Int J Clin Exp Med 2020;13(8):5673-5689
www.ijcem.com /ISSN:1940-5901/IJCEM0110648

Original Article

The role of acupuncture in cardiac anesthesia: a meta-analysis

Haiyan Wang[1], Xiaolan Xie[1], Gaofeng Zhao[1], Shuo Yang[2], Jinfeng Li[1]

[1]Department of Anesthesiology, Guangdong Provincial Hospital of Chinese Medicine, Guangzhou 510120, Guangdong, PR China; [2]Health Management Department of Traditional Chinese Medicine, Guangzhou 11th People's Hospital, Guangzhou 510000, Guangdong, PR China

Received March 10, 2020; Accepted May 4, 2020; Epub August 15, 2020; Published August 30, 2020

Abstract: Objective: To explore the role of acupuncture in cardiac anesthesia. Methods: We searched MeSH terms including "acupuncture", "electric acupuncture", "anesthesia", "heart surgery", "open chest surgery" in PubMed, CNKI, Wanfang Data, China Journal Net, Vipnet, Longyuan Journal Net and Springer Database. Randomized clinical trials regarding comparison between acupuncture-assisted anesthesia (AAA) and general anesthesia (GA) from January 1979 to January 2020 were obtained. The data quality of the enrolled studies was evaluated following Cochrane handbook with Review Manager 5.1.0 as the analysis tool. Results: Nine randomized, controlled studies were included. AAA was superior to GA in the following outcomes: elevated SpO_2 ($Z = 17.13$, $P < 0.00001$), longer length of stay in resuscitation room ($Z = 80.81$, $P < 0.0001$), higher mean arterial pressure ($Z = 18.26$, $P < 0.0001$) and Prince-Henry scores ($Z = 40.23$, $P < 0.0001$), reduced consumption of inhalation anesthetics ($Z = 94.34$, $P < 0.0001$) and intravenous anesthesia ($Z = 130.86$, $P < 0.0001$), lower postoperative VAS score ($Z = 39.15$, $P < 0.0001$), incidence of low blood pressure ($Z = 3.31$, $P = 0.0009$), postoperative nausea and vomiting ($Z = 4.49$, $P < 0.0001$), chills ($Z = 3.31$, $P = 0.0009$) and dysphoria ($Z = 3.44$, $P = 0.006$), and shortened extubation time in patients undergoing thoracotomy ($Z = 66.87$, $P < 0.0001$). Conclusion: Meta-analysis shows that AAA has beneficial clinical effects in open heart surgery. It can improve respiratory and circulatory functions, reduce the consumption of anesthetic drugs, extubation time, recovery time, pain intensity and adverse reactions in the early stage of anesthesia, which is suitable for thoracotomy.

Keywords: Acupuncture, anesthesia, cardiac surgery, thoracotomy, clinical effect

Introduction

The history of cardiac surgery dates back to 1950s, and nowadays the number of heart surgeries performed worldwide has almost doubled every year [1]. Although minimally invasive cardiac surgery has been preferred by many cardiac surgeons, the traditional open-chest surgery with cardiopulmonary bypass is still the dominant strategy for treating heart diseases [2]. New technology has greatly improved the safety of open-heart surgery and decreased its mortality [3]. Since China's population is aging fast, the number of elderly patients undergoing open heart surgery continues to increase [4]. The elderly usually experience decreased reserve capacity, which greatly affects circulatory function and their ability to recover from surgical trauma [5]. The Stability of hemodynamics during the operation and the body's stress response during and after the operation should be concerns of anesthetists.

Acupuncture is the practice of TCM in preventing and treating diseases, which gives birth to the acupuncture-assisted anesthesia (AAA) [6]. AAA is a model of integrated Chinese-Western Medicine [7] and is funded by National Basic Research Program of China (973 Program).

In July 2006, a team led by Zhou Jia, who is the chief physician of the Cardiothoracic Surgery Department at Shu Guang Hospital which is affiliated with the Shanghai University of Traditional Chinese Medicine, began research on acupuncture-assisted heart surgery, and creatively changed the state of patients undergoing heart surgery from "awake" to "light sleep

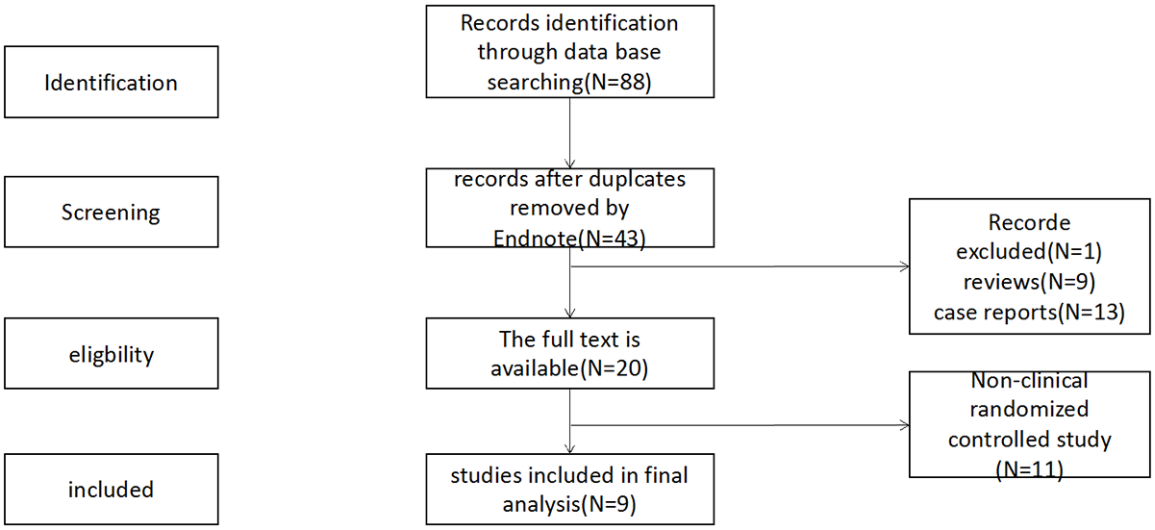

Figure 1. After a comprehensive search of the database, a total of 88 articles were obtained. EndNote software was used to check for duplicates and got 43 articles. By reading the title of the literature, 20 articles were obtained. By carefully studying the full text of the literature, 9 eligible studies were finally included.

and spontaneous breathing". This anesthesia method is applicable to many diseases and surgical indications, thereby reducing the consumption of anesthetics during surgery, incidence of postoperative complications, and postoperative recovery time [8]. Acupuncture-assisted anesthesia has been performed for decades. While it overcomes the shortcomings of traditional analgesia during surgery, it also shows a benign adjustment process that is difficult to be realized with anesthetic drugs, providing a new idea for anesthesia in cardiac surgery.

Regarding the possible mechanism for acupuncture anesthesia, a large number of studies centered on (electroacupuncture) acupuncture as well as biological media and transmitters were performed in the late 1970s and early 1980s [6, 7]. Studies have found that low frequency transcutaneous electrical nerve stimulation (TENS) (2 Hz) can increase the release of β-endorphin and methionine and enkephalin in the brain and midbrain, and induce analgesia by binding to related receptors. High frequency (100 Hz) stimulation can increase the release of endorphins in the spinal cord [9]. Therefore, both frequencies could result in analgesia mediated by opioid receptors. In addition, related studies have found that acupuncture can promote the release of adrenal and enkephalin into the blood from the pituitary gland. In addition to opioid peptides, varying signaling molecules also participate in acupuncture analgesia. After performing acupuncture, the peripheral spinal nucleus and gray matter of the catheter are stimulated, thereby promoting the release of norepinephrine and 5-HT. Both norepinephrine and 5-HT can inhibit the signal transduction of the spinothalamic tract and prevent pain sensation from being transmitted in synaptic spaces [5].

The purpose of a systematic review is to perform a meta-analysis to evaluate the clinical efficacy of acupuncture-assisted anesthesia in patients undergoing open heart surgery.

Materials and methods

This study strictly followed the PRISMA guidelines

This study looked at Mesh terms including thoracic surgery, acupuncture, acupuncture therapy, and cardiac surgical procedures in PubMed, CNKI, Wanfang Data, China Journal Net, Vipnet, Longyuan Journal Net and Springer databases. The included studies are all human-related analysis.

Inclusion criteria [1]: Published randomized controlled trials (RCTs) with eligible odds ratios, 95% confidence intervals calculated from large sample size, irrespective of publication language, were enrolled. They all involv-

