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ABOUT COVER

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The primary aim of *World Journal of Clinical Cases* (WJCC, *World J Clin Cases*) is to provide scholars and readers from various fields of clinical medicine with a platform to publish high-quality clinical research articles and communicate their research findings online.

WJCC mainly publishes articles reporting research results and findings obtained in the field of clinical medicine and covering a wide range of topics, including case control studies, retrospective cohort studies, retrospective studies, clinical trials studies, observational studies, prospective studies, randomized controlled trials, randomized clinical trials, systematic reviews, meta-analysis, and case reports.

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Comparison of different methods of nasogastric tube insertion in anesthetized and intubated patients: A meta-analysis

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Abstract

BACKGROUND

Several techniques of nasogastric tube (NGT) insertion have been described in the literature with different success rates.

AIM

To systematically search the literature and conduct a meta-analysis comparing the success rates, insertion time and complications associated with different techniques of NGT insertion in anesthetized and intubated patients.

METHODS

An electronic search of the PubMed, Scopus, CENTRAL (Cochrane Central Register of Controlled Trials), and Google Scholar databases were performed up to October 31, 2019. We included 17 randomized controlled trials with 2500 participants in the meta-analysis.

RESULTS

As compared to the conventional method, successful insertion of the NGT on first attempt was higher with modified techniques such as the reverse Sellick's maneuver [relative risk (RR) 1.94; 95% confidence interval (CI): 1.62-2.31], use of a frozen NGT (RR 1.55; 95%CI: 1.13-2.13), inserting the NGT with neck flexion and lateral neck pressure (RR 1.64; 95%CI: 1.10-2.45), endotracheal tube-assisted (RR 1.88; 95%CI: 1.52-2.32) and video-assisted placements (RR 1.60; 95%CI: 1.31-1.95). All the modified techniques also led to comparatively higher insertion success rates than the conventional technique.

CONCLUSION

The use of modified techniques of NGT insertion such as the reverse Sellick's maneuver, neck flexion with lateral neck pressure, frozen NGT, endotracheal tube-guided or video-assisted methods result in a significantly better chance of successful tube insertion at first attempt as compared to the conventional tech-

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nique. All modified techniques also significantly improve the overall chance of successful NGT placement as compared to the conventional method.

Key Words: Nasogastric tube; Anesthetized patient; Intubated patients; Mucosal bleeding

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Core Tip: Our study indicates that the use of modified techniques of nasogastric tube (NGT) insertion such as the reverse Sellick's maneuver, neck flexion with lateral neck pressure, frozen NGT, endotracheal tube-guided or video-assisted methods result in a significantly better chance of successful tube insertion at first attempt as compared to the conventional technique.

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INTRODUCTION

Nasogastric tube (NGT) placement is one of the most commonly performed procedures in anesthetized and intubated patients. A number of indications exist for NGT insertion in such patients including gastric deflation, gastric suctioning or more commonly for enteral feeding[1,2]. Several methods have been used by clinicians for placing NGTs depending upon their skills and the availability of equipment, and success rates have varied with different techniques[3]. Some of the commonly used methods include placement using a fibre-optic guide, endotracheal tube-guided placement, flexion of the patient's head and applying lateral neck pressure, freezing the tube prior to placement to make it rigid, and NGT placement after anterior displacement of the larynx[3]. In a patient who is awake and conscious placing a NGT is easy as opposed to the difficulty encountered in patients who are anesthetized and intubated. A number of complications of NGT placement have been reported such as misplacement of tubes in the pulmonary region, esophageal perforations, and the incidence of infections and mucosal bleedings[4-7].

In most clinical settings, the primary responsibility of placing NGTs is that of trained nurses and resident physicians[8-10]. With the significantly increasing role of nurses, they must be aware and well-trained in various techniques of NGT insertion whilst minimizing complications. There are merits and demerits to the different techniques used for placing NGTs in anesthetized and intubated patients, and different studies have addressed them. A few systematically conducted reviews on the subject exist[3], but to the best of our knowledge no meta-analysis has summarized the evidence with the intent to provide reliable information both in terms of relative advantages of the techniques and their associated complication rates. Therefore, the purpose of this study was to systematically search the literature and conduct a pooled analysis comparing the success rates, insertion time and complications associated with different techniques of NGT insertion to provide high-level evidence to guide clinical practice.

