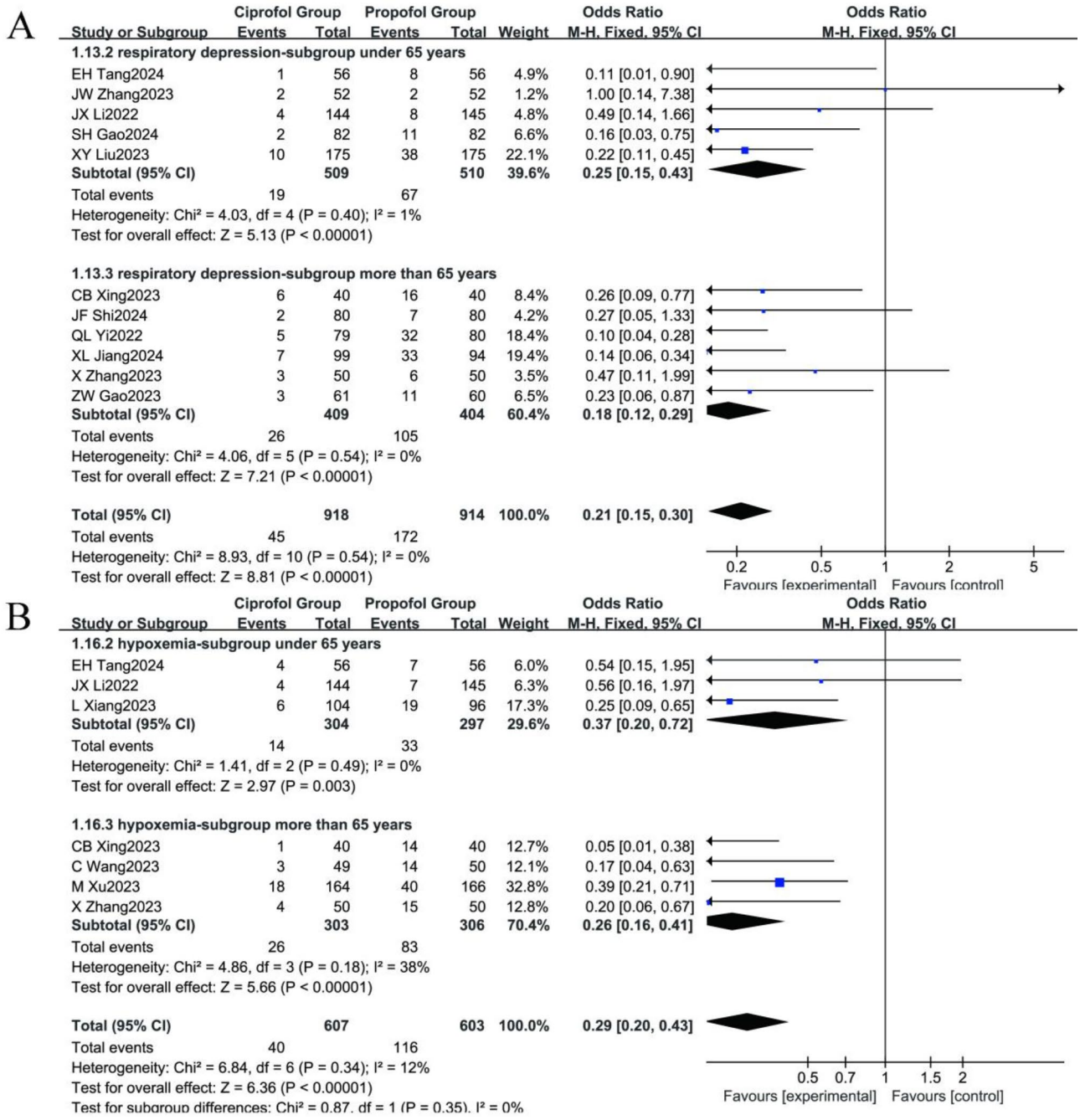

Fig. 6 The pooled results of **(A)**. respiratory depression **(B)**. hypoxemia

Subgroup analysis: (2) 3 documents [21, 25, 27] reported the number of ADRs of hypoxemia in patients under 65 years old after induction of anesthesia. The heterogeneity test ($P = 0.49$, $I^2 = 0\%$) showed that there was no statistical heterogeneity among the studies, so the fixed effects model was used. The results showed that among patients under 65 years old, there was a statistically significant difference in the incidence of ADRs of hypoxemia between the ciprofol group and the propofol group (OR = 0.37, 95%CI: 0.20 ~ 0.72, $P = 0.003$). The number of ADRs of hypoxemia in the ciprofol group was less than that in the propofol group; (3) 4 documents [26, 28, 29, 32] reported the number of cases of hypoxemia after induction of anesthesia in patients over 65 years old. The heterogeneity test ($P = 0.18$, $I^2 = 38\%$) showed that there was no statistical heterogeneity among the studies, so the fixed effects model was used for analysis. The results showed that among patients over 65 years old, there was a statistical significance in the number of ADRs of hypoxemia after anesthesia induction in the

ciprofol group and the propofol group (OR = 0.26, 95%CI: 0.16 ~ 0.41, *P*<0.0001). The incidence of ADRs of hypoxemia in the ciprofol group was less than that in the propofol group, as shown in Fig. 6.