Table 1. General information

study		Bai Dan 2019	Xu Meiying 2019	Yu Huijie 2016	Jia Zhou 2011	Yang Xiaochu 2018	Zhou Qi 2018	Liu Liu 2015	*Li Shuopeng 2013*	Li Xiaotao 2015
study period		2018-2019	2016-2019	2014-2016	2009-2011	2015-2017	2013-2018	2013-2014	*2011-2012*	2014-2015
country		China	China	China	China	China	China	China	*China*	China
		single centered	single centered	single centered	single centered	single centered	single centered	single centered	*single centered*	single centered
Study design		Retrospective cohort study	Retrospective cohort study	Retrospective cohort study	Retrospective cohort study	Retrospective cohort study	Retrospective cohort study	Retrospective cohort study	*Retrospective cohort study*	Retrospective cohort study
case		78	135	106	83	221	301	42	*35*	50
control		76	135	107	80	226	314	40	*34*	50
SpO_2 (%)	case	99.5±4.5	99.6±2.5	99.5±0.4	0.68±0.21	0.86±0.31	0.60±0.26	99.7±1.3	*99.3±1.6*	0.91±0.36
	control	98.1±3.5	99+2.2	98.7±0.3	0.74±0.28	0.79±0.21	0.74±0.48	99±1.4	*98.2±1.5*	0.64±0.42
MAP (mmHg)	case	88.21±3.2	88.74±2.9	/	86.47±4.5	/	85.98±3.5	/	*87.95±2.3*	/
	control	85.2±3.5	85.98±2.5	/	81.89±5.5	/	82.45±3.2	/	*83.27±3.8*	/
Extubation time (min)	case	36.1±1.7	36.8±1.8	36.6±2.4	35.3±1.5	37.6±1.9	37.8±2.2	42.6±1.2	*33.8*±2.3	38.3±1.3
	control	43.2±2.1	41.7±1.5	39.9±1.3	40.5±1.3	41.4±2.2	44.7±1.9	45.6±1.7	*40.9*±1.5	45.8±1.8
Resuscitation time (min)	case	70.2±3.2	77.6±2.9	69.1±2.7	68.8±2.5	70.8±1.5	69.7±3.1	71.3±3.1	*73.6*±1.8	75.8±2.9
	control	82.5±3.5	86.5±4.2	79.5±3.2	76.5±2.3	78.8±1.8	78.3±2.8	80.5±3.6	*82.9*±2.6	84.6±2.6
Prince-Henry score	case	3.21±0.31	3.02±0.25	/	3.05±0.21	3.36±0.33	/	2.98±0.17	/	3.12±0.16
	control	1.53±0.41	1.62±0.38	/	1.49±0.19	1.77±0.41	/	1.45±0.23	/	1.7±0.25
Steward score	case	5.3±0.21	4.42±0.25	/	/	5.32±0.29	/	5.1±0.5	*4.5*±0.32	/
	control	3.1±0.11	2.95±0.29	/	/	3.21±0.22	/	3.12±0.23	*2.8*±0.18	/
Inhalation anesthetic μg/(kg·h)	case	0.25±0.01	0.26±0.02	0.27±0.06	0.32±0.05	0.3±0.08	0.3±0.03	0.34±0.05	*0.28*±0.03	0.26±0.03
	control	0.39±0.03	0.4±0.03	0.39±0.06	0.39±0.08	0.42±0.05	0.48±0.07	0.42±0.07	*0.39*±0.04	0.43±0.03
Intravenous anesthetic μg/(kg·h)	case	11.1±2.3	13.5±2.8	12.6±1.9	11.5±2.1	14.6±2.9	11.3±1.8	10.9±2.6	*10.8*±1.5	10.6±1.9
	control	15.3±2.4	16.9±3.1	16.2±2.1	16.4±2.6	17.8±2.4	15.6±2.6	15.1±2.2	*14.6*±1.9	14.6±1.8
Hypotension (cases)	case	2	/	4	4	5	8	1	*1*	/
	control	5	/	7	9	12	17	2	*3*	/
Feelsick and vomit (cases)	case	/	3	/	/	6	/	1	1	/
	control	/	12	/	/	20	/	8	7	/
Chill (cases)	case	1	2	1	/	/	3	/	*0*	1
	control	3	6	5	/	/	13	/	*1*	2
Restlessness (cases)	case	1	/	2	2	/	/	1	/	0
	control	5	/	9	7	/	/	3	/	3

Table 2. Quality evaluation of 9 studies and evaluations

Study	Random sequence generation	Distribution of hidden	Blinded for the object of study or intervention	Blinded for the outcome measure	Incomplete data report	Select the report	Other sources of bias	The quality of evidence
Bai Dan 2019	High	High	High	Low	Low	Low	Low	A
Xu Meiying 2019	Low	Low	High	Low	Low	Low	Low	B
Yu Huijie 2016	High	High	High	Low	Low	Low	Low	A
Jia Zhou 2011	High	High	High	Low	Low	Low	Low	A
Yang Xiaochu 2018	High	High	High	Low	Low	Low	Low	A
Zhou Qi 2018	High	High	Low	Low	Low	Low	Low	B
Liu Liu 2015	High	Low	High	Low	Low	Low	Low	B
Li Shuopeng 2013	High	High	High	Low	Low	Low	Low	A
Li Xiaotao 2015	High	Low	High	Low	Low	Low	Low	B

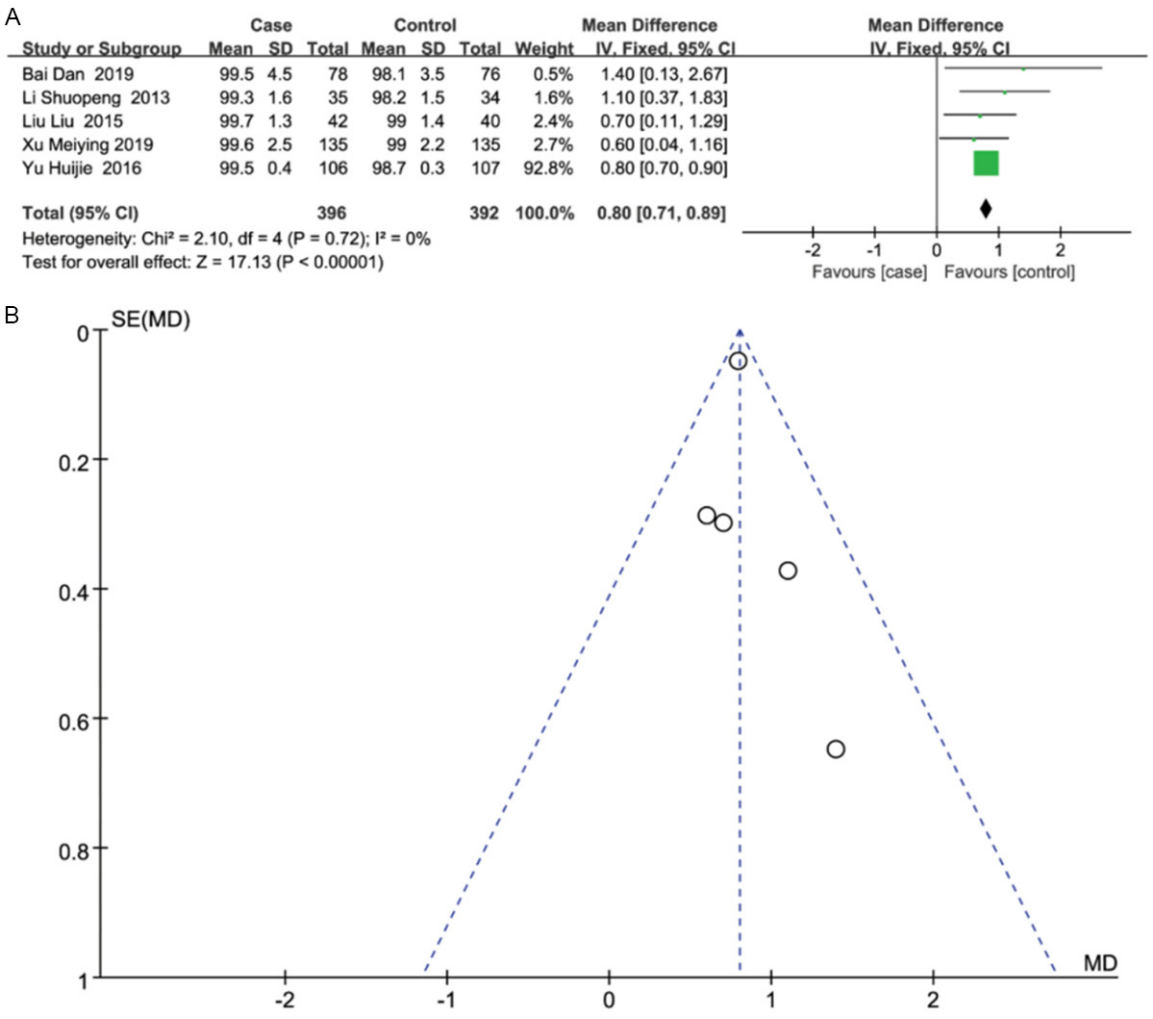

Figure 2. A. Effect of acupuncture-assisted anesthesia on SpO_2 in patients undergoing open heart surgery (Forest plot). B. Effect of acupuncture-assisted anesthesia on SpO_2 in patients undergoing open heart surgery (Funnel plot).

ed open heart surgery under acupuncture combined with standard anesthetics.

Exclusion criteria [1]: Animal studies, studies with low level of evidence, studies without acu-

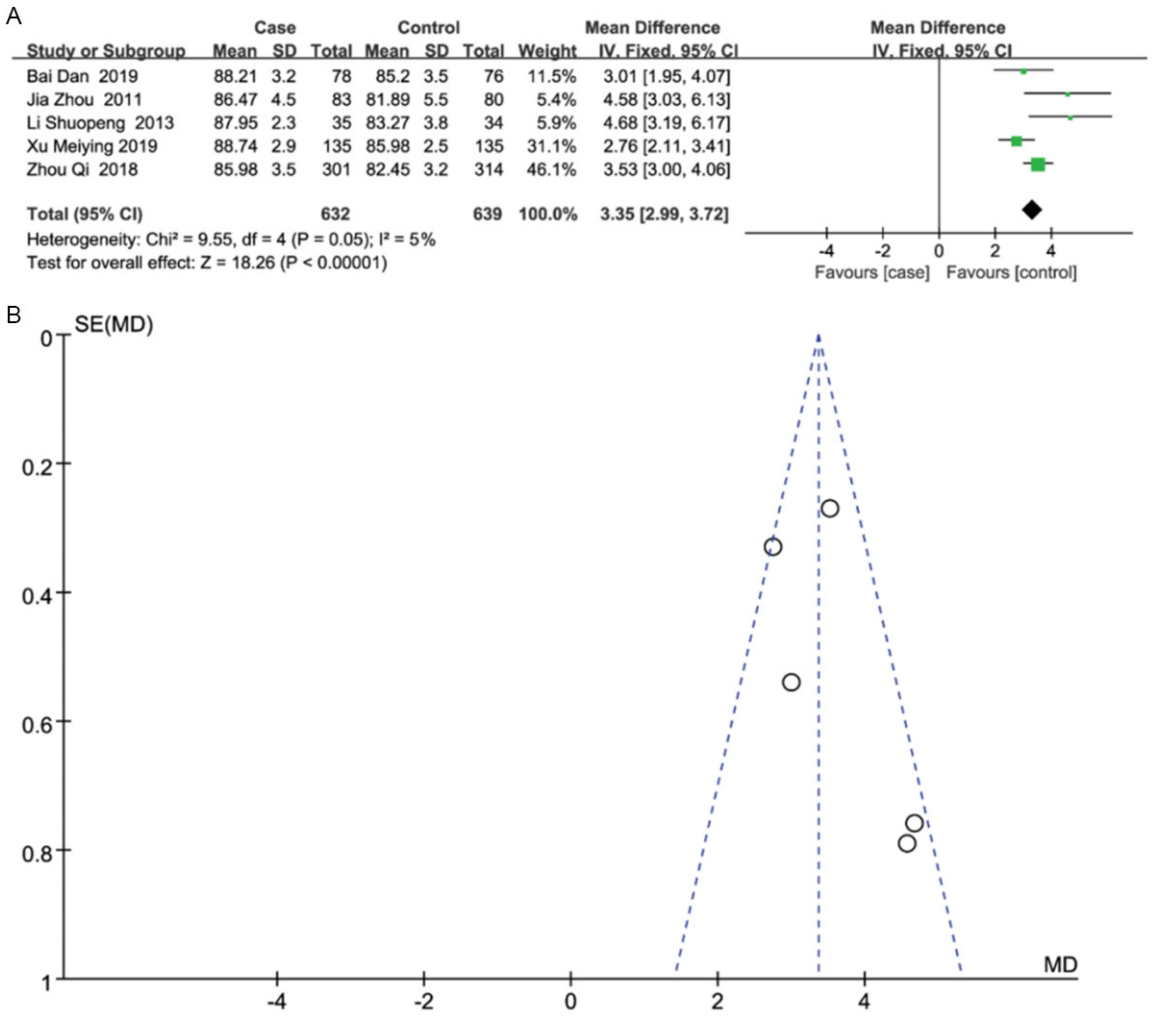

Figure 3. A. Effect of acupuncture-assisted anesthesia on mean arterial pressure in patients undergoing open heart surgery (Forest plot). B. Effect of acupuncture-assisted anesthesia on mean arterial pressure in patients undergoing open heart surgery (Funnel plot).

puncture and general anesthesia during surgery; studies with non-thoracotomy cardiac surgery.

