DEEP SUCTION PERFORM MORE EFFECTIVE THAN SHALLOW SUCTION IN TRACHEA INTUBATION PATIENTS: A META-ANALYSIS OF RANDOMIZED CONTROLLED TRIALS

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ABSTRACT

Background*: Suction is a routine practice in trachea intubation patients in Intensive Care Units to avoid a store of secretions and blockage of the airway. Effectiveness and complication of suction varied according to the depth of catheter. Many guidelines supported care providers in determining the most appropriate method but the most appropriate depth of suctioning is still unclear.*

Objective*: To identify evidence about the benefits and risks of deep and shallow suction.*

Date Source Ten electronic databases were comprehensive searched (Cochrane Library, PubMed, Medline, EMBASE, CINAHL, Academic Search Complete, Science Direct, Chinese and Technology Periodicals database (VIP), Wangfang database, and Chinese National Knowledge Infrastructure (CNKI) database) until September 30, 2017 with no restriction for language.

Method*: Two reviewers independently evaluated selected randomized controlled trials (RCTs) according to Cochrane Handbook 5.3.*

Results*: Totally 11 RCTs and 617 patients were involved. Deep suction performed more effective with fewer suction times daily (WMD=1.32, 95% CI: 1.11 to 1.53, P<0.01), longer suction interval (WMD=-0.48, 95% CI: -0.61 to -0.36, P<0.01) and better arterial blood oxygen saturation (SPO2) improvement (WMD=-0.58, 95% CI: -0.77 to -0.39, P<0.01). Deep suction will cause bigger fluctuation in heart rate (HR) (WMD=-3.32, 95% CI: -3.50 to -3.15, P<0.01). Unexpected, no significant difference of tracheal or bronchial damage rate (OR=0.45, 95% CI: 0.11 to 1.90, P > 0.01)and Systolic blood pressure (SBP) change level (WMD=0.16, 95% CI: -0.02 to 0.33, P > 0.01)were found between the two different suction depth.*

Conclusions*: This meta-analysis provides evidence for benefits and risks of different suction depth. It is clear that deep suction performed more effective in airway clean. A clear risk of deep suction has not been established.*

Keywords*: Suction, trachea intubation, Intensive Care Units, Periodicals database (VIP), Chinese National Knowledge Infrastructure (CNKI).*

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Introduction

Trachea intubation is conducted by inserting the endotracheal tube through nose/mouth into the trachea(1). It is applied to assist breathing in the Intensive Care Unit. But the establishment of trachea intubation may let the epiglottis out of work, weak the cough reflex and reduce the ability of clearing respiratory secretion(2). Thus, suction is essential for trachea intubation patients to eliminate respiratory secretion.

Guidelines and protocols of keeping endotracheal tube patently varied widely among institutions(3). Depth of catheter inserted is a major reason associated with the effectiveness and complications of suction. Shallow suction performed ineffectively in clearing respiratory secretion(4). However, various complications related to deep suction were reported such as hypoxaemia, tachycardia, atelectasis, fluctuations in blood pressure and intracranial pressure, tracheal or bronchial damage(5-7). Endotracheal tube suction was frequently applied in the Intensive Care

Unit and play an important role in caring, examining the appropriate depth of suction helps improving patients' recovery.

Practical guidelines aim to assist caregivers in determining the most suitable depth of suction. American Association for Respiratory Care (AARC) had suggested two kinds of suction depth, but had not clarified the most appropriate depth[8]. Also, practice survey indicates that guidelines are not based on sound evidence[9]. For instance, deep suction had to be applied after shallow suction in clinical practice; and there was no difference of tracheal or bronchial damage rate between deep and shallow suction[10].

In addition, a Cochrane review has been performed to identify the benefits and risks of different depth of suction in ventilated patient. But only one study was involved. Over the past few decades, several RCTs with small sample were conducted to assess the benefits and risks of different depth of suction. Thus, the authors performed a meta-analysis of RCTs to identify the benefit and complication of different depth of suction.

The objective of the work is to compare the effectiveness and complications between deep and shallow suction in trachea intubation patients, and to provide evidence in determining the most appropriate depth of suction in nursing care.

Subgroup analysis were planned based on the time of intubation (with four subgroups of the third day, over one day, 2~7 days, and 1~3 day), opportunity of data collection (four subgroups, 1 min, 2 min, 3 min and 5 min after suction), suction method(three subgroups, closed suction, open suction, closed and open suction mixed).