Analysis of other relevant indicators mate

Regarding other related indicators: (1) In the 7 studies [20–22, 27, 28, 32, 34] on the insertion time, it was found that the ciprofol group took less time than the propofol group; (2). In the 2 studies [18, 28] on patients over 65 years old, the exit time in the ciprofol group was longer than that in the propofol group; (3). In 3 studies [28, 29, 34] on patients over 65 years old, the diastolic blood pressure in the ciprofol group was lower than that in the propofol group. Moreover, the other indicators had no statistical significance (as shown in Table 2).The forest plot can be found in the supplementary materials.

Safety and publication bias analysis

9 articles [24, 26, 27, 29–32, 34] included in the study reported the success rate of sedation. The results of the Egger test showed that *P* = 0.988; 11 documents included in the study [21, 23–33] reported the number of ADRs of hypotension. The results of the Egger test showed that *P* = 0.747; 12 documents [20, 21, 23, 24, 26, 28–31, 33–35] reported the number of cases of injection pain ADRs. The results of the Egger test showed that *P* = 0.267; 10 documents [20, 22, 24–26, 29, 31–34] reported the number of ADRs of bradycardia. The results of the Egger test showed that *P* = 0.808; 11 documents [21, 23–25, 28, 30–35] reported the number of cases of ADRs to respiratory depression. The results of the Egger test showed that *P* = 0.137; 16 documents [19–32, 34, 35] reported the recovery time after anesthesia induction with ciprofol versus propofol. The results of the Egger test showed that *P* = 0.488; 13 documents [19, 21–30, 32, 34] reported the anesthesia induction time of ciprofol versus propofol. The results of the Egger test showed that *P* = 0.141. The Egger test data show that there is no publication bias. In order to verify this result, we make a funnel plot. The results are shown in Figs. 7 and 8. For details of Egger test, please see supplementary materials.

Discussion

Gastrointestinal endoscopy is a minimally invasive surgical technique that is important in the diagnosis of disease [36]. However, during routine operations, patients may experience some discomfort, such as patients with chronic pharyngitis, long-term smokers, and people with sensitive throat [9]. In addition, colonoscopy may cause intestinal cramps, pain and abdominal distension. Some patients have to interrupt the examination because they

Table 2 Analysis of other relevant indicators mate

Index	Number of studies	Heterogeneity test		Effect model	HR(95%)	*p*-value
		t^2(%)	*p*-value			
Inspection time	6	I^2 = 79%	*P* = 0.002	Random	-0.62(-1.58~0.33)	*P*=0.20
Recovery time	6	I^2 = 93%	*P*<0.0001	Random	0.47(-0.60~1.53)	*P*=0.39
Insertion time	7	I^2 = 95%	*P*<0.0001	Random	0.35(0.03~0.67)	*P*=0.03
under 65 years of age	4	I^2 = 97%	*P*<0.0001	Random	0.57(0.01~0.14)	*P*=0.05
over 65 years old	3	I^2 = 0%	*P* = 0.56	Immobilization	0.01(-0.07~0.10)	*P*=0.77
Exit time	6	I^2 = 98%	*P*<0.0001	Random	0.48(-1.58~2.53)	*P*=0.65
under 65 years of age	4	I^2 = 99%	*P*<0.0001	Random	-0.07(-2.49~2.34)	*P*=0.95
over 65 years old	2	I^2 = 35%	*P* = 0.22	Immobilization	1.57(0.59~2.55)	*P*=0.002
Systolic blood pressure	6	I^2 = 90%	*P*<0.0001	Random	0.25(-3.18~3.67)	*P*=0.89
under 65 years of age	3	I^2 = 85%	*P* = 0.002	Random	3.67(-2.52~9.87)	*P*=0.24
over 65 years old	3	I^2 = 87%	*P* = 0.0005	Random	-2.53(-6.49~1.44)	*P*=0.21
Diastolic blood pressure	6	I^2 = 87%	*P*<0.0001	Random	0.05(-2.02~2.11)	*P*=0.96
under 65 years of age	3	I^2 = 79%	*P* = 0.008	Random	2.69(-1.17~6.56)	*P*=0.17
over 65 years old	3	I^2 = 66%	*P* = 0.06	Random	-2.24(-3.71~0.78)	*P*=0.003
Heart rate	7	I^2 = 93%	*P*<0.0001	Random	-0.34(-3.90~3.22)	*P*=0.85
Blood oxygen saturation	6	I^2=0%	*P* = 0.74	Immobilization	0.01(-0.00~0.02)	*P*=0.05
Cough	2	I^2 = 36%	*P* = 0.21	Immobilization	0.96(0.48~1.92)	*P*=0.92
Operating time	5	I^2 = 72%	*P* = 0.006	Random	0.70(-0.24~1.63)	*P*=0.14
MAP	7	I^2 = 87%	*P*<0.0001	Random	2.85(-0.12~5.82)	*P*=0.06
Awakening time	16	I^2 = 92%	*P*<0.001	Random	0.19(-0.05~0.42)	*P*=0.12
under 65 years of age	8	I^2 = 96%	*P*<0.001	Random	0.45(-0.22~1.11)	*P*=0.19
over 65 years old	8	I^2 = 66%	*P* = 0.005	Random	0.09(-0.21~0.39)	*P*=0.55