Treatment methods

Experimental group: acupuncture-assisted general anesthesia for open-heart surgery.

Control group: open heart surgery under general anesthesia.

Outcome measurement

Intraoperative arterial oxygen pressure (SpO_2), intraoperative mean arterial pressure (MAP), extubation time, length of stay in resuscitation room, Prince-Henry score, Stewand score, consumption of inhaled anesthetics, and adverse reactions (low blood pressure, nausea, vomiting, chills, dysphoria).

Literature screening and data extraction

Two researchers independently screened the database strictly in accordance with the inclusion and exclusion criteria, and excluded articles that clearly did not meet the requirements. They carefully read all the selected literature and cross-checked the results of them. A third researcher was invited to discussion if there was a wide gap between the opinions of two reserchers.

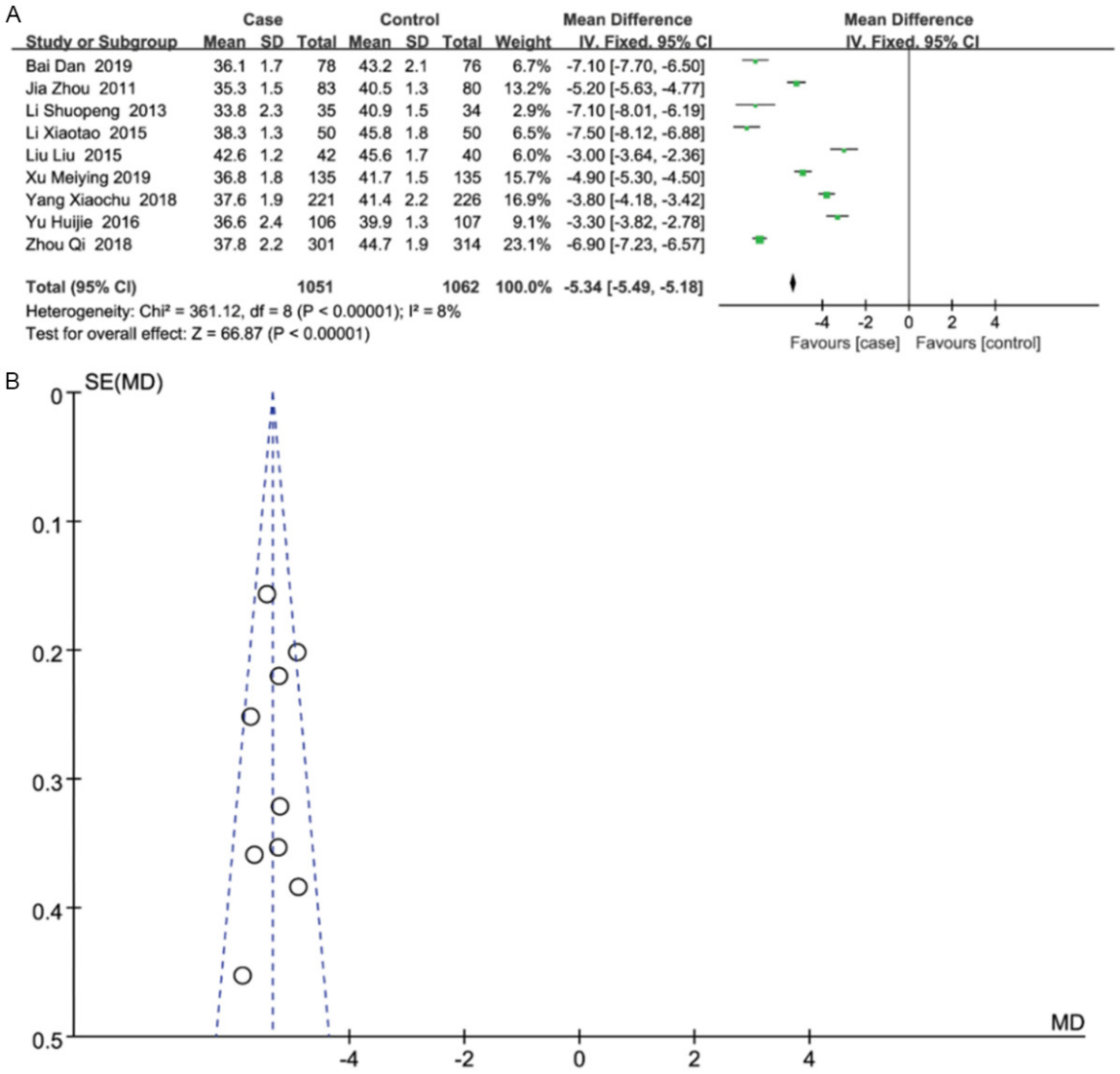

Figure 4. A. Effect of acupuncture-assisted anesthesia on extubation time in patients undergoing open heart surgery (Forest plot). B. Effect of acupuncture-assisted anesthesia on extubation time in patients undergoing open heart surgery (Funnel plot).

Data of included studies were extracted into a pre-made unified form which included: (1) general information: title, first author, and publication time; (2) subjects: sample size; (3) patient-related outcome measures.

Data quality evaluation

With Review Manager 5.1.0, the quality of ultimately included studies was assessed. Specifically, the following seven evaluation standards were included: (1) random sequence generation; (2) allocation concealment; (3) double-blind procedures for participants and experimenters; (4) blind evaluation; (5) result data integrity; (6) choice reports; (7) other sources of bias. SIGN checklist (http://www.sign.ac.uk/methodology/checklists.html) was adopted to summarize risk of bias for each study: bias judgments are expressed as “low risk”, “high risk”, or “risk is unclear”. All discrepancies are resolved by consensus. “A” means compliance with all or most of the quality standards; “B” means compliance with partial standards; “C” means little or no compliance.

“A”: study is rated as “high quality” and “B”: study is rated as “medium quality”.

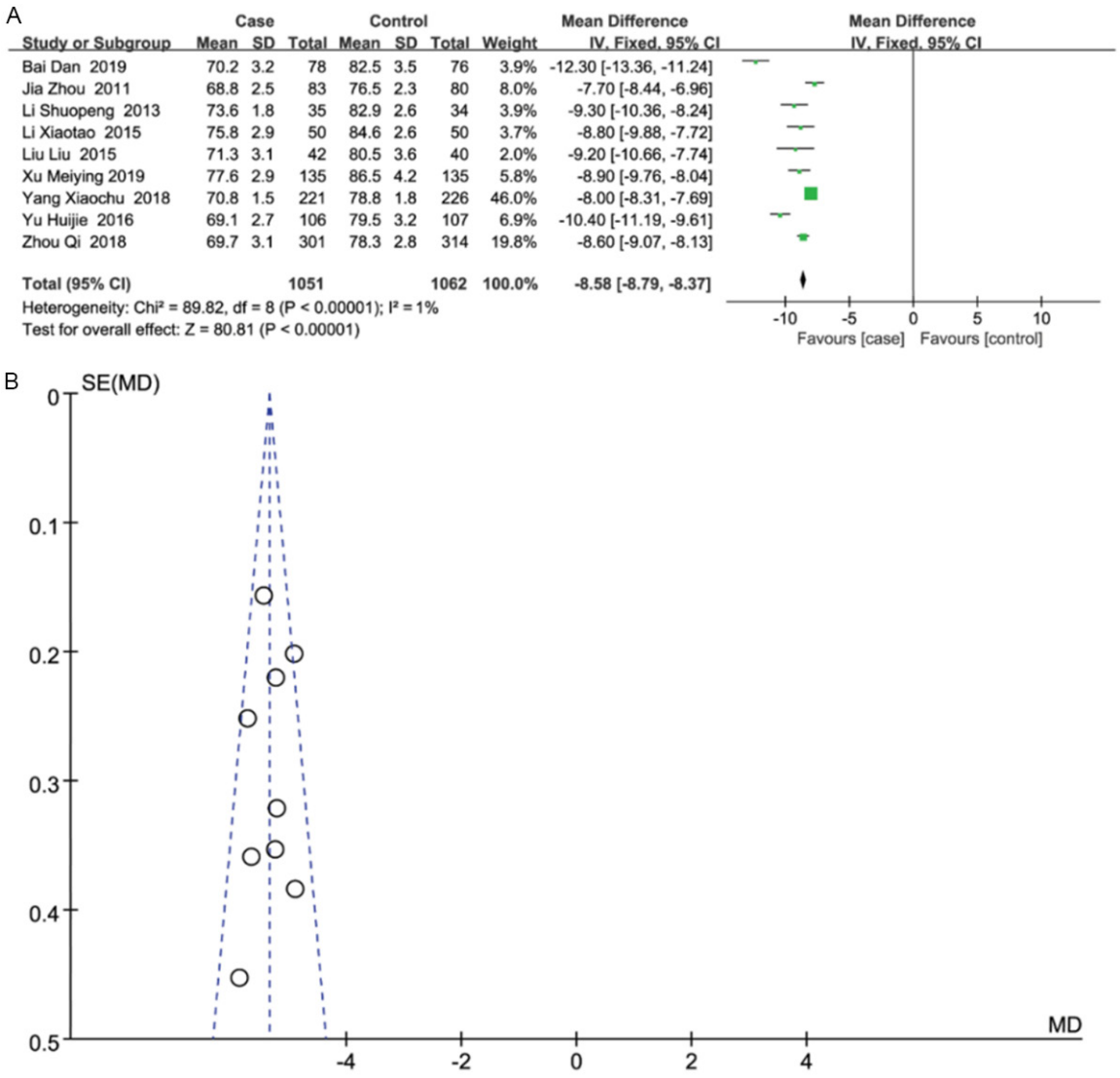

Figure 5. A. Effect of acupuncture-assisted anesthesia on length of stay in resuscitation room in patients undergoing open heart surgery (Forest plot). B. Effect of acupuncture-assisted anesthesia on dwell time of resuscitation room in patients undergoing open heart surgery (Funnel plot).