Materials and methods

Selection criteria

Types of studies: randomized controlled trials

Types of participants: patients receiving ventilator support with an endotracheal tube. Neonates, infants and patients with pulmonary were excluded.

Types of interventions

Deep suction: the catheter should be inserted into the endotracheal tube until a cough of resistance is met and pulled back 0.5~2cm[11].

Shallow suction: the catheter should be passed to the tip of the tube or extend beyond 1~2cm, the average depth was about 16.87~31.63cm.

Types of outcomes

Primary outcomes: suction times daily, suction interval, tracheal or bronchial damage (measured through bronchoscope).

Secondary outcomes: level of SPO2, HR and SBP change after suction (measured on a cardio-respiratory monitor).

Search strategy

Multiple electronic databases were comprehensive searched (Cochrane Library, PubMed, Medline, EMBASE, CINAHL, Academic Search Complete, Science Direct, Chinese and Technology Periodicals database (VIP), Wangfang database, and Chinese National Knowledge Infrastructure (CNKI) database) until September 30, 2017 with no restriction for language and the search was limited in human subjects. Following medial subject headings were used: "intratracheal intubation", "intubation", "endotracheal intubation", "suction", "suctioning", "aspiration", "deep suction", "shallow suction", "suction adverse effects" and "suction methods". Some additional studies were identified by reviewing the reference sections of relevant publications and consulting pulmonary experts.

Data extraction

Two reviewers (one has got the certification of systematic review approved by the Joanna Briggs Institute) independently extracted the following contents from the included studies: study designs, sample sizes, follow-up duration, inclusion and matching criteria, participant characteristics, inclusion and matching criteria, suction methods, data collecting time point and intubation period. Inconsistencies between the findings of the two reviewers were resolved by a third reviewer. Authors were e-mailed if additional information were needed.

Methodological quality assessment

Methodological qualities of selected RCTs were independently assessed according to Cochrane Collaboration's tool[12].

Statistical analysis

All data were analyzed using the Review Manager 5.3 software and processed according to the Cochrane Handbook. MD/ORs and corresponding 95% CIs were employed. P values < 0.05 were considered as statistically significant. I2 was used to analysis the heterogeneity among studies (I2 $< 50\%$ indicates the heterogeneity among studies is not significant and Mantel-Haenszel fixed-effect model was used to calculate the pooled WMD/ORs. Otherwise, DerSimonian and Laird random-effects model was used. Sensitivity analysis will conducted when significant heterogeneity existed. In addition, Begg's test and Egger test will be used to evaluate the publication risk bias (P values < 0.05 indicates significant bias).

Results

Characteristics of the studies

Meta-analysis was performed according to the PRISMA guidelines. A detailed flow chart of the study selection process is shown in Figure 1. Briefly, 232 studies were searched after searching the nine databases and removing duplicates. 217 studies were excluded due to no relevance, non-human experiment, non-original study and not matching standards of intervention or outcome. Finally, 11 studies enrolled 617 participants were included in the meta-analysis.

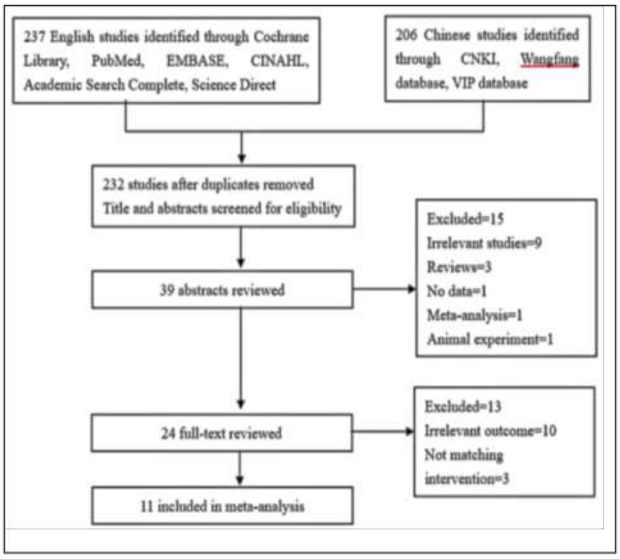

Figure 1: Study selection process.

Baseline characteristics of the 11 included studies are summarized in Table 1. In the 11 studies, nine sampling populations were Chinese, two were Iranian[13-23]. Suction method used in these studies included closed and open suction. Time of intubation in these studies was over one day and data were collected 1, 3 and 5 minutes after suction. Subgroup analysis was performed to explore the effects of different suction method, opportunity of data collection and time of intubation on the relationship between different depth of suction and its effectiveness and complications.