Inspection time [18, 21, 23, 27, 28, 30], Recovery time [16, 17, 19, 21, 23, 27], Insertion time [16–18, 23, 24, 28, 30], Exit time [16, 18, 20, 21, 23, 28], Systolic blood pressure [15, 16, 20, 24, 25, 30], Diastolic blood pressure [15, 16, 20, 24, 25, 30], Heart rate [15, 16, 19–21, 27, 31], Blood oxygen saturation [15, 16, 19–21, 27], Cough [18, 21], Operating time [15, 16, 19, 22, 30], Awakening time [15–28, 30, 31], MAP [16, 19, 21, 23, 27, 30, 31]

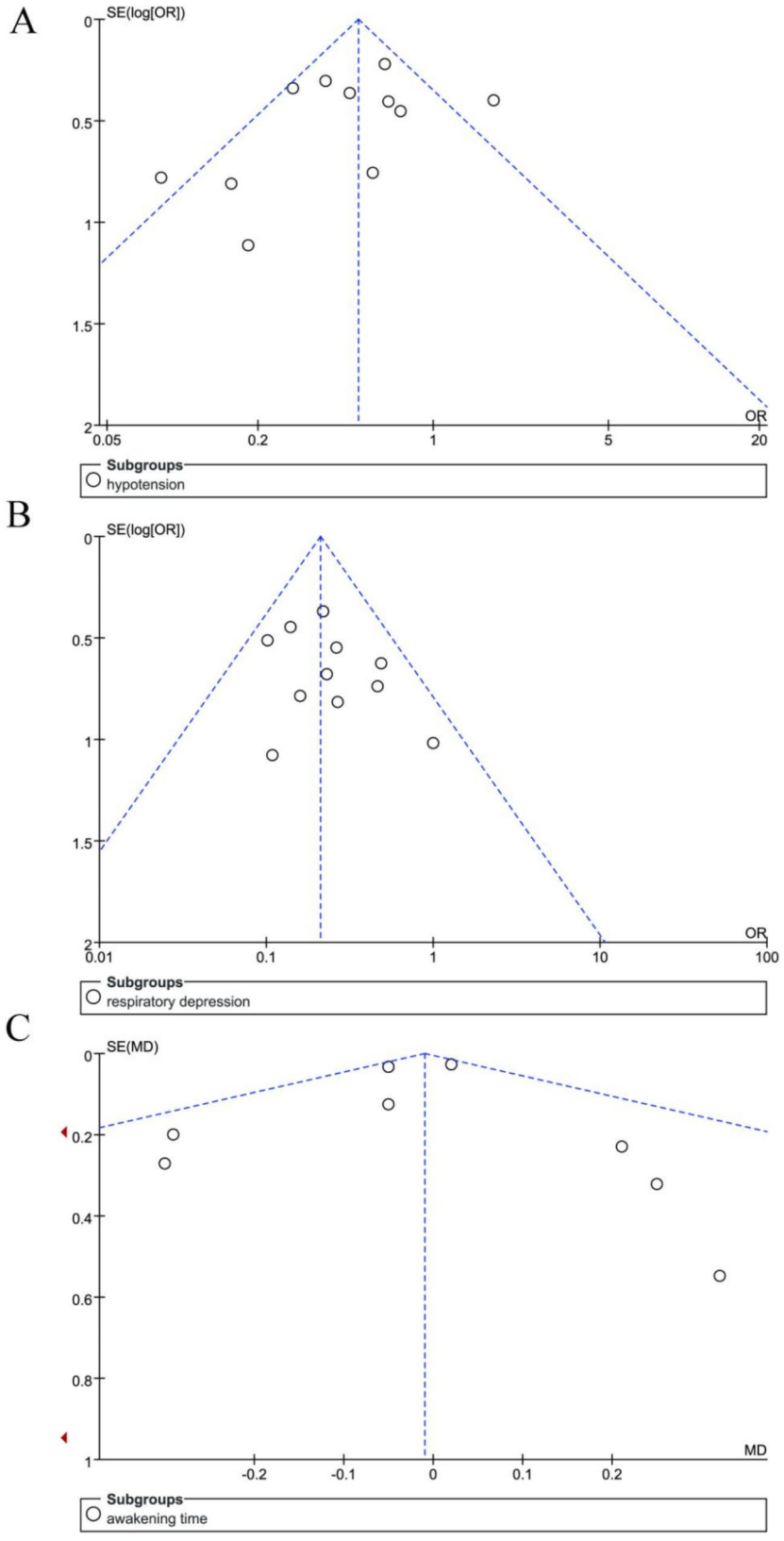

Fig. 7 Bias method analysis legend. **(A)**. Hypotension funnel plot; **(B)**. Respiratory depression funnel plot; **(C)**. Wake-up time funnel plot;