Statistical methods

All data were analyzed using Review Manager version 5.1.0, and $P < 0.05$ represented significant difference. Aggregate effects are estimated using the standardized mean of difference (SMD) and the 95% confidence interval (95% CI). Risk ratio (RR) and 95% CI were used for dichotomous variables. By excluding low-quality studies, and using different statistical methods/models to analyze the same data, etc., we observed the changes in the merger indicators (such as OR, RR). If excluding a certain document has a significant impact on the merged RR, the document is considered to have a combined sensitivity, otherwise it has no sensitivity. In the process of literature inclusion, we excluded certain low-quality studies and then analyzed them. Therefore, the quality of the finally included articles was relatively high, and the included articles were not excluded in the sensitivity analysis. Heterogeneity was assessed by χ^2 and I^2. Non-significant heterogeneity test was performed with a fixed effect model ($I^2 > 50\%$, $P < 0.1$). The random effects model (SMD/RR) was used to calculate heterogeneous data ($I^2 < 50\%$, $P < 0.1$). The publication bias was visually assessed from funnel plots.

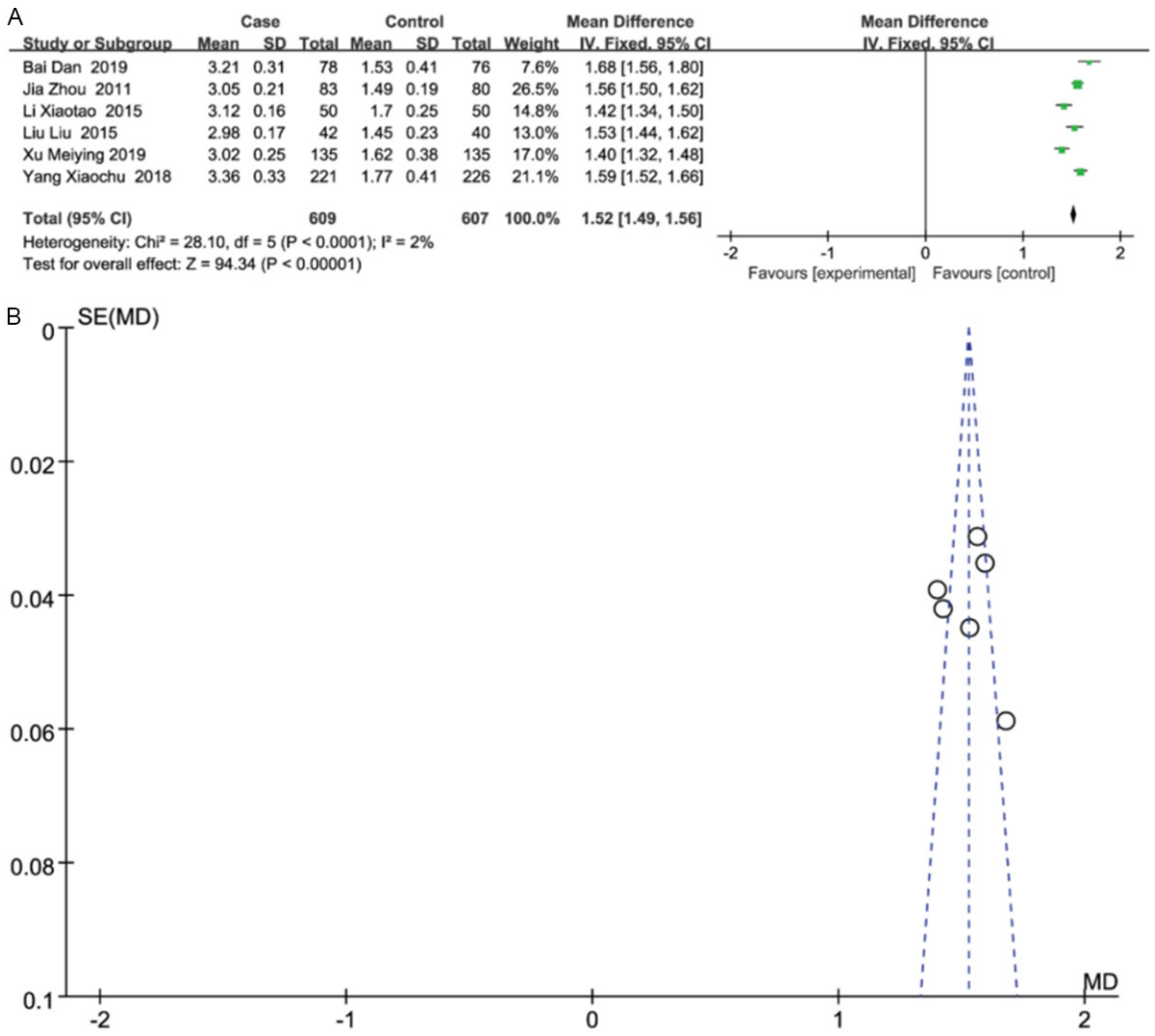

Figure 6. A. Effect of acupuncture-assisted anesthesia on plasma anesthetic in patients with thoracic heart surgery (Forest plot). B. Effect of acupuncture-assisted anesthesia on plasma anesthetic in patients with thoracic heart surgery (Funnel plot).

Results

A comprehensive search of the database yielded 88 studies. By running a duplicate check with EndNote, 43 studies were obtained. Among them, eligible studies (Bai Dan 2019 [10], Xu Meiying 2019 [11], Yu Huijie 2016 [12], Jia Zhou 2011 [13], Yang Xiaochu 2018 [14], Zhou Qi 2018 [15], Liu Liu 2015 [16], Li Shuopeng 2013 [17], Li Xiaotao 2015 [4]) were enrolled. The flow diagram (**Figure 1**) depicts the process of literature search. **Table 1** summarizes the characteristics of the nine randomized, controlled studies centered on 2113 patients undergoing open heart surgery.

Quality review

According to methods outlined in Cochrane's handbook, risks of bias in studies were evaluated. The results showed that most studies presented with clear design methods, but rarely reported allocation concealment method; some studies provided detailed blind designs. According to the quality criteria, 5 and 4 manuscripts were rated as A and B, respectively (**Table 2**).

Effect of AAA on SpO_2 in patients undergoing open heart surgery

Studies by Bai Dan 2019 [10], Xu Meiying 2019 [11], Yu Huijie 2016 [12], Liu Liu 2015 [16],

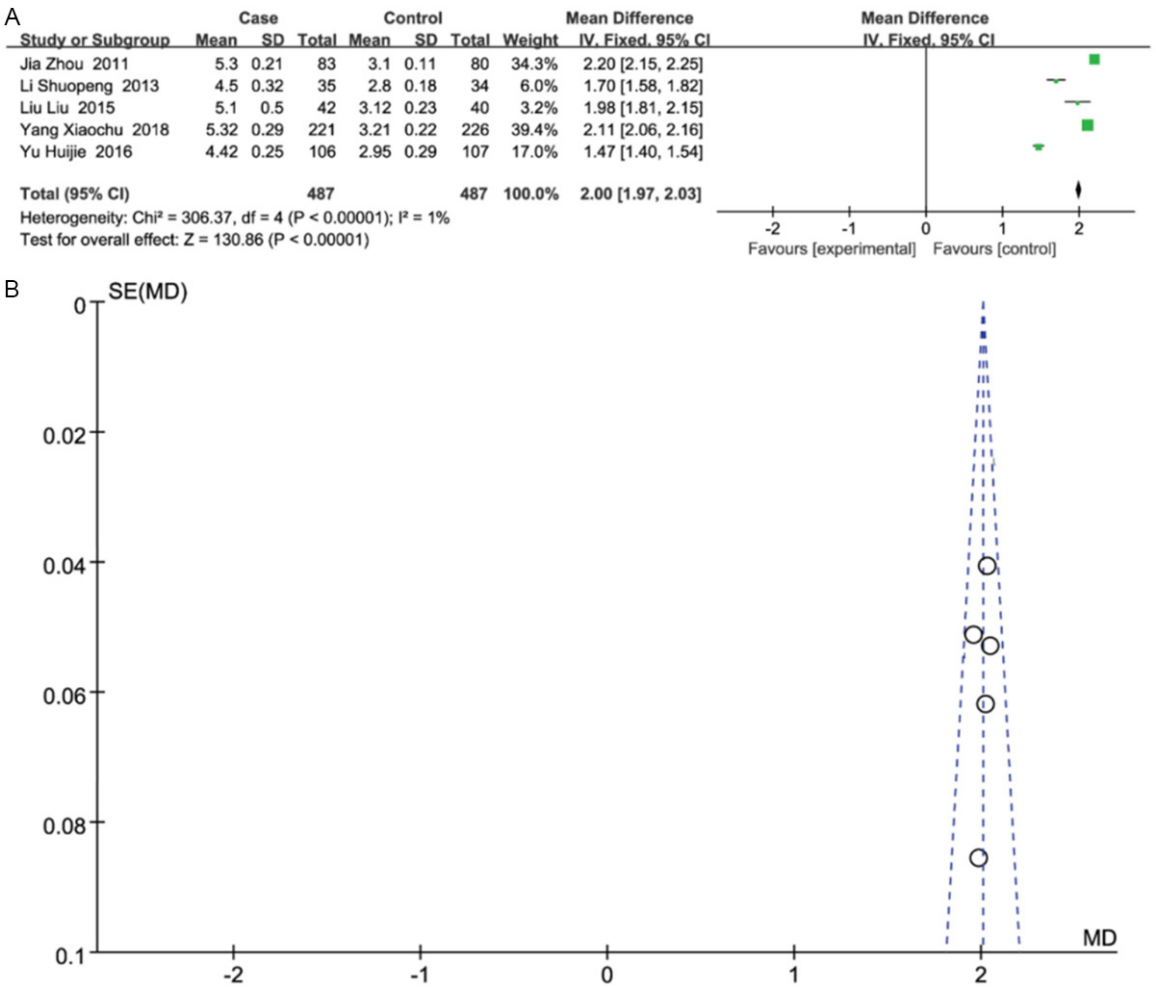

Figure 7. A. Effect of acupuncture-assisted anesthesia on the amount of intravenous anesthesia in patients undergoing open heart surgery (Forest plot). B. Effect of acupuncture-assisted anesthesia on the amount of intravenous anesthesia in patients undergoing open heart surgery (Funnel plot).

and Li Shuopeng 2013 [17] showed that AAA can significantly increase the SpO_2 in patients undergoing open-heart cardiac surgery (chi-squared = 2.10, P < 0.00001, I^2 = 0%, 95% CI), indicating that AAA resulted in higher SpO_2 (Z = 17.13, P < 0.00001) (**Figure 2**).