Author	Year	Age(years)	Ethnicity	Suction Method	NO. of sample shallow	NO. of sample deep	Outcome	Time point of data collection	Period of intubation(day)
Hong	2014	23~65 (45.8±6.2)	Chinese	Shallow: closed suction Deep: open suction	20	20	3.4	3 min after suction	The third day
Hu	2012	44.00±17.00	Chinese	Open suction	19	19	1.2	——	The third day
Liang	2017	52.1±1.5	Chinese	Closed suction	50	50	1	——	≥1
Liang	2012	21~38	Chinese	Half-closed suction	27	28	1	——	1~3
Qian	2016	65±16	Chinese	Closed suction	20	20	4.5	1 min after suction	≥1
Wang	2014	27~68 (59.1±15.6)	Chinese	Open suction	32	32	1.2.3.4.5.6	5 min after suction	≥1
Yan	2014	30~80 (60.2±10.3)	Chinese	Unclear	25	25	1.2	——	≥1
Zhang	2009	34~89 (70.88±15.54)	Chinese	Open suction	18	16	1.2.3.4.5.6	5 min after suction	≥1
Zhang	2014	27~70 (47.43±10.64)	Chinese	Closed suction	24	24	1.2	——	The third day
Iragipour	2014	Shallow: 59.4±21.45 Deep: 60.0±22.3	Iranian	Open suction	37	37	4.5	1,2 min after suction	2~7
Abbasinia	2014	Shallow: 59.4±21.45 Deep: 60.0±22.3	Iranian	Open suction	37	37	3	1,3 min after suction	2~7

Table 1: Baseline of characteristics of studies included in the meta-analysis.

Outcome: 1. suction times daily; 2. suction interval; 3. level of oxygenation change after suction; 4. heart rate change after suction; 5. Level of Systolic blood pressure change after suction; 6. Tracheal or bronchial damage;

Methodological quality assessment

11 studies selected in the meta-analysis were RCTs. The methodological quality assessment is shown in Figure 2. Eight studies did not report the method of randomization, while other studies reported a randomly sampling method[24-33].

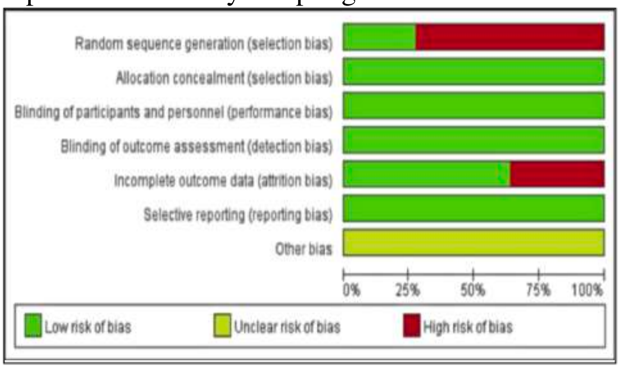

Figure 2: Risk of bias assessment.
(a)Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

All of the participants in these studies were reported as randomly allocated to shallow suction group and deep suction group. Blind method was used in these studies and data was collected through bronchoscope and cardio-respiratory monitor. Four studies had attrition bias for the reason that no information about opportunity of data collection was found in these studies. The other biases were unclear in these studies as most of the studies (n=9) were conducted in China, publication bias might present in the meta-analysis. And suction method maybe different between studies, what will cause bias. Besides, the diagnosis of included sample varied, which might influence the outcome detected[34,35].

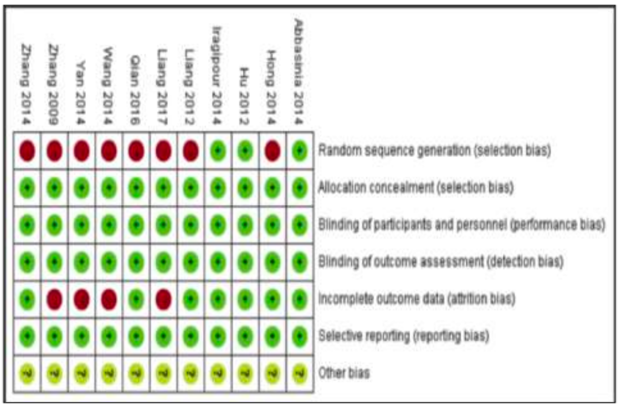

Figure 2: Risk of bias assessment.
(b)Risk of bias summary: review authors' judgements about each risk of bias item for each included study.