MATERIALS AND METHODS

Search strategy

A comprehensive electronic search of the PubMed, Scopus, CENTRAL (Cochrane Central Register of Controlled Trials), and Google Scholar databases was conducted for English as well as non-English language papers published up to October 31, 2019. For non-English language papers, we used Google translator to extract relevant information. Both free text words and medical subject heading terms were used for the systematic search. Details of the search strategy are provided in the supplementary

document ([Supplementary Table 1](#)). Our key aim was to identify randomized controlled trials (RCTs) that evaluated different NGT insertion techniques among anesthetized and intubated patients. We included all studies that reported relevant outcomes in this meta-analysis.

Selection criteria and methods

Two authors reviewed citations and selected studies. After removing duplicates, the studies were screened by their titles and abstracts. Thereafter, potentially eligible trials were reviewed by their full text. We resolved any discrepancies related to the inclusion of studies through detailed discussion among the study authors. A hand-search of bibliographic lists of the identified studies and relevant reviews was conducted to identify any additional studies.

Inclusion criteria

We included only RCTs on anesthetized and intubated patients that compared at least two different techniques of NGT insertion. Studies were to report any of the following outcomes of interest: success rate on first insertion, overall success rate of insertion (more than two attempts at insertion labeled as failure), time required for successful intubation, and complications (such as mucosal bleeding, gag reflex, cough, kinking and coiling of the NGT).

Exclusion criteria

We excluded studies conducted on awake and non-intubated patients. Studies not reporting relevant outcomes, non-randomized studies, retrospective studies, case reports and review articles were also excluded.

Data extraction and quality assessment

Two authors independently collected relevant data from the included studies using a data extraction sheet. The data from eligible studies included: authors, year of publication, study site, study design, sample size, study groups, and outcomes. Two authors independently evaluated the study methodologies using the Cochrane assessment tool[11].

Statistical analysis

RCTs comparing the same techniques were pooled for the meta-analysis. In instances where RCTs compared different techniques and pooling of studies was not feasible, results were presented in a descriptive format. Statistical analyses were carried out using STATA version 13.0. Weighted mean differences (WMD) were used to pool effect size for continuous variables. For ordinal data, the relative risk (RR) ratio was calculated. All estimates were expressed with 95% confidence intervals (CIs). We assessed heterogeneity of effects and quantified them based on the I^2 value. I^2 values > 50% represented substantial heterogeneity[12]. We applied the random-effects model to cases with substantial heterogeneity[12]. A P value of < 0.05 was considered statistically significant. Publication bias was assessed using Egger's test and visual inspection of funnel plots.

RESULTS

Selection of articles, study characteristics, and quality of included studies

We obtained 1042 unique citations after our search in the PubMed, Scopus, CENTRAL (Cochrane Central Register of Controlled Trials), and Google scholar databases ([Figure 1](#)). Of these, 983 papers were excluded after screening the titles, and 30 citations after reading the abstracts. Twenty-nine studies were reviewed by their full texts. Twelve articles did not fulfill the inclusion criteria and were excluded. A total of 17 trials were included in the RCT with a total of 2500 participants[13-29]. The characteristics of the included studies are presented in [Table 1](#). All the included studies were RCTs (6 were conducted in India, 4 in Korea, 2 in Taiwan, 2 in Iran, and 1 in China, Malaysia, and Turkey). The authors' judgment of risk of bias of the included studies is presented in [Supplementary Table 2](#). All the studies adopted random sequence generation, allocation concealment was reported in 15 studies, blinding of participants in 15 studies, and blinding of study personnel in 14; in all the studies, the outcome assessment team was blinded and none of the studies had attrition bias.

Table 1 Summary of the studies included in this meta-analysis and systematic review