Effect of AAA on MAP in patients undergoing open heart surgery

According to Bai Dan 2019 [10], Xu Meiying 2019 [11], Jia Zhou 2011 [13], Zhou Qi 2018 [15], and Li Shuopeng 2013 [17], AAA could increase the MAP in patients undergoing open-heart surgery (chi-squared = 9.55, P = 0.05, I^2 = 5%, 95% CI). The results showed that patients received AAA experienced a higher MAP (Z = 18.26, P < 0.0001) (**Figure 3**).

Effect of AAA on extubation time in patients undergoing open heart surgery

In studies of Bai Dan 2019 [10], Xu Meiying 2019 [11], Yu Huijie 2016 [12], Jia Zhou 2011 [13], Yang Xiaochu 2018 [14], Zhou Qi 2018 [15], Liu Liu 2015 [16], Li Shuopeng 2013 [17] and Li Xiaotao 2015 [4], researchers have found that AAA could shorten the extubation time (chi-squared = 361.12, P < 0.00001, I^2 = 8%, 95% CI). The results showed that AAA led to a shorter extubation time than GA (Z = 66.87, P < 0.0001) (**Figure 4**).

Effect of AAA on length of stay in resuscitation room in patients undergoing open heart surgery

On the basis of the studies by Bai Dan 2019 [10], Xu Meiying 2019 [11], Yu Huijie 2016 [12],

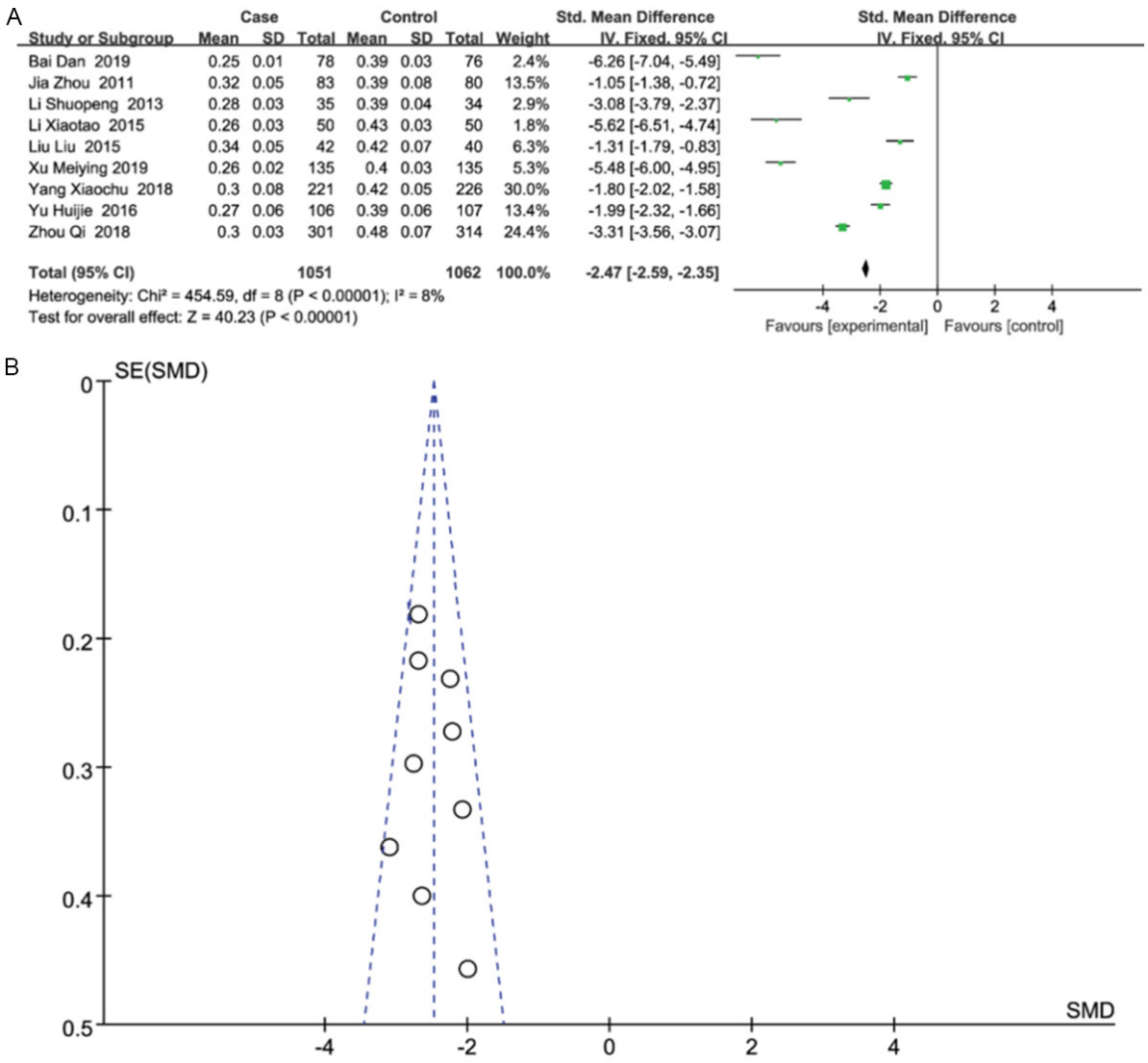

Figure 8. A. Effect of acupuncture-assisted anesthesia on Prince-Henry score in patients undergoing open heart surgery (Forest plot). B. Effect of acupuncture-assisted anesthesia on Prince-Henry score in patients undergoing open heart surgery (Funnel plot).

Jia Zhou 2011 [13], Yang Xiaochu 2018 [14], Zhou Qi 2018 [15], Liu Liu 2015 [16], Li Shuopeng 2013 [17] and Li Xiaotao 2015 [4], we found that AAA can shorten the length of stay in resuscitation room in patients undergoing open-heart surgery (chi-squared = 89.82, P < 0.00001, I^2 = 1%, 95% CI). Compared with GA, AAA resulted in a shorter length of stay in resuscitation room (Z = 80.81, P < 0.0001) (**Figure 5**).

Effect of AAA on the consumption of inhalation anesthetics in patients undergoing open heart surgery

Studies by Bai Dan 2019 [10], Xu Meiying 2019 [11], Jia Zhou 2011 [13], Yang Xiaochu 2018 [14], Liu Liu 2015 [16], and Li Xiaotao 2015 [4] showed that AAA reduced the consumption of inhalation anesthetics in comparison of GA (chi-squared = 28.10, P < 0.00001, I^2 = 2%, 95% CI; Z = 94.34, P < 0.0001) (**Figure 6**).

Effect of AAA on the amount of intravenous anesthesia in patients undergoing open heart surgery

According to Yu Huijie 2016 [12], Jia Zhou 2011 [13], Yang Xiaochu 2018 [14], Liu Liu 2015 [16], and Li Shuopeng 2013 [17], AAA can reduce the amount of intravenous anesthesia in patients undergoing open heart surgery compared with GA (chi-squared = 306.37, P <

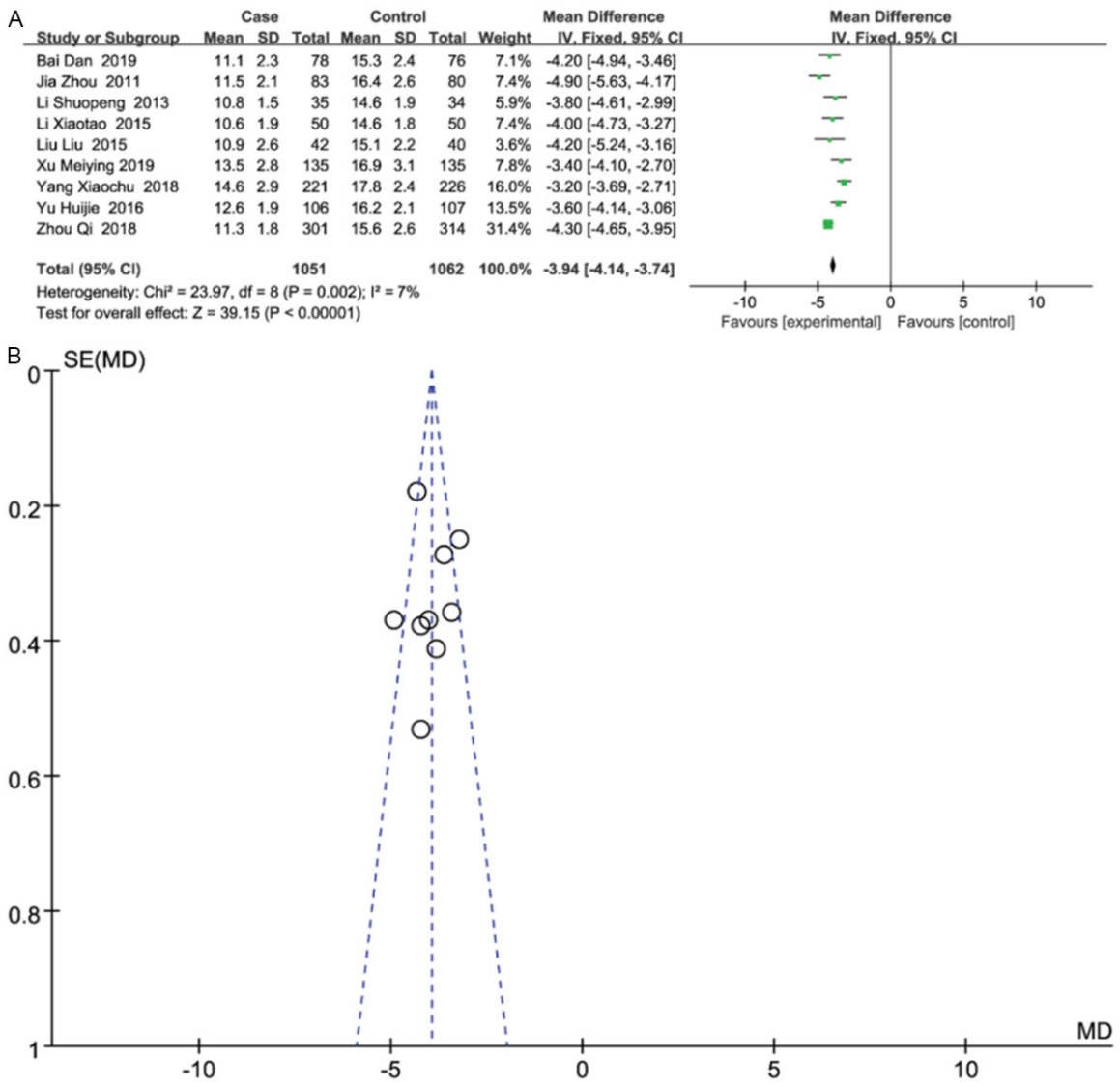

Figure 9. A. Effect of acupuncture-assisted anesthesia on postoperative VAS scores of patients undergoing open heart surgery (Forest plot). B. Effect of acupuncture-assisted anesthesia on postoperative VAS scores of patients undergoing open heart surgery (Funnel plot).