Effectiveness of suction

As shown in Figure 3, three kinds of outcome (suction times daily, suction interval and SPO2 change level) were used to analysis the effectiveness of suction.

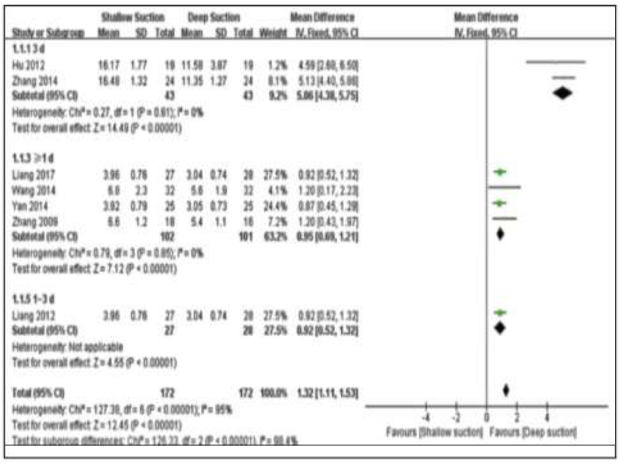

Figure 3: Forest plots for suction effectiveness analysis.
(a)Suction times daily.

Suction times daily

Seven studies reported suction times daily. As shown in Figure 3(a), no significant heterogeneity was found in both subgroup analysis of 3d intubation period and over 1d intubation period (I2=0%, P=0.61 and I2=0%, P=0.85). Results of three subgroup analysis demonstrated that deep suction can significantly decreased suction times daily (subgroup of 3d intubation period: WMD=5.06, 95% CI: 4.38 to 5.75, P<0.01; subgroup of 1d intubation period: WMD=0.95, 95% CI: 0.69 to 1.21, P<0.01; subgroup of 1d~3d intubation period: WMD=0.92, 95% CI: 0.52 to 1.32, P<0.01).

Suction interval

Five studies provided data about suction interval. As shown in Figure 3(b), no significant heterogeneity was found in selected studies (I2=38%, P=0.17). Results of the meta-analysis demonstrated that suction interval of deep suction group is significant longer than shallow suction group (WMD=-0.48, 95% CI: -0.61 to -0.36, P<0.01).

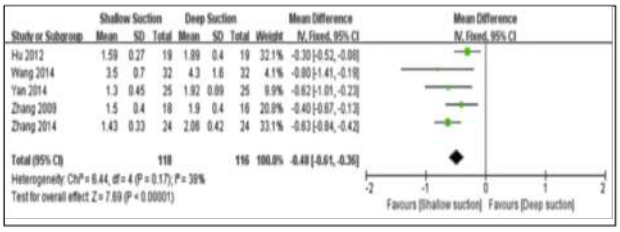

Figure 3: Forest plots for suction effectiveness analysis.
(b)Suction interval.

SPO_2 change level

SPO_2 change level is an important assessment standard to evaluate the effectiveness of suction practice. Four studies reported both deep and shallow suction can improve the SPO_2 level of patients. The improvement of deep suction group is better than shallow suction group when using closed suction (WMD=-1.17, 95% CI: -1.37 to -0.96, P<0.01; I2=42%, P=0.18, Figure 3(c)). One study indicated that shallow suction group performed better in improving SPO_2 level (WMD=2.09, 95% CI:1.65 to 2.53, P<0.01). Considering the suction method of shallow suction was closed but deep suction was open in the study, and the effect of two different kinds of suction method is still unclear, result of the subgroup analysis need further discuss.

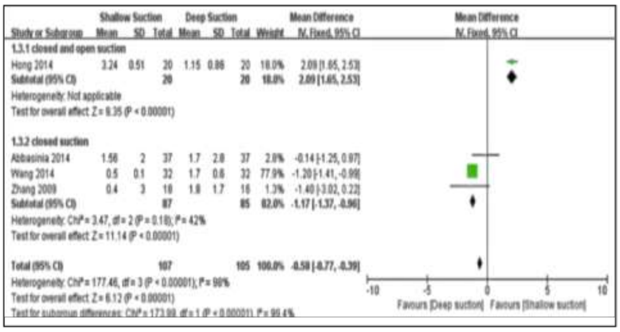

Figure 3: Forest plots for suction effectiveness analysis.
(c)SPO_2 change level

Complication analysis

It is argued that deep suction will cause trauma of airway, tachycardia and fluctuations in blood pressure. Thus, tracheal or bronchial damage rate, change level of SBP and HR will be used to analysis the complication of different depth of suction in this meta-analysis.