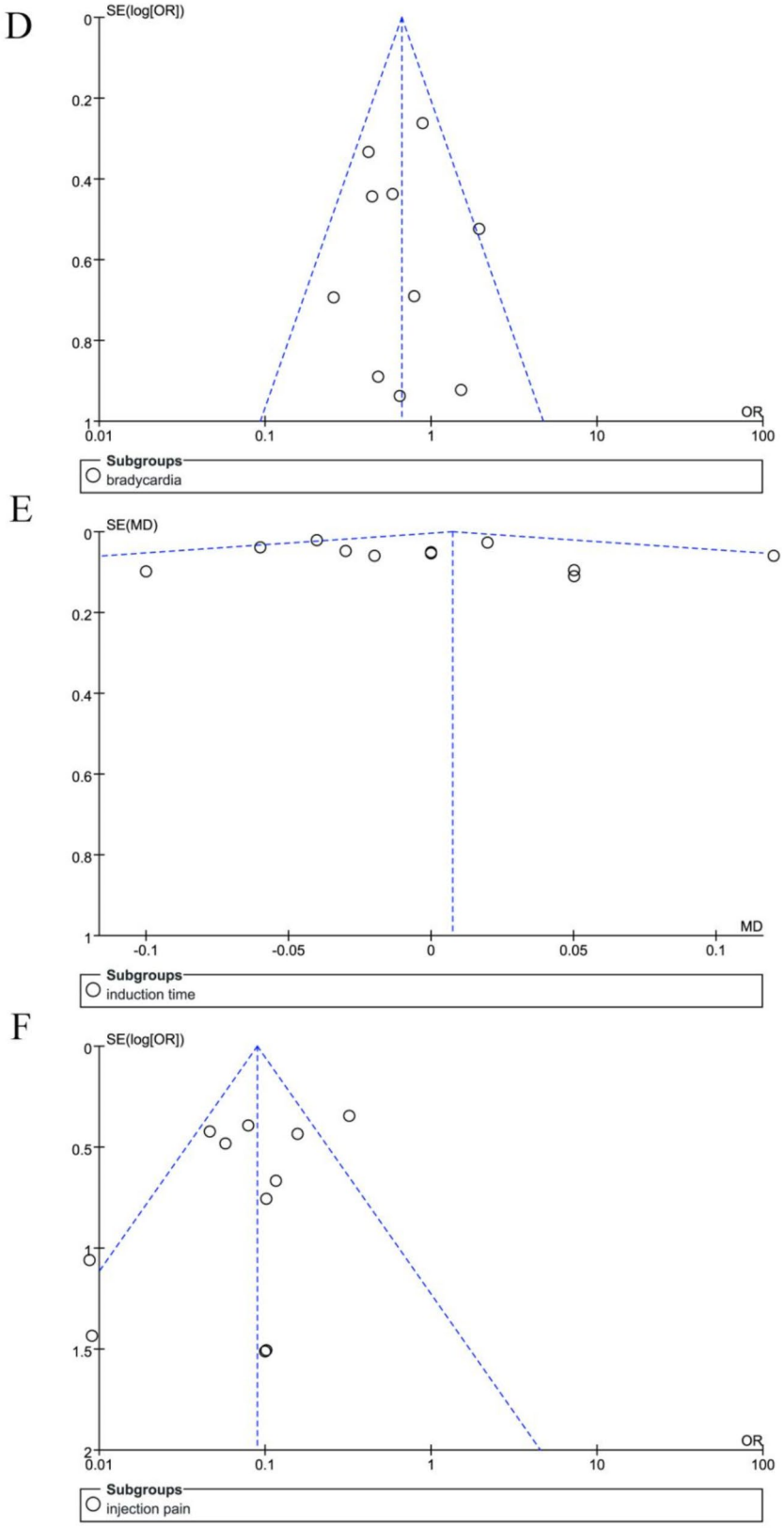

Fig. 8 Bias method analysis legend **(D)**. Bradycardia funnel plot; **(E)**. Induction time funnel plot; **(F)**. Injection pain funnel plot

cannot tolerate these problems, thus delaying diagnosis and treatment [37]. At the same time, routine gastrointestinal endoscopy may also stimulate the vagus nerve, resulting in detrusor pain and reflexive heart rate reduction, bringing additional physical and psychological burden to patients [38]. In order to alleviate patients' pain and improve the comfort and safety of the examination, the painless gastrointestinal endoscopy technique was developed [37]. This technique is performed under anesthesia, which significantly improves patient tolerance, reduces adverse effects, shortens examination and processing time, and provides a safer, faster and more comfortable examination experience for patients [39].

In painless gastrointestinal endoscopy, propofol is a commonly used anesthetic drug, which has a significant sedative effect but also shows some side effects during use, such as respiratory depression, decreased blood pressure, and slowed heart rate [40]. In order to find safer and more effective anesthesia drugs, researchers developed ciprofol [41] based on the activity of propofol. Ciprofol is a new type of intravenous anesthesia drug, whose potency is 4–5 times higher than that of propofol, which is highly effective, safe and easy to control, and shows great potential in painless gastrointestinal endoscopy anesthesia [42].