Ref.	Country	Sample size	Study participant characteristics	Practitioner inserting NGT with level of expertise	Study groups	Key outcome(s)
Zhao <i>et al</i> [13], 2018	China	110	Patients with cerebral hemorrhage or traumatic brain injury	Not specified	Control group (C): Nasogastric tube (NGT) insertion using conventional technique <i>i.e.</i> , with head in a neutral position; Intervention group (I): Nasogastric tube insertion in right lateral decubitus position	Success rate on 1 st attempt: C = 36/54 (66.7%); I = 50/56 (89.3%). Overall success rate of insertion: C = 47/54 (87.0%); I = 55/56 (98.2%). Intubation time, mean (SD): C = 114.1 (35.6) s; I = 77.9 (33.5) s. Complication rate: (1) Gag reflex: C = 20/54 (37.0%); I = 7/56 (12.5%); (2) Cough: C = 8/54 (14.8%); I = 1/56 (1.8%); (3) Mucosal bleeding: C = 14/54 (25.9%); I = 3/56 (5.4%); and (4) No major adverse events in both groups
Mandal <i>et al</i> [14], 2018	India	195	Adult patients undergoing abdominal surgery	Not specified	Group A: Conventional; Group B: Frozen NGT; Group C: Reverse Sellick's manoeuvre	Success rate on 1 st attempt: Group A = 29/65 (44.6%); Group B = 45/65 (69.2%); Group C = 59/63 (93.6%). Overall success rate of insertion: Group A = 45/65 (69.2%); Group B = 55/65 (84.6%); Group C = 60/63 (95.2%). Intubation time, mean (SD): Group A = 42.2 (21.4) s; Group B = 42.1 (13.2) s; Group C = 31.5 (9.5) s. Complication rate: (1) Mucosal bleeding: Group A = 3/65 (4.6%); Group B = 20/65 (30.8%); Group C = 0/63 (0.0%); (2) Coiling: Group A = 12/65 (18.5%); Group B = 16/65 (24.6%); Group C = 5/63 (7.9%); (3) Kinking: Group A = 8/65 (12.3%); Group B = 6/65 (9.2%); Group C = 0/63 (0.0%); and (4) No major adverse events in any of the three groups
Chun <i>et al</i> [15], 2009	Korea	100	Patients undergoing elective general anesthesia	Not specified	Patient placed in a neutral position with moderate head elevation; Control (C)-normal silicone NGT; Intervention (I)-frozen NGT	Overall success rate of insertion: C = 29/50 (58.0%); I = 44/50 (88.0%). Intubation time, mean (SD): C = 120 (133) s; I = 83 (43) s. Complication rate: (1) Mucosal bleeding: C = 6/50 (12.0%); I = 3/50 (6.0%); and (2) No major adverse events in any of the groups
Siddhartha <i>et al</i> [16], 2017	India	120	Patients undergoing laparoscopic hysterectomy	Not specified	Group C (Control group): Conventional technique with head in a neutral position and NGT through nostril; Group R: Reverse Sellick's manoeuvre; Group F: Neck flexion with lateral neck pressure	Success rate on 1 st attempt: Group C = 15/40 (37.5%); Group F = 16/40 (40.0%); Group R = 31/40 (77.5%). Overall success rate of insertion: Group C = 30/40 (75.0%); Group F = 31/40 (77.5%); Group R = 37/40 (92.5%). Intubation time, mean (SD): Group C = 25.5 (4.5) s; Group F = 20.5 (4.7) s; Group R = 13.1 (2.6) s. Complication rate: (1) Mucosal bleeding: Group C = 12/40 (30.0%); Group F = 12/40 (30.0%); Group R = 10/40 (25.0%); (2) Coiling: Group C = 25/40 (62.5%); Group F = 12/40 (30.0%); Group R = 7/40 (17.5%); and (3) Kinking: Group C = 3/40 (7.5%); Group F = 3/40 (7.5%); Group R = 3/40 (7.5%)
Appukutty <i>et al</i> [17], 2009	India	200	Patients receiving GA and tracheal intubation for various surgical procedures	Group of four 3 rd year anaesthesia residents; all judged proficient in insertion techniques by the authors	Group C (Control group): Conventional technique with head in a neutral position and NGT through nostril; Group W: Guidewire group; guidewire introduced within a 14-F nasogastric tube; Group S: Slit endotracheal group; Group F- Neck flexion with lateral neck pressure	Success rate on 1 st attempt: Group C = 17/50 (34.0%); Group W = 33/50 (66.0%); Group S = 41/50 (82.0%); Group F = 41/50 (82.0%). Overall success rate of insertion: Group C = 36/50 (72.0%); Group W = 46/50 (92.0%); Group S = 46/50 (92.0%); Group F = 47/50 (94.0%). Intubation time, mean (SD): Group C = 56 (36) s; Group W = 42 (29) s; Group S = 98 (43) s; Group F = 31 (19) s. Complication rate: (1) Mucosal bleeding: Group C = 0/50 (0.0%); Group W = 0/50 (0.0%); Group S = 11/50 (22.0%); Group F =