SBP change level

Four studies indicated that both deep and shallow suction will increase the SBP of patients. In the context of using closed suction method, SBP change level of shallow suction was significantly lower than deep suction (WMD=-14.00, 95% CI:-17.20 to -10.80, P<0.01, Figure 4(a)). However, the subgroup analysis of open suction demonstrated that no difference of SBP change level between deep suction and shallow suction (WMD=0.20, 95% CI: 0.03 to 0.37, P<0.01; I2=0%, P=0.95; Figure 4(a)).

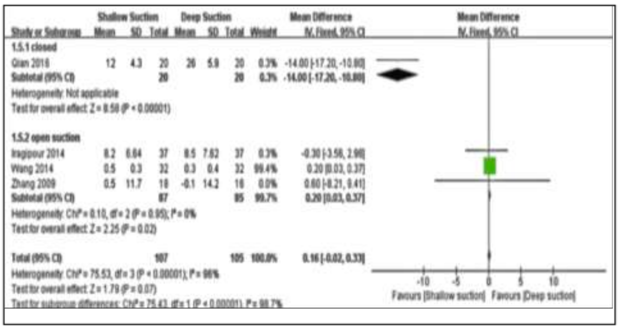

Figure 4: Forest plots for complication analysis.
(a)SBP change level.

HR change level

As shown in Figure 4(b), HR change level of deep suction is higher that shallow suction. A scholar indicated that HR change level of open and deep suction is significantly higher than closed and shallow suction(WMD=-5.22, 95% CI:-5.65 to -4.79, P<0.01). Meanwhile, in the context of using closed suction in both two groups(Qian et al., 2016), HR change level of deep suction group is significantly higher shallow suction group (WMD=-6.90, 95% CI:-7.31 to -6.49, P<0.01). Similarity, subgroup analysis of open suction demonstrated that HR change level of deep suction group is significantly higher shallow suction group (WMD=-1.90, 95% CI: -2.12 to -1.69, P<0.01; I2=0%, P=0.73).

Tracheal or bronchial damage rate

Two studies demonstrated that deep suction lead to more damage in tracheal or bronchial than shallow suction. But there was no significant difference between deep suction group and shallow suction group (OR=0.45, 95% CI: 0.11 to 1.90, P=0.28; I2=0%, P=0.94; Figure 4(c))

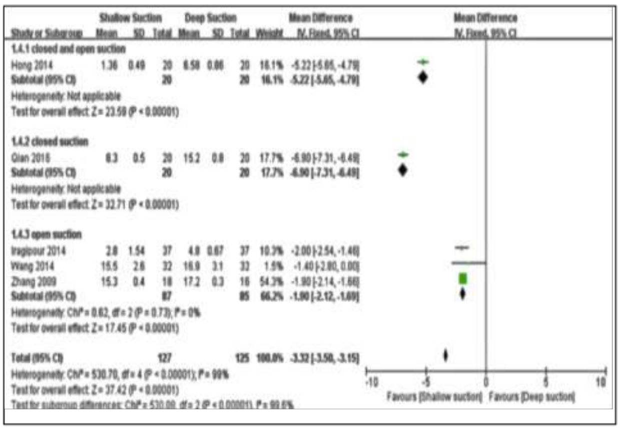

Figure 4: Forest plots for complication analysis.
(b) HR change level.

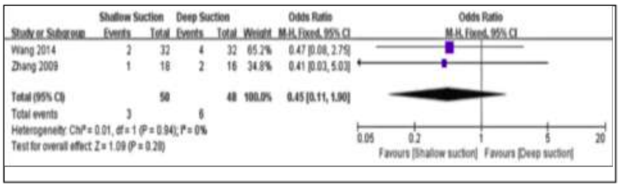

Figure 4: Forest plots for complication analysis.
(c)Tracheal or bronchial damage rate.

Discussion

Suction was applied for airway cleaning and improving the efficacy of air entering the lungs. Deep suction was regarded as more effective but easier to cause complications including hypoxia, bronchpspasm, tracheal tissue injury and cardiac dysrhythmia. A group of scholars indicated that nearly half of patients need deep suction again after shallow suction and blood in mucus of deep suction is significant more often than shallow suction. Besides, the study by a scholar showed shallow suction would significantly cause a slight increase in patients' HR. The difference in the study is because in the shallow suction group, normal saline was not used. A scholar indicated that there was no significant difference in SPO_2 and HR change level between deep and shallow suction. But deep suction's incidence of adverse effect such as hypoxia, fluctuation in blood pressure and tracheal tissue injury was significant higher compared to shallow suction. But the studies were performed on infants. Because infants' organs are immature and tolerance of fluctuations on HR and blood pressure performed poor, the result is inappropriate to be generalized to adults.