0.00001, I^2 = 1%, 95% CI; Z = 130.86, P < 0.0001) (**Figure 7**).

Effect of acupuncture-assisted anesthesia on Prince-Henry score after open heart surgery

Studies by Bai Dan 2019 [10], Xu Meiying 2019 [11], Yu Huijie 2016 [12], Jia Zhou 2011 [13], Yang Xiaochu 2018 [14], Zhou Qi 2018 [15], Liu Liu 2015 [16], Li Shuopeng 2013 [17] and Li Xiaotao 2015 [4] found that AAA could lead to higher post-treatment Prince-Henry score than GA (chi-squared = 454.59, P < 0.00001, I^2 = 8%, 95% CI; Z = 40.23, P < 0.0001) (**Figure 8**).

Effect of AAA on postoperative VAS scores of patients undergoing open heart surgery

Studies by Bai Dan 2019 [10], Xu Meiying 2019 [11], Yu Huijie 2016 [12], Jia Zhou 2011 [13], Yang Xiaochu 2018 [14], Zhou Qi 2018 [15], Liu Liu 2015 [16], Li Shuopeng 2013 [17] and Li Xiaotao 2015 [4] showed that AAA reduced the VAS score more than GA, effectively reliving the pain (chi-squared = 23.97, P = 0.002,

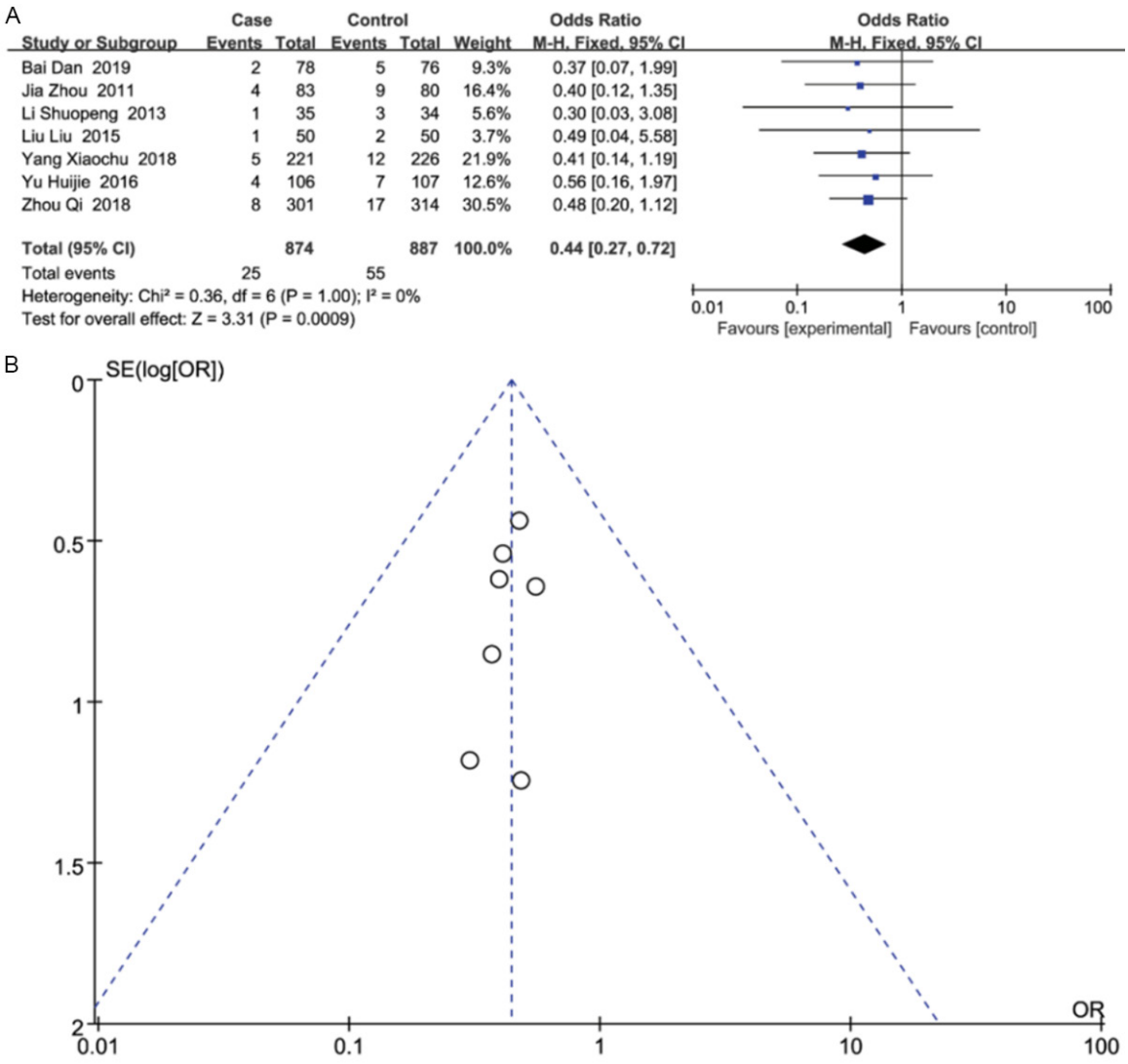

Figure 10. A. Effect of acupuncture-assisted anesthesia on postoperative hypotension in patients undergoing open heart surgery (Forest plot). B. Effect of acupuncture-assisted anesthesia on postoperative hypotension in patients undergoing open heart surgery (Funnel plot).

I^2 = 17%, 95% CI; Z = 39.15, P < 0.0001) (**Figure 9**).

Effect of AAA on postoperative blood pressure in patients undergoing open heart surgery

Accoridng to Bai Dan 2019 [10], Yu Huijie 2016 [12], Jia Zhou 2011 [13], Yang Xiaochu 2018 [14], Zhou Qi 2018 [15], Liu Liu 2015 [16], and Li Shuopeng 2013 [17], patients receiving AAA had a lower incidence of hypotension than GA (chi-squared = 0.36, P = 1, I^2 = 0%, 95% CI; Z = 3.31, P = 0.0009) (**Figure 10**).

Effect of AAA on the incidence of postoperative nausea and vomiting in patients undergoing open heart surgery

Studies by Xu Meiying 2019 [11], Yang Xiaochu 2018 [14], Liu Liu 2015 [16] and Li Shuopeng 2013 [17] found that compared with GA, AAA exhibited lower incidence of postoperative nausea and vomiting (chi-squared = 1.14, P = 0.77, I^2 = 0%, 95% CI; Z = 4.49, P < 0.0001) (**Figure 11**).

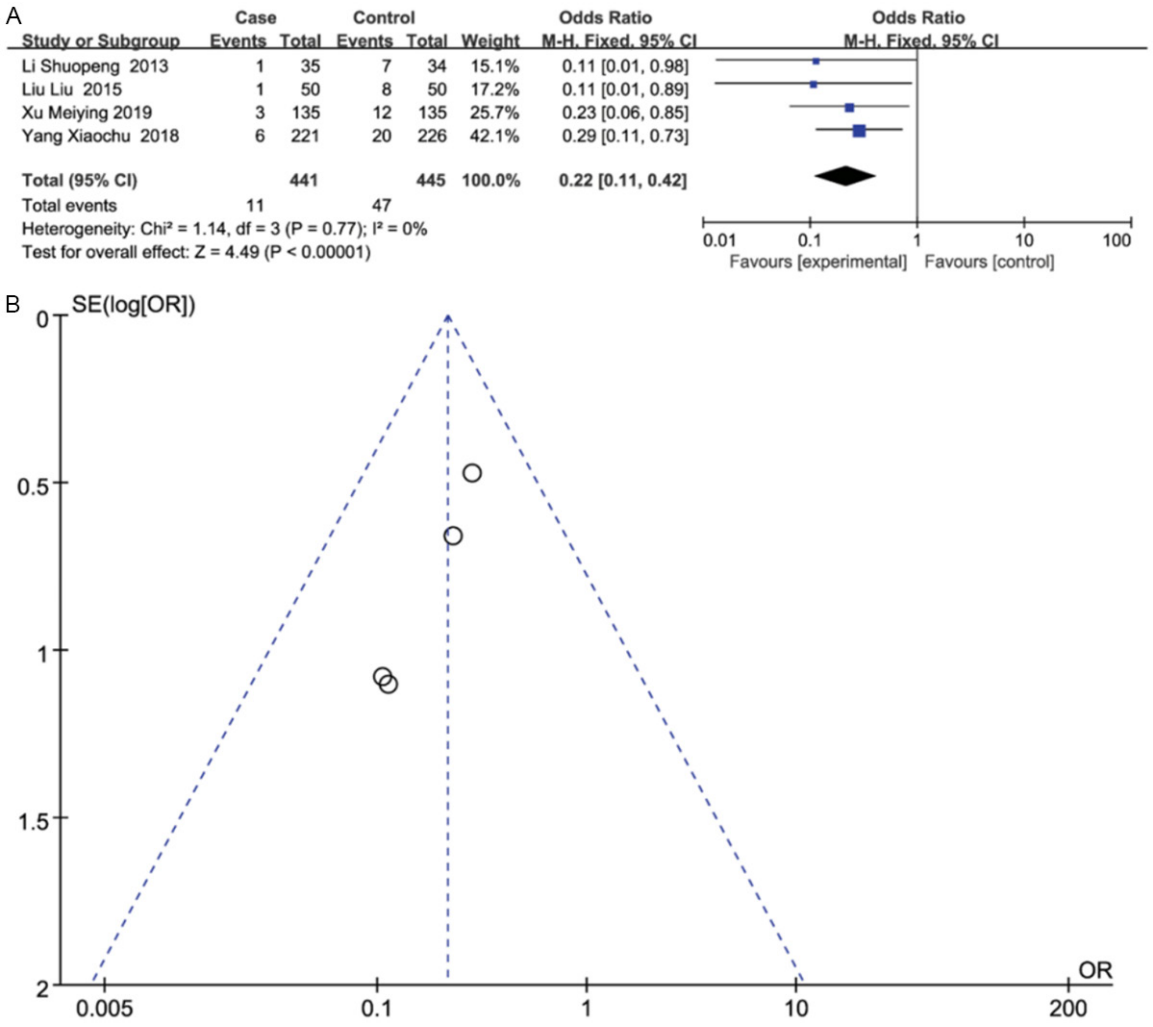

Figure 11. A. Effect of acupuncture-assisted anesthesia on the incidence of postoperative nausea and vomiting in patients undergoing open heart surgery (Forest plot). B. Effect of acupuncture-assisted anesthesia on the incidence of postoperative nausea and vomiting in patients undergoing open heart surgery (Funnel plot).