						0/50 (0.0%); (2) Coiling: Group C = 1/50 (2.0%); Group W = 1/50 (2.0%); Group S = 0/50 (0.0%); Group F = 0/50 (0.0%); and (3) Kinking: Group C = 10/50 (20.0%); Group W = 4/50 (8.0%); Group S = 0/50 (0.0%); Group F = 4/50 (8.0%)
Kwon <i>et al</i> [18], 2014	Korea	56	Intubated patients in the emergency department	By 3 paramedics; 8 h of education and practice on a mannequin for NGT insertion	Control group (C): Conventional technique with head in a neutral position and NGT through nostril; Intervention group (I): Endotracheal tube-assisted insertion through mouth	Success rate on 1 st attempt: C = 14/28 (50.0%); I = 28/28 (100.0%). Overall success rate of insertion: C = 18/28 (64.0%); I = 28/28 (100.0%). Intubation time, mean (SD): C = 111.7 (74.5) s; I = 58 (16.9) s. Complication rate: (1) Mucosal bleeding: C = 2/28 (7.0%); I = 5/28 (17.8.0%); and (2) Kinking: C = 5/28 (17.8%); I = 0/28 (0.0%)
Illias <i>et al</i> [19], 2013	Taiwan	150	Patients intubated for gastrointestinal surgery	By 2 experienced anesthesiologists	Control group: Conventional technique with head in a neutral position and NGT through nostril; Group F: Neck flexion with lateral neck pressure; Group L: NGT placed after lifting of the larynx	Success rate on 1 st attempt: Control = 26/50 (52.0%); Group F = 41/50 (82.0%); Group L = 44/50 (88.0%). Overall success rate of insertion: Control = 30/50 (60.0%); Group F = 44/50 (88.0%); Group L = 46/50 (92.0%). Intubation time, mean (SD): Control = 26.7 (16.0) s; Group F = 29.5 (14.8) s; Group L = 21.3 (8.4) s. Complication rate: (1) Mucosal bleeding: Control = 5/50 (10.0%); Group F = 1/50 (2.0%); Group L = 1/50 (2.0%); (2) Kinking: Control = 20/50 (40.0%); Group F = 8/50 (16.0%); Group L = 6/50 (12.0%); (3) Coiling: Control = 19/50 (38.0%); Group F = 2/50 (4.0%); Group L = 0/50 (0.0%); and (4) Bradycardia: Control = 0/50 (0.0%); Group F = 0/50 (0.0%); Group L = 1/50 (2.0%)
Kavakli <i>et al</i> [20], 2017	Turkey	200	Patients intubated for gastrointestinal surgery	By 3 anesthesiologists of similar experience	Control group: Conventional technique with head in a neutral position and NGT through nostril; Group L: head in lateral position; Group ET: Endotracheal tube-assisted NGT placement; Group MG: McGrath video laryngoscope-assisted NGT placement	Success rate on 1 st attempt: Control = 27/50 (54.0%); Group L = 39/50 (78.0%); Group ET = 50/50 (100.0%); Group MG = 46/50 (92.0%). Overall success rate of insertion: Control = 33/50 (66.0%); Group L = 44/50 (88.0%); Group ET = 50/50 (100.0%); Group MG = 49/50 (98.0%). Intubation time, mean (SD): Control = 62.5 (15.3) s; Group L = 43.4 (7.8) s; Group ET = 82.3 (7.9) s; Group MG = 42.4 (4.2) s. Complication rate: (1) Mucosal bleeding: Control = 10/50 (20.0%); Group L = 9/50 (18.0%); Group ET = 10/50 (20.0%); Group MG = 1/50 (2.0%); and (2) Coiling: Control = 10/50 (20.0%); Group L = 3/50 (6.0%); Group ET = 0/50 (0.0%); Group MG = 1/50 (2.0%)
Wan Ibadullah <i>et al</i> [21], 2016	Malaysia	96	Patients scheduled for surgery under GA requiring tracheal intubation and NGT insertion	Multiple anesthetists proficient in both techniques of insertion	Group A: NGT insertion using GlideScope visualization; Group B: NGT insertion using direct MacIntosh laryngoscope	Success rate on 1 st attempt: Group A = 35/47 (74.5%); Group B = 28/48 (58.3%). Overall success rate of insertion: Group A = 46/47 (97.8%); Group B = 46/48 (95.8%). Intubation time, mean (SD): Group A = 17.2 (9.3) s; Group B = 18.9 (13.0) s. Complication rate: (1) Mucosal bleeding: Group A = 4/47 (8.5%); Group B = 4/48 (10.4%); (2) Coiling: Group A = 11/47 (23.4%); Group B = 17/48 (35.4%); and (3) Kinking: Group A = 2/47 (4.3%); Group B = 1/48 (2.1%)
Tsai <i>et al</i> [22], 2012	Taiwan	103	Patients scheduled for gastrointestinal or hepatic surgery under GA	Single anesthetist; practice of both techniques for 2 wk with 20 patients per technique	Control (C): Conventional technique with head in a neutral position and NGT through nostril; Intervention (I)- NGT insertion with help of "Rusch" intubation stylet tied together at the tips by a slipknot	Success rate on 1 st attempt: C = 27/50 (54.0%); I = 50/53 (94.3%). Overall success rate of insertion: C = 32/50 (64.0%); I = 52/53 (98.1%). Intubation time, mean (SD): Control = 39.5 (19.5) s; I = 40.3 (23.2) s. Complication rate: (1) Mucosal bleeding: Control = 6/50 (12.0%); I = 6/53 (11.3%); and (2)