From the physician's point of view, ciprofol is highly effective in painless gastrointestinal endoscopy [43]. Ciprofol can rapidly bring patients into a state of deep sedation without pain and without intraoperative movements and ADRs [44].The use of ciprofol has been shown to be effective in painless gastrointestinal endoscopy. However, the operation of ciprofol is simple and easy to use, and the patient recovers rapidly after awakening, without dizziness, nausea, vomiting and other symptoms, and can immediately carry out daily activities, which significantly improves the quality and efficiency of the procedure [45]. From the patient's point of view, painless gastrointestinal endoscopy using ciprofol is a very comfortable experience [46]. The patient had no pain during the entire procedure, had no reaction when the needle was pushed, and was in good physical condition upon awakening, and was able to answer questions quickly and without discomfort [47]. This painless experience not only reduces patients' psychological stress, but also increases their satisfaction with healthcare services [47]. Although ciprofol is 4–5 times more effective than propofol, requires lower dosage, is more effective, and provides faster and more efficient sedation than propofol, the subsequent slight changes in its dosage may have adverse effects on patients. have a greater impact on the sedation or anesthesia effect. This requires clinicians to more accurately calculate and adjust doses when formulating dosage regimens. There are also large individual differences in the sensitivity of different patients to ciprofol, and this difference is more prominent in the case of higher potency. Some patients may respond strongly to conventionally recommended doses, while others may require slightly higher doses to achieve satisfactory results. Clinicians need to spend more time and effort assessing patients' individual circumstances.

The results of 17 (RCTs) show that compared with propofol, ciprofol has a lower incidence of ADRs such as injection pain, hypotension, hypoxemia, and respiratory depression during painless gastrointestinal anesthesia. In patients over 65 years old, ciprofol remains highly safe.In the overall sample, the induction time of the ciprofol group was longer than that of the propofol group by about 0.13 min, and the induction time of the ciprofol group was longer than that of the propofol group in patients under 65 years old by about 0.41 min. However, there was no significant difference in the induction time between the two in elderly patients. It may be that young patients have better physical functions and faster distribution and metabolism, while elderly patients have declining metabolic functions. Physiological changes, such as reduced body water, increased fat proportion, etc., will affect the distribution volume of the drug and change the sensitivity of the central nervous system. These physiological changes will lead to differences in induction time as they affect the distribution volume of the drug and change the sensitivity of the central nervous system. In terms of insertion time, the ciprofol group was longer than the propofol group in young patients, but there was no significant difference between the two in elderly patients. In the overall sample, the ciprofol group took longer than the propofol group; In terms of the time to leave the room, the ciprofol group was less than the propofol group in young patients. In terms of the time to wake up after anesthesia (for example), the ciprofol group took longer than the propofol group in elderly patients. However, in the overall sample, the time needed for ciprofol group to reach full recovery was less than that of the propofol group. These differences might be related to the different pharmacological mechanisms of the two drugs. For instance, ciprofol may have a quicker onset of action and a better ability to maintain stable sedation and anesthesia states, which could contribute to a better overall recovery process. Additionally, through integrated analysis of 17 RCTs, we found that ciprofol showed higher safety than propofol in both patients under 65 years old and patients over 65 years old. For example, it had a lower incidence of ADRs in these patient groups. Therefore, we believe that ciprofol is a safer sedative anesthetic drug than propofol in terms of applicability to patients of all ages.

It has important clinical significance by reducing the incidence of ADRs, which helps to ensure the safety of the treatment process and reduce the treatment

interruption, additional medical intervention and psychological burden of patients caused by adverse drug reactions. From the perspective of medical institutions and medical staff, the lower incidence of ADRs helps to improve the quality of medical care. This is especially significant when it comes to elderly patients, as they have a decline in physical function and a decline in liver and kidney function, and a weakened drug metabolism ability [10]. At the same time, they are often accompanied by a variety of chronic diseases, and their tolerance to drugs is poor. Moreover, the effect of ciprofol on the cardiovascular system is small. Compared with propofol, it can reduce the risk of hypotension and arrhythmia in elderly patients. The respiratory function reserve of elderly patients is low, the respiratory muscle strength is weakened, and the inhibitory effect of ciprofol on respiratory function is relatively light, which can ensure the respiratory safety of elderly patients.For patients with cardiovascular diseases such as hypertension and coronary heart disease, ciprofol can avoid excessive stimulation of the heart and large fluctuations in blood pressure [48]. It can reduce myocardial oxygen consumption and reduce the risk of arrhythmia, thereby reducing the adverse prognosis caused by cardiac events. In patients with respiratory diseases such as asthma and COPD, the effect of ciprofol on the reduction of adverse events of respiratory depression is particularly important. This can reduce the complications such as pulmonary infection and respiratory failure caused by the deterioration of respiratory function, and help the patient 's respiratory function to be stable [49]. ADRs like hypotension may lead to an increase or decrease in the patient's blood glucose. Reducing the incidence of hypotension helps maintain the relative stability of blood glucose, which is beneficial to the control and progression of diabetes.

Compared with other propofol substitutes, for example, etomidate can also be used for sedation during endoscopy, but its onset time may be delayed compared with ciprofol and propofol, which may affect the examination effect [50]. Moreover, etomidate may cause transient adrenal cortical function inhibition after use, which is unfavorable for some patients who have long-term use of glucocorticoids or have adrenal cortical dysfunction. It may cause pain at the injection site, cause stress response in patients, and then affect the circulatory system. Such as midazolam, the depth of sedation is relatively shallow. Although it can achieve sufficient sedation at a higher dose, it will increase the risk of ADRs, such as respiratory depression and delayed recovery caused by excessive sedation. In addition, midazolam is not as effective as propofol in inhibiting laryngopharyngeal reflex, which may lead to nausea and vomiting during the examination.In contrast, some alternatives have a longer recovery time [51]. For example, after dexmedetomidine is used for endoscopic sedation, the patient's recovery time may be extended to about 15～20 min, and hypotension and conditions like bradycardia may affect the patient's recovery and discharge time [52]. Although ketamine has less respiratory depressant effects, it can cause an increase in secretions and increase the risk of airway obstruction, especially during gastrointestinal endoscopy, which may irritate the pharynx.