Several instruments were used to assess the effectiveness of suction such as mucus volume, improvement of wheezy phlegm and incidence of bradycardia. However, the key of suction is to eliminate the blockage rather than assessing the accumulation of mucus volume. Wheezy phlegm is an important sign to assess the effectiveness of suction. But the measurement of wheezy phlegm is subjective, and nurses' capability of measuring wheezy phlegm is still inadequate. Serval studies assessed the safety of different suction depth through evaluating incidence of bradycardia, but there was no association between incidence of bradycardia and patients' outcome. Thus, the instruments should be objective, easy to accurate measure and can reflect patients' outcome. Suction times daily and interval can observed, and the data is feasible to collect. Decline of SPO2 is a sign of requiring suction. Thus, improvement of SPO2 was frequently applied to assess the effectiveness of suction.

According to this meta-analysis, deep suction performed more effective than shallow suction. Number of times of daily deep suction is significant less than shallow suction. And the situation of airway cleaning can keep longer. As demonstrated, interval of deep suction is significant longer than shallow suction, and SPO_2 of deep suction improves significantly.

In addition, the fluctuation of HR and SBP can reflect the degree of stimulating of suction on patients. The HR and SBP of patients would significantly increase and recover to 5 minutes after suction. Thus, all of the data on change level of HR and SBP should be collected in 5 minutes of suction. Results of the meta-analysis showed that deep suction will cause a great fluctuation of HR. When using closed suction, there was no significant difference of SBP's fluctuation between two kinds of suction depth. But SBP's fluctuation of deep suction was significant bigger than shallow suction. While, only one study was involved in the subgroup analysis, more RCTs were needed to get further exploration. In sum, even though the deep suction will cause greater fluctuation in SBP and HR, these vital signs will return back to baseline in 5 minutes.

Tracheal damage is a common adverse effect can be accurate assessed through bronchoscope. Several studies claimed that deep suction is prone to cause tracheal damage than shallow suction. However, according to the results of this meta-analysis, there was no significant difference between deep and shallow suction although the injury rate of deep suction is higher. Participants in the study of a scholar were infants and cannot be generalized to adults. Additionally, a scholar conducted a trail on rabbits and found that the tracheal damage rate was significant higher, which was the first evidence about the complication of deep suction versus shallow suction. But the two groups received same times of suction in the trial. Nowadays, nurses provide suction when patients need. The suction times daily of shallow suction is significant more than deep suction. Thus, it is supposed that shallow suction performed inefficient and increased the frequency of suction, what increase the risk of tracheal damage.

It is noteworthy that high degree of heterogeneity was found in four indices: suction times daily (I2=95%, Figure 3(a)), SPO_2 change level (I2=98%, Figure3(c)), SBP change level (I2=96%, Figure 4(a)), and HR change level (I2=99%, Figure 4(b)). Through analyzing the included studies, following possible reasons for the discrepancies were speculated: (1) different suction method used in these studies; (2) different opportunity for data collection; (3) different time of intubation of participants in these studies. Degree of heterogeneity of the four indices decreased a lot in these subgroup analyze. Thus, these reasons should be pay attention in further research.

Some limitations of this meta-analysis need to be acknowledged. Firstly, the methodological quality of included studies had defects. It was hard to exclude the potential risk of bias in these studies. Secondly, only 617 participants were involved in these 11 trials, which limited the evaluating of benefits and complications of deep and shallow suction. Thirdly, the period of intubation on patients varied widely in these studies, from over one day to 2~7 days, and data of three studies was collected on the third day of intubation. As patients' physical signs performed different in different period of intubation, it is highly recommended to collect data in a same time point. Owing to these limitations, further research needs to be more accurately to analysis the benefits and complications of deep and shallow suction.

Conclusions

The meta-analysis demonstrates that deep suction performs more effective in airway cleaning. The deep suction can decrease suction times daily, extend suction interval and improve patient's SPO2 better. Meanwhile, deep suction may cause bigger fluctuation in HR and SBP than shallow suction. Although the tracheal or bronchial damage rate of deep suction is higher than shallow suction, there is no statistic difference between them.

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Completing interest
All authors had declared that they have no competing interests.

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