						Kinking: C = 9/50 (18.0%); I = 0/53 (0.0%)
Kirtania <i>et al</i> [23], 2012	India	480	Patients scheduled for gastrointestinal surgery under GA	2 independent operators trained by authors before the study; the operators demonstrated the techniques on one patient each before the study	Group 1: NGT placement with esophageal guidewire with manual forward displacement of larynx; Group 2: Neck flexion with lateral neck pressure	Success rate on 1 st attempt: Group 1 = 230/240 (99.2%); Group 2 = 136/240 (56.7%). Overall success rate of insertion: Group 1 = 240/240 (100.0%); Group 2 = 205/240 (85.4%). Intubation time, mean (SD): Group 1 = 54.9 (7.4) s; Group 2 = 90.1 (43.6) s. Complication rate: (1) Mucosal bleeding: Group 1 = 10/240 (4.2%); Group 2 = 36/240 (15.0%); (2) Coiling: Group 1 = 2/240 (0.8%); Group 2 = 104/240 (43.3%); and (3) Moderate injury: Group 1 = 1/240 (0.42%); Group 2 = 9/240 (3.8%)
Shwetha Odeyar <i>et al</i> [24], 2019	India	60	Patients scheduled for laparoscopic or laparotomy under GA	Single anesthesiologist	Group A: Conventional technique with head in a neutral position and NGT through nostril; Group B: Reverse Sellick's maneuver	Success rate on 1 st attempt: Group A = 6/30 (20.0%); Group B = 14/30 (46.7%). Overall success rate of insertion: Group A = 27/30 (90.0%); Group B = 27/30 (90.0%). Intubation time, mean (SD): Group A = 97 (23.1) s; Group B = 84 (17.3) s. Complication rate: Mucosal bleeding: Group A = 2/30 (6.7%); Group B = 1/30 (3.3%)
Ghaemi <i>et al</i> [25], 2013	Islamic Republic of Iran	80	Patients undergoing elective GA and required NGT insertion	Single anesthesiologist	Control (C): Conventional technique with head in a neutral position and NGT through nostril; Intervention (I): NGT insertion same as control except the NGT was equipped with a Nelaton catheter. Nelaton equipped NGT was inserted through nostril as deeply as the Nelaton catheter length. Then the catheter was withdrawn and NGT was inserted further to reach the stomach	Overall success rate of insertion: C = 23/40 (57.5%); I = 36/40 (90.0%). Intubation time, mean (SD): Control = 92 (35) s; Intervention = 80 (43) s. Complication rate: Mucosal bleeding: C = 3/40 (7.5%); I = 5/40 (12.5%)
Kim <i>et al</i> [26], 2018	Korea	70	Patients undergoing gastrointestinal surgery under GA	Single anesthesiologist	Control: Conventional (C) technique with head in a neutral position and NGT through nostril; Intervention (I): NGT insertion using GlideScope and Modified Magill forceps	Success rate on 1 st attempt: C = 13/35 (37.1%); I = 35/35 (100.0%). Overall success rate of insertion: C = 26/35 (74.3%); I = 35/35 (100.0%). Intubation time, mean (SD): C = 96.7 (57.5) s; I = 71.3 (22.6) s
Kim <i>et al</i> [27], 2016	Korea	100	Patients undergoing gastrointestinal surgery under GA	Not Specified	Control: Conventional (C) technique with head in a neutral position and NGT through nostril; Intervention (I): NGT insertion same as the control except that a lubricated tube exchanger was used to facilitate insertion	Success rate on 1 st insertion: C = 34/50 (68.0%); I = 46/50 (92.0%). Overall success rate of attempt: C = 46/50 (92.0%); I = 50/50 (100.0%). Intubation time; Mean (SD): C = 75.1 (9.8) s; I = 18.5 (8.2) s. Complication rate: (1) Mucosal bleeding: C = 9/50 (18.0%); I = 1/50 (2.0%); and (2) Kinking: C = 10/50 (20.0%); I = 0/50 (0.0%)
Singh <i>et al</i> [28], 2016	India	300	Patients requiring admission to intensive care unit and NGT insertion	3 rd year anesthesia residents judged proficient in insertion techniques	Control group: Manual anterior displacement of cricoid cartilage and NGT insertion; Group W: NGT insertion using guidewire; Group B: Combination of Manual anterior displacement of cricoid cartilage and guidewire	Success rate on 1 st attempt: Control = 64/100 (64.0%); Group B = 88/100 (88.0%); Group W = 84/100 (84.0%). Overall success rate of insertion: Control = 82/100 (82.0%); Group B = 97/100 (97.0%); Group W = 90/100 (90.0%). Intubation time, mean (SD): Control = 60.2 (20.9) s; Group B = 39.3 (9.6) s; Group W = 42.9 (10.1) s. Complication rate: (1) Mucosal bleeding: Control = 3/100 (3.0%); Group B = 7/100 (7.0%); Group W = 7/100 (7.0%); and (2) Kinking: Control = 7/100 (7.0%); Group B = 1/100 (1.0%); Group W = 2/100 (2.0%)
Moharari <i>et al</i> [29], 2010	Iran	80	Patients requiring intraoperative placement of NGT	Single anesthesiologist	Control group (C): Conventional technique with head in a neutral position and NGT through nostril; Intervention (I): NGT inserted and placed using GlideScope	Success rate on 1 st attempt: Control = 23/40 (57.5%); I = 34/40 (85.0%). Overall success rate of insertion: Control = 27/40 (67.5%); Intervention = 35/40 (87.5%). Intubation time, mean (SD): Control = 38.6 (29) s; Intervention