Although this study has made some progress in exploring the choice of anesthetic drugs in painless gastroscopy, there are still some limitations. (1) First of all, as a new drug developed and marketed in China, the sample size is limited to China. It is not clear whether our research results can be extended to other races. If it is applied in other countries, it will also include sample data of more races. (2). In the included literature, there are differences in the choice of combined drugs used among various studies, which may introduce a certain risk of bias to the research results. In future studies, the choice of combined drugs should be unified as much as possible to reduce the impact of bias on the results. (3) There are differences in the definition of anesthesia protocol and some outcome indicators in the study, which leads to high heterogeneity in some results. (4) The lack of long-term data monitoring and follow-up in elderly patients leads to some potential deviations. (5) The effects of different doses were not evaluated in this study. More RCTs controlled trials are needed to determine the optimal dose of ciprofol in gastrointestinal examination in the future. (6) The criteria for sedation success rate in the literature are not comprehensive enough. In the future, more literature with diverse samples are needed to enrich and evaluate these criteria. (7) In this study, there was no specific classification of the severity of adverse reactions. In the future, classification should be carried out as much as possible for statistics and description.

In clinical applications, ciprofol is usually used in combination with opioids, which can cause a series of compounding stability problems. When two or more drugs are mixed, due to the differences in their physicochemical properties, they will cause different reactions, including some changes visible to the naked eye (e.g., precipitation, discoloration, turbidity, etc.) and changes not visible to the naked eye (e.g., hydrolysis, redox, etc.). Since ciprofol is an emulsion, its compounding is much more difficult than that of a general solution. Coupled with the relatively short time that ciprofol has been on the market, there are relatively limited studies on its compounding stability in the market, which poses a certain risk to the safety of clinical medication. Therefore, strengthening the investigation and research on the compounding stability and compatibility of ciprofol when used in combination with other drugs to ensure the safety of clinical use will be the focus of our future research.

Conclusion

In conclusion, the application of ciprofol in painless gastrointestinal endoscopy anesthesia is of high value, which can effectively relieve pain, reduce injection pain, improve patient comfort, and reduce the occurrence of complications. Therefore, ciprofol is worth being widely used in gastrointestinal endoscopy in patients of adults. Starting from a lower dose, elderly patients can consider starting from 0.2 mg/kg-0.4 mg/kg, and then gradually adjust the dose according to the patient's response (such as sedation depth, changes in vital signs).

Abbreviations

RCTs	Randomised controlled trials
ADRs	Adverse drug reactions
CNKI	China national knowledge infrastructure
GABA	γ-aminobutyric acid
GABAA	γ-aminobutyric acid type A
TBOB	T-butyl bicyclic ortho benzoate
MD	Mean difference
RD	Risk difference
CI	Confidence interval
SBP	Systolic blood pressure
HR	Heart rate
VAS	Visual analogue scale

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12876-025-03734-0.

Supplementary Material 1

Acknowledgements

Not applicable.

Author contributions

C, Z and F conceived this review. C, Z, J, F conducted retrieval, data filtering and extraction. C, Z and J analyzed the included data. C and Z finished the first draft. F and F changed the first draft. All authors have seen and endorsed the definitive manuscript.

Funding

This study was supported by Hubei Provincial Natural Science Foundation of China (2024AFD097) and the Technology Key Program of Shiyan, China (number 24Y153).

Data availability

All data generated or analysed during this study are included in this published article [and its supplementary information files].

Declarations

Ethics approval and consent to participate

Not applicable.

Consent to publication

Not applicable.

Competing interests

The authors declare no competing interests.

Author details

[1]Sinopharm Dongfeng General Hospital, Hubei University of Medicine, Hubei Shiyan 442008, China

[2]School of Pharmaceutical Sciences, Hubei University of Medicine, Hubei Shiyan 442000, China

Received: 1 November 2024 / Accepted: 25 February 2025
Published online: 03 March 2025