Effect of AAA on the incidence of postoperative chills in patients undergoing open heart surgery

In the literature of Bai Dan 2019 [10], Xu Meiying 2019 [11], Yu Huijie 2016 [12], Zhou Qi 2018 [15], Li Shuopeng 2013 [17], Li Xiaotao 2015 [4], researchers have found that AAA reduced the incidence of postoperative chills more than GA (chi-squared = 0.44, P = 0.99, I^2 = 0%, 95% CI; Z = 3.31, P = 0.0009) (**Figure 12**).

Effect of AAA on the incidence of postoperative dysphoria in patients undergoing open heart surgery

Researchers such as Bai Dan 2019 [10], Yu Huijie 2016 [12], Jia Zhou 2011 [13], Liu Liu 2015 [16], and Li Xiaotao 2015 [4] demonstrated that AAA showed less incidence of postoperative dysphoria than GA (chi-squared = 0.24, P = 0.99, I^2 = 11%, 95% CI; Z = 3.44, P = 0.006) (**Figure 13**).

Discussion

This study analyzed the benefits of acupuncture-assisted anesthesia in open-heart surgery with a meta-analysis of the literature. A total of 9 RCT studies involving 700 patients were included. Through meta-analysis, we found that compared with traditional intravenous anesthesia, acupuncture-assisted anesthesia can increase blood oxygen saturation and mean arterial pressure, reduce the use of volatile anesthetics, shorten extubation time and

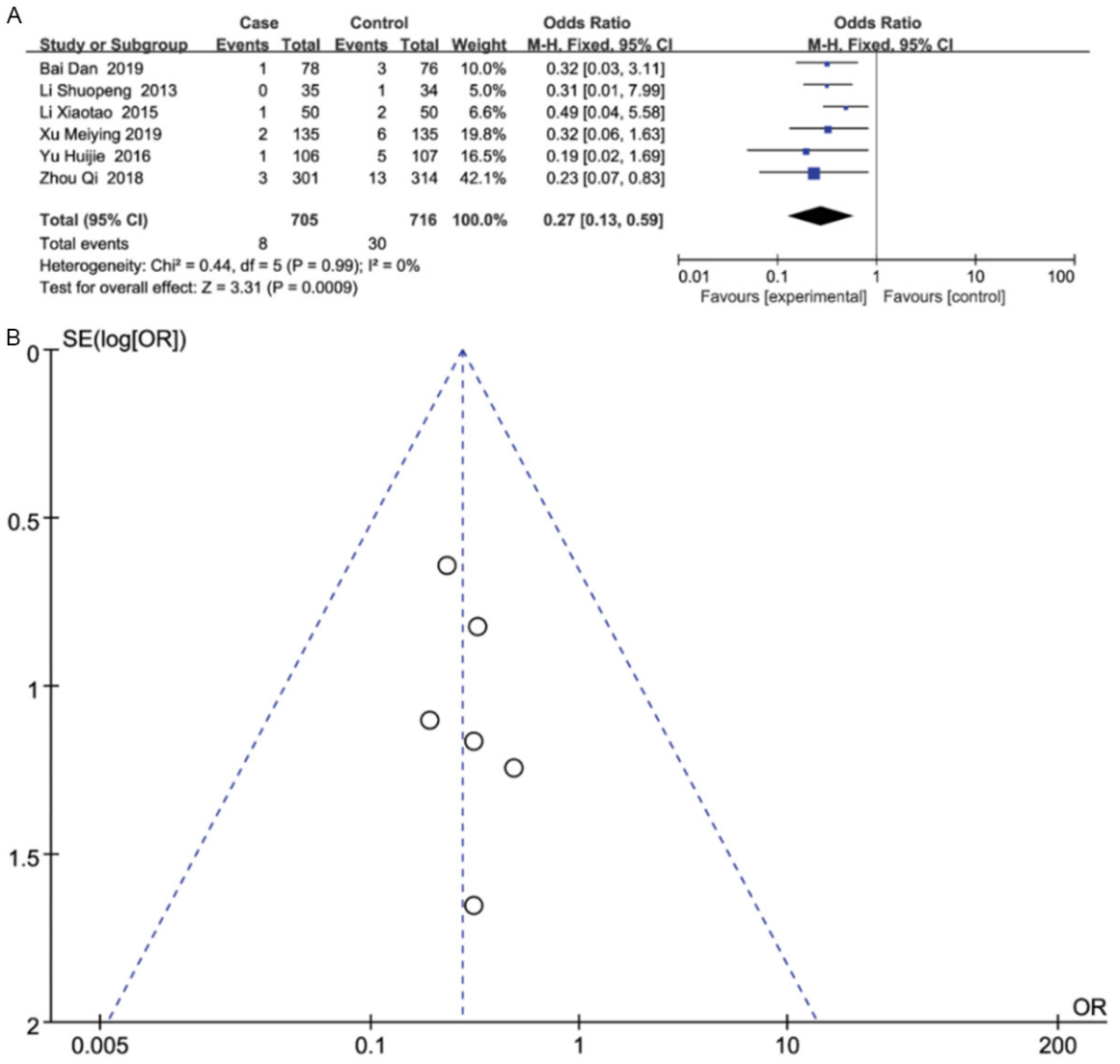

Figure 12. A. Effect of acupuncture-assisted anesthesia on the incidence of postoperative nausea and vomiting in patients undergoing open heart surgery (Forest plot). B. Effect of acupuncture-assisted anesthesia on the incidence of postoperative nausea and vomiting in patients undergoing open heart surgery (Funnel plot).

length of stay in resuscitation room, and reduce complications such as nausea and vomiting.

We can infer that acupuncture-assisted anesthesia has significant benefits for open heart surgery. In acupuncture-assisted anesthesia, blood oxygen saturation and mean arterial pressure of the patients were significantly higher than those of general anesthesia group. The case study conducted by Coura [2] and animal studies by Cassu [18] concluded that acupuncture-assisted anesthesia could improve patients' blood oxygen saturation and mean arterial pressure [13], which are consistent with the results of this study. The acupoints selected in the literature are mainly bilateral Neiguan, Hegu, Quchi, etc. In Chinese medicine, Neiguan could improve cardiothoracic symptoms such as heartache, chest tightness, palpitations, chest pain, etc. Hegu shows the effects of promoting blood circulation, and relieving pain and exterior syndrome while Quchi has the functions of clearing the heat and relieving exterior syndrome, reducing swelling and pain, and rectifying qi and blood. Acupuncture treatment on the basis of these acupoints will improve the patient's breathing and circulation function under anesthesia.