visualization

= 10.9 (9.0) s. Complication rate:
Mucosal bleeding: Control = 14/40
(35.0%); Intervention = 8/40 (20.0%)

NGT: Nasogastric tube.

Comparison between the conventional NGT placement technique and the reverse Sellick's maneuver

The results of the meta-analysis indicated a nearly 2-fold increased chance of successful first insertion using the reverse Sellick's maneuver than using the conventional technique (RR 1.94; 95% CI: 1.62-2.31) (Figure 2). Similarly, we found a significant difference in overall successful insertion among the two groups (RR 1.26; 95% CI: 1.04-1.52). The pooled mean time involved in NGT placement was comparatively less in the trial with the reverse Sellick's maneuver than in the trial with the conventional technique (WMD: -10.34; 95% CI: -13.99 to 6.68) (Supplementary Figure 1). The reverse Sellick's maneuver was associated with a reduced risk of coiling (RR 0.32; 95% CI: 0.18-0.58), but not with mucosal bleeding (RR 0.73; 95% CI: 0.38-1.43) or kinking of the tube (RR 0.31; 95% CI: 0.02-6.23) (Supplementary Figure 2). We found no evidence of publication bias ($P = 0.8$) (Supplementary Figure 3).

Comparison between conventional NGT placement technique and neck flexion with lateral neck pressure

The results of our meta-analysis indicated a 1.64-fold increased chance of successful first insertion using neck flexion with lateral neck pressure (NFLNP) than using the conventional technique (RR 1.64; 95% CI: 1.10-2.45) (Figure 3). Also, with NFLNP, the chance of overall successful insertion was 1.26 times higher than that with the conventional technique (RR 1.26; 95% CI: 1.05-1.52). The pooled mean time involved in placement of the NGT was statistically similar for the two groups [WMD: -7.60; 95% CI: -17.73 to 2.53] (Supplementary Figure 4). NFLNP was associated with a reduced risk of coiling (RR 0.40; 95% CI: 0.24-0.65) and kinking of the NGT (RR 0.45; 95% CI: 0.26-0.79), but no significant effect on the risk of mucosal bleeding was noted (RR 0.86; 95% CI: 0.46-1.63) (Supplementary Figure 5). We found no evidence of publication bias ($P = 0.912$) (Supplementary Figure 6).