References

1. Yongtong Z, Shuqing L, Zecheng Y, et al. Efficacy and safety of subanesthetic doses of Esketamine combined with Propofol in painless Gastrointestinal endoscopy: a prospective, double-blind, randomized controlled trial. BMC Gastroenterol. 2022;22(1):391–391.
2. Young DJ, Pinnell JL, Wolfe AC, et al. The biogeography of Gastrointestinal mucosal microbiota of beef cattle at harvest. Front Microbiol. 2024;17(3):82–5.
3. Sarofim M, Mackenzie S, Gibson K, et al. Can we achieve even better outcomes with prophylactic intravenous antibiotics in Gastrointestinal surgery. Tech Coloproctol. 2024;28(1):151–151.
4. Gökce E, Devisscher L, Rashidian N, et al. Lumen-apposing metal stents for anastomosis creation throughout the Gastrointestinal tract: a large single-center experience. Deease Open. 2025;5(1):19–23.
5. Jahnvi D, Daryl R, Jayanta S, et al. Hemostatic powders and gels in Gastrointestinal endoscopy: current perspective and future recommendations. Expert Rev Gastroenterol Hepatol. 2023;17(11):1061–5.
6. Liu GH, Xiong Y. Analysis of stress response and analgesic effect of remazolam combined with etomidate in painless gastroenteroscopy. Contrast Media Mol Imaging. 2022;15(3):25–7.
7. Mi SC et al. Effect of modified Shengyangyiwei Decoction on painless gastroscopy and Gastrointestinal and immune function in gastric cancer patients. World J Gastrointest EndosCopy 2023, 15(5): 376–85.
8. Kaumudi S, Swapnil S, Prerna S, et al. Early definitive diagnosis and management of incidental neuroendocrine tumors found on Gastrointestinal endoscopy. Cureus. 2023;15(9):44718–44718.
9. Sun HH, You ZB. Adoption of remifentanil combined with Propofol in general anesthesia surgery: meta-analysis. Farmacia 2024, 72(1): 116–24.
10. Chen Y, Yu T, Jiang J. Effects of Propofol on the electrophysiological properties of glutamatergic neurons in the ventrolateral medulla of mice. BMC Anesthesiol. 2024;24(1):432–432.
11. Liu J, Hong A, Zeng J, et al. The efficacy of Ciprofol versus Propofol on anesthesia in patients undergoing endoscopy: a systematic review and meta-analysis of randomized controlled trials. BMC Anesthesiol. 2024;24(1):359–359.
12. Jun H, Xiuxia G, Wenhao Z, et al. Comparison of anesthetic effects of different doses of alfentanil combined with Ciprofol in elderly patients undergoing Ercp: a randomized controlled trial. BMC Anesthesiol. 2023;23(1):353–353.
13. Gongchen D, Haiyan L, Weifeng S, et al. Clinical effect of different doses of Ciprofol for induction of general anesthesia in elderly patients: a randomized, controlled trial. Pharmacol Res Perspect. 2023;11(2):1055–66.
14. Liang GL, Zhi GW, Dong G, et al. Efficacy and safety of Ciprofol for agitation and delirium in the Icu: a multicenter, single-blind, 3-arm parallel randomized controlled trial study protocol. Front Med. 2023;11(2):62–3.
15. Lini C, Yongguo X, Xueke D, et al. The effect of different doses of Ciprofol in patients with painless Gastrointestinal endoscopy. Drug Des Devel Ther. 2023;17(5):1733–40.
16. Abhijit N, Suresh S. Ciprofol- a game changing intravenous anesthetic or another experimental drug. Saudi J Anaesth. 2022;16(2):258–9.
17. Yi T, MengChan O, Xiao W, et al. Pharmacokinetic and pharmacodynamic properties of Ciprofol emulsion in Chinese subjects: a single center, open-label, single-arm dose-escalation phase 1 study. Am J Translational Res. 2021;13(12):13791–802.
18. Alexander K, Panagiota B, et al. Postprandial glucose and Gastrointestinal hormone responses of healthy subjects to wheat biscuits enriched with l-arginine or branched-chain amino acids of plant origin. Nutrients. 2022;14(20):4381–4381.
19. Lini C, Yongguo X, Xueke D, et al. The effect of different doses of Ciprofol in patients with painless Gastrointestinal endoscopy. Drug Des Devel Ther. 2023;14(17):1733–40.
20. Xingqu C, Ping G, Li Y, et al. Comparison and clinical value of Ciprofol and Propofol in intraoperative adverse reactions, operation, resuscitation, and satisfaction of patients under painless gastroenteroscopy anesthesia. Contrast Media Mol Imaging. 2022;14(18):954–1060.