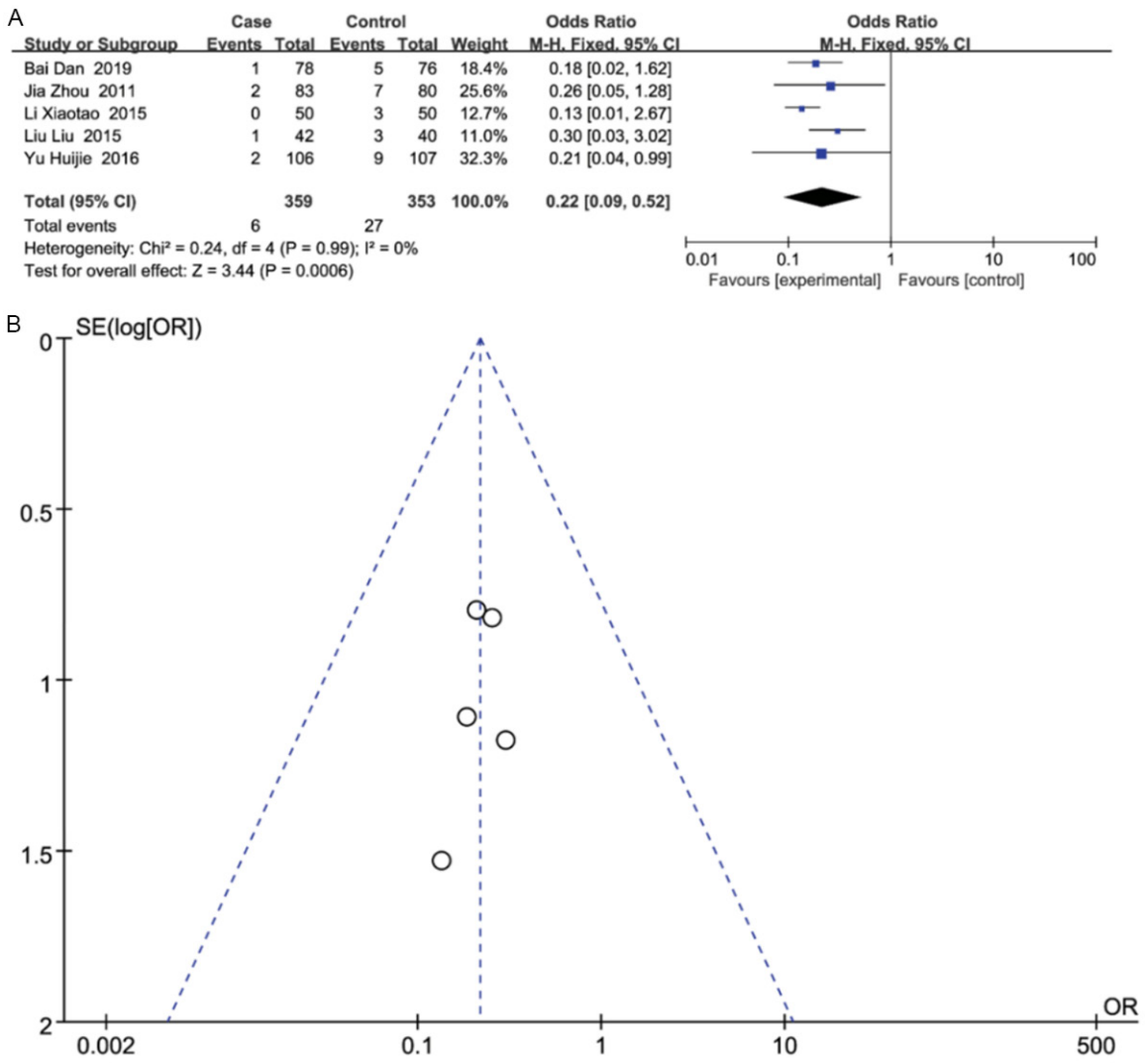

Figure 13. A. Effect of acupuncture-assisted anesthesia on the incidence of postoperative restlessness in patients undergoing open heart surgery (Forest plot). B. Effect of acupuncture-assisted anesthesia on the incidence of postoperative restlessness in patients undergoing open heart surgery (Funnel plot).

Shuopeng [17] proposed that acupuncture anesthesia can reduce the consumption of volatile anesthetics, and patients have early extubation, faster recovery time, and shorter stay in the operating room. Liu [16] further verified these results with a study that used acupuncture-assisted anesthesia in plastic surgery. Other studies also found that acupuncture-assisted intravenous anesthesia can shorten patients' extubation time and reduce the need for intravenous anesthesia. These results are consistent with the results of this meta-analysis. Therefore, we believe that acupuncture-assisted anesthesia can reduce the consumption of volatile anesthetics and intravenous anesthetics. AAA reduces the overall cost of surgical anesthesia by reducing the consumption of anesthetics. The result of a meta-analysis by Asmussen et al. [1] further supports these findings.

Han evaluated patients with postoperative Prince-Henry scores and Stewand scores and found that two groups of patients with AAA showed higher Prince-Henry and Stewand scores. Yang et al. also pointed out that patients with AAA scored less on visual analog scale and required less opioids [19]. Cassu et al. found in animal studies that electroacupuncture significantly reduced inflammatory pain,

neuropathic pain, cancerous pain, and visceral pain [18]. These results are consistent with this study, that is, acupuncture-assisted anesthesia can improve postoperative pain. Faircloth et al. [20] found that acupuncture can improve ischemia and reduce the expression of glutamate which is an excitatory mediator and has a potential toxic effect on cells. Wang et al. [21] found that acupuncture-assisted anesthesia can improve tissue oxygenation and protect myocardial tissue.

Adverse reactions such as nausea and vomiting, hypotension, and chills after anesthesia cause great pain for patients [22]. Our meta-analysis results show that AAA can reduce the incidence of postoperative adverse reactions. In a randomized controlled study by Wu et al., it was proved that AAA can reduce the incidence of adverse reactions such as nausea and vomiting in patients after surgery [23]. Cheng and Tang also believed that AAA can significantly reduce the incidence of postoperative anesthesia complications compared to GA [24, 25], which is consistent with the results of this meta-analysis. The reason may be that AAA reduces the consumption of anesthetic drugs during surgery, maintains good circulation function, accelerates the metabolism of postoperative drugs, and reduces the accumulation of anesthetic drugs.

Conclusion

Although the sample size and number of studies are relatively small, our study is based on literature of high-level evidence. This meta-analysis shows that patients who undergo open heart surgery with a trained acupuncturist have smoother breathing and circulation during the operation, reduced consumption of anesthetic drugs, faster recovery, and less adverse reactions. However, the included studies all fall within the area of Traditional Chinese medicine, and there may be regional differences. In addition, the included literature is mostly single-center experiment. It is necessary to conduct randomized, controlled, multicenter trials to better understand its underlying mechanism, and further elucidate the protective effect of acupuncture on myocardial tissue as well as its economic potential in reducing the consumption of anesthetic drugs.

Acknowledgements

This work was supported by Project of Guangdong Province Traditional Chinese Medicine Bureau (No. 20171128).

Disclosure of conflict of interest

None.

Address correspondence to: Jinfeng Li, Department of Anesthesiology, Guangdong Provincial Hospital of Chinese Medicine, No. 111 Dade Road, Yuexiu District, Guangzhou 510120, Guangdong, PR China. Tel: +86-020-87351238-62402; +86-13822100-525; E-mail: ljf2525@163.com; Shuo Yang, Health Management Department of Traditional Chinese Medicine, Guangzhou 11th People's Hospital, No. 2 Dougang West Street, Huangpu District, Guangzhou 510000, Guangdong, PR China. Tel: +86-020-82259890-1888; +86-18102558998; E-mail: beautyshuo@sina.com

References

[1] Asmussen S, Przkora R, Maybauer DM, Fraser JF, Sanfilippo F, Jennings K, Adamzik M and Maybauer MO. Meta-analysis of electroacupuncture in cardiac anesthesia and intensive care. J Intensive Care Med 2019; 34: 652-661.

[2] Coura LE, Manoel CH, Poffo R, Bedin A and Westphal GA. Randomised, controlled study of preoperative electroacupuncture for postoperative pain control after cardiac surgery. Acupunct Med 2011; 29: 16-20.

[3] Darbois N, Evain JN, Guillaud A, Lilot M and Pinsault N. Open heart surgery under acupuncture? Sante Publique 2018; 30: 455-464.

[4] Li X and Yu Q. Application of acupuncture-assisted anesthesia in cardiovascular surgery. J Clin Anesthesiol 2015; 7: 101-105.

[5] Bigeleisen PE and Goehner N. Novel approaches in pain management in cardiac surgery. Curr Opin Anaesthesiol 2015; 28: 89-94.

[6] Katz AM. Acupuncture anesthesia for open heart surgery. A case report. Am J Cardiol 1974; 34: 250-253.

[7] Hollinger I, Richter JA, Pongratz W and Baum M. Acupuncture anesthesia for open heart surgery: a report of 800 cases. Am J Chin Med 1979; 7: 77-90.

[8] Yang QG, Hang YN, Sun DJ, Chen XM, Wang XR, Xu CR and Yao JL. Changes of IFN-gamma, IL-2, IL-6 and IL-10 in the patient with cardiac surgery under combined acupuncture anesthesia. Zhongguo Zhen Jiu 2006; 26: 503-506.

[9] Caracausi SR. Electro-acupuncture in thoracic and cardiovascular surgery. Minerva Med 1979; 70: 3857-3860.
[10] Bai D and Zhang H. Application of acupuncture-assisted anesthesia in elderly heart surgery. Chinese Modern Doctor 2019; 14: 108-111.
[11] Xu M, Wang D, Lu J and Wang X. Acupuncture combined with general anesthesia for non-stop coronary artery bypass surgery. Chinese Journal of Pain Medicine 2019; 25: 461-466.
[12] Yu H, Xiaoqin X, Xu S, Xu J and Cao W. Effect of acupuncture compound on analgesia and sedation in patients with heart surgery. China Journal of Integrated Traditional Chinese and Western Medicine 2016; 289-293.
[13] Zhou J, Chi H, Cheng TO, Chen TY, Wu YY, Zhou WX, Shen WD and Yuan L. Acupuncture anesthesia for open heart surgery in contemporary China. Int J Cardiol 2011; 150: 12-6.
[14] Yang X, Zhou R, Zhu Z, Xu H, Wang Y, He M and Lv X. Application of acupuncture-assisted general anesthesia in cardiovascular surgery. Henan Journal of Traditional Chinese Medicine 2018; 38: 139-142.
[15] Zhou Q and Peng S. Effect of acupuncture-assisted anesthesia on hemodynamic indexes of patients undergoing cardiac surgery. Journal of Yunnan College of Traditional Chinese Medicine 2018; 5: 72-74.
[16] Liu L. Observation on the effect of acupuncture-assisted anesthesia on cardiac surgery. Journal of Clinical Acupuncture and Moxibustion 2015; 1: 8-10.
[17] Li S. Analysis of the clinical efficacy of acupuncture-assisted anesthesia for cardiac surgery anesthesia. China Prescription Drug 2013; 17: 36-37.
[18] Cassu RN, Melchert A, Canoa JT and Martins PD. Sedative and clinical effects of the pharmacopuncture with xylazine in dogs. Acta Cir Bras 2014; 29: 47-52.
[19] Yang QG, Hang YN and Sun DJ. Effect of combined drug-acupuncture anesthesia on hypothalamo-pituitary-adrenocortical axis response and glucose metabolism in open-heart surgery patients. Zhongguo Zhong Xi Yi Jie He Za Zhi 2001; 21: 729-731.
[20] Nikolaev AS, Dubovoy AV and Istomina TK. CME article: perceptions of acupuncture and acupressure by anesthesia providers: a quantitative descriptive study. Med Acupunct 2016; 28: 79-86.
[21] Yang QH, Ma WH and Li YH. Comparison of effects of acupuncture-assisted anesthesia with different acupoint combination in gynecologic laparoscopy operation. Zhongguo Zhen Jiu 2012; 32: 59-64.
[22] Takamiya T, Kubo Y, Benharash P and Zhou W. Effect of electroacupuncture on porcine cardiac excitability induced by left stellate ganglion stimulation. Auton Neurosci 2018; 213: 15-22.
[23] Wu Y, Yuan J and Feng XM. Effect of acupuncture-assisted anesthesia on stress response during laparoscopic cholecystectomy in aged patients. Zhongguo Zhen Jiu 2011; 31: 155-157.
[24] Cheng TO. Acupuncture anesthesia for open heart surgery: past, present and future. Int J Cardiol 2011; 150: 1-3.
[25] Tang W, Wang J, Fu GQ and Yuan L. Effect of dexmedetomidine and midazolam on respiration and circulation functions in patients undergoing open heart surgery under acupuncture-assisted general anesthesia. Zhen Ci Yan Jiu 2014; 39: 216-221.