21. Junxiang L, Xiao W, Jin L, et al. Comparison of Ciprofol (hsk3486) versus Propofol for the induction of deep sedation during gastroscopy and colonoscopy procedures: a multi-center, non-inferiority, randomized, controlled phase 3 clinical trial. Basic Clin Pharmacol Toxicol. 2022;131(2):138–48.
22. Yi T, Mengchan O, Xiao W, et al. Efficacy and safety of Ciprofol for the sedation/anesthesia in patients undergoing colonoscopy: phase IIa and IIb multicenter clinical trials. Eur J Pharm Sci. 2021;10(15):904–12.
23. Gao ZW, Zhou RH, Li JX. Applicability of Ciprofol combined with Nalbuphine in painless gastroenteroscopy on elder-ly patients. Chin J Armed Police Med. 2023;34(04):330–4.
24. Liu XY. Effect of Cyclophenol on sedation and recovery quality of awakening of patients undergoing painless gastroscopy. Henan Med Res. 2023;32(08):1437–41.
25. Tang EH, et al. Comparison of anesthesia effect of Ciprofol and Propofol combined with sufentanil in painless colonoscopy. Lab Med Clin. 2024;21(3):393–7.
26. Wang C, Dong X, Zhao KF. Effect of Cipofol combined with afentanil on colonoscopy of senile patients. J Clin Anesthesiology. 2023;39(05):550–2.
27. Ning W, YanYing L. ShanShan Wei. Effect of ciprofol and propofol in the diagnosis and treatment of painless gastroscopy. Journal Of Clinical Practice Hospital. 2023, 20(3): 109–113.
28. Xing CB. A clinical study comparing the safety and efficacy of ciprofol and propofol in elderly patients with painless gastroscopy anesthesia. 2023 Master's Thesis: Jilin University.
29. Xu M, et al. Comparison of sedative effect of Ciprofol and Propofol in elderly patients with fibrocolonoscopy. J Clin Anesthesiology. 2023;39(7):705–8.
30. Yi QL, Mo LZ, Hu H, et al. Comparison of Ciprofol and Propofol in painless gastroscopy in elderly patients. J Clin Anesthesiology. 2022;38(7):712–5.
31. Zhang JW, et al. Efficacy and safety of Ciprofol in painless gastroscopy. J Clin Pract Hosp. 2023;20(06):174–7.
32. Zhang X, Zhu T. Effects of Ciprofol on respiratory function in elderly patients undergoing painless gastroscopy. J Clin Anesthesiology. 2023;39(03):330–2.
33. Gao HS, Tang QQ, Wang MC, et al. The efficacy and safety of Ciprofol and Propofol in patients undergoing colonoscopy: a double-blind, randomized, controlled trial. J Clin Anesth. 2024;95(15):467–74.
34. Jiang, Xl, et al. Comparison of the effects of Propofol and Propofol on painless Gastrointestinal endoscopy in the elderly. Chin J Clin Health. 2024;27(04):529–32.
35. Shi JF, et al. Comparison of the application of Propofol and Propofol combined with Butorphanol anesthesia in painless Gastrointestinal endoscopy in the elderly. Shaanxi Med J. 2024;53(06):814–7.
36. Yan M, Hongyi X, Teng Z, et al. Study on the effectiveness and safety of Ciprofol in anesthesia in gynecological day surgery: a randomized double-blind controlled study. BMC Anesthesiol. 2023;23(1):92–92.
37. YiChao W, MengJun W, ShengLiang Z, et al. Protective effects of combined treatment with Ciprofol and mild therapeutic hypothermia during cerebral ischemia-reperfusion injury. World J Clin Cases. 2023;11(3):487–92.
38. WY KQ. Effect of Ciprofol on induction and maintenance of general anesthesia in patients undergoing kidney transplantation. Eur Rev Med Pharmacol Sci. 2022;26(14):5063–71.
39. Wei Y, Jia L, Cheng S, et al. Efficacy and safety of Ciprofol for general anesthesia induction in female patients with frailty: a prospective randomized controlled trial. BMC Anesthesiol. 2024;24(1):396–396.
40. Xia L, Miao R, Anqi Z, et al. Nrf2 attenuates oxidative stress to mediate the protective effect of Ciprofol against cerebral ischemia–reperfusion injury. Funct Integr Genom. 2023;23(4):345–345.
41. Jiqiang Z, Ruijuan L, Ruirui B, et al. Comparison of ciprofol-alfentanil and propofol-alfentanil sedation during bidirectional endoscopy. Study Liver. 2023;56(4):663–71.
42. Lini C, Yongguo X, Xueke D, et al. The effect of different doses of Ciprofol in patients with painless Gastrointestinal endoscopy. Drug Des Dev Therapy. 2023;5(2):1733–40.
43. Mróz M, Czub M, Brytek-Matera A. Heart rate variability-an index of the efficacy of complementary therapies in irritable bowel syndrome: a systematic review. Nutrients. 2022;14(16):3–6.
44. Rongfang L. Effectiveness of remimazolam benzenesulfonate combined with alfentanil in elderly patients undergoing painless gastroenteroscopy. J Clin Nurs Res. 2024;8(8):92–8.
45. Erel S, Aydın ME, Nazlıel B, et al. Evaluation of delirium risk factors in intensive care patients. Turkish J Anaesthesiol. 2024;52(6):213–22.
46. Bansal T, Singhal S, Kundu K. Prospective randomized double-blind study to evaluate Propofol and combination of Propofol and Sevoflurane as maintenance agents in reducing postoperative nausea and vomiting in female patients undergoing laparoscopic surgery. Med Gas Res. 2022;12(4):137–40.
47. Liu H, Yang C, Wang X, et al. Propofol improves sleep deprivation-induced sleep structural and cognitive deficits via upregulating the bmal1 expression and suppressing microglial m1 polarization. CNS Neurosci Ther. 2024;30(7):147–98.
48. Jansen G, Deicke M, Fischer D, et al. Pre-hospital post-arrest anaesthesia for reintubation of an extraglottic airway to an endotracheal tube with Midazolam. Resuscitation. 2024;203(S1):S34–34.
49. Bhardwaj M, Mathur V, Sisodia SR, et al. Dexmedetomidine versus Fentanyl in intraoperative neuromuscular monitoring using a propofol-based. Turkish J Anaesthesiol Reanimation. 2024;52(5):180–7.
50. Li Y, Koomen VJ, Eleveld JD, et al. Population Pharmacokinetic modelling of norepinephrine in healthy volunteers prior to and during general anesthesia. Clin Pharmacokinet. 2024;63(11):1–12.
51. He QK, Huang TT, Tan YM, et al. Efficacy and safety of Ciprofol versus Propofol as anesthetic for patients undergoing painless colonoscopy. Pain Therapy. 2024;13(6):1–12.
52. Nair A, Seelam S. Ciprofol- a game changing intravenous anesthetic or another experimental drug. Saudi J Anaesth. 2022;16(2):258–9.

Publisher's note