Comparison between conventional NGT placement technique and use of frozen NGT

The pooled estimates indicated a 1.55-fold increased chance of successful first insertion using frozen NGTs compared to the use of the conventional technique (RR 1.55; 95% CI: 1.13-2.13) (Figure 4). However, only one study provided this comparison. Moreover, the chance of overall successful insertion was 1.32 times higher with the use of frozen NGTs (RR 1.32; 95% CI: 1.13-1.54). The pooled mean time involved in NGT placement was statistically similar for the two groups [WMD: -13.39; 95% CI: -48.10 to 21.33] (Supplementary Figure 7). We found no differences in terms of the risk of complications between the two groups; pooled risk of mucosal bleeding (RR 1.86; 95% CI: 0.14-24.08), or risk of NGT coiling (RR 1.33; 95% CI: 0.69-2.59) and risk of kinking of NGT (RR 0.75; 95% CI: 0.28-2.04) (Supplementary Figure 8). We found no evidence of publication bias ($P = 0.317$) (Supplementary Figure 9).

Comparison between conventional NGT placement technique and endotracheal tube-assisted NGT placement

The pooled estimates indicated an approximately 2-fold increased chance of successful first insertion with endotracheal tube-assisted NGT placement than with the conventional technique (RR 1.88; 95% CI: 1.52-2.32) (Figure 5). The chance of overall successful insertion was 1.5 times higher with the endotracheal tube (RR 1.52; 95% CI: 1.29-1.79). The pooled mean time involved in NGT placement was statistically similar for the two groups (WMD: -15.57; 95% CI: -87.55 to 56.41) (Supplementary Figure 10). We found no differences in the risk of mucosal bleeding (RR 1.20; 95% CI: 0.60-2.43) or kinking (RR 0.09; 95% CI: 0.01-1.57) between the two groups. However, the risk of coiling (RR 0.05; 95% CI: 0.00-0.79) of the NGT was close to being significantly different and reflected the decreased risk with the use of an endotracheal tube (Supplementary Figure 11). We found no evidence of publication bias ($P = 0.312$) (Supplementary Figure 12).

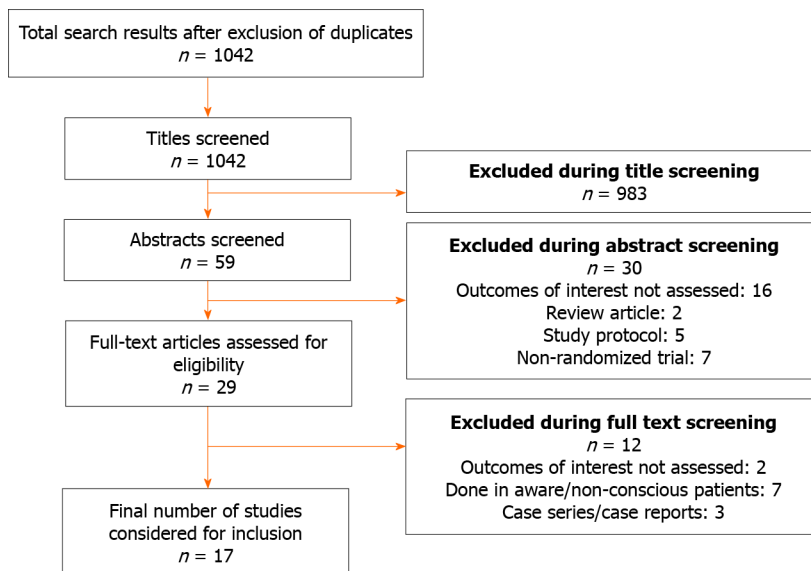


Figure 1 Selection process of the studies included in the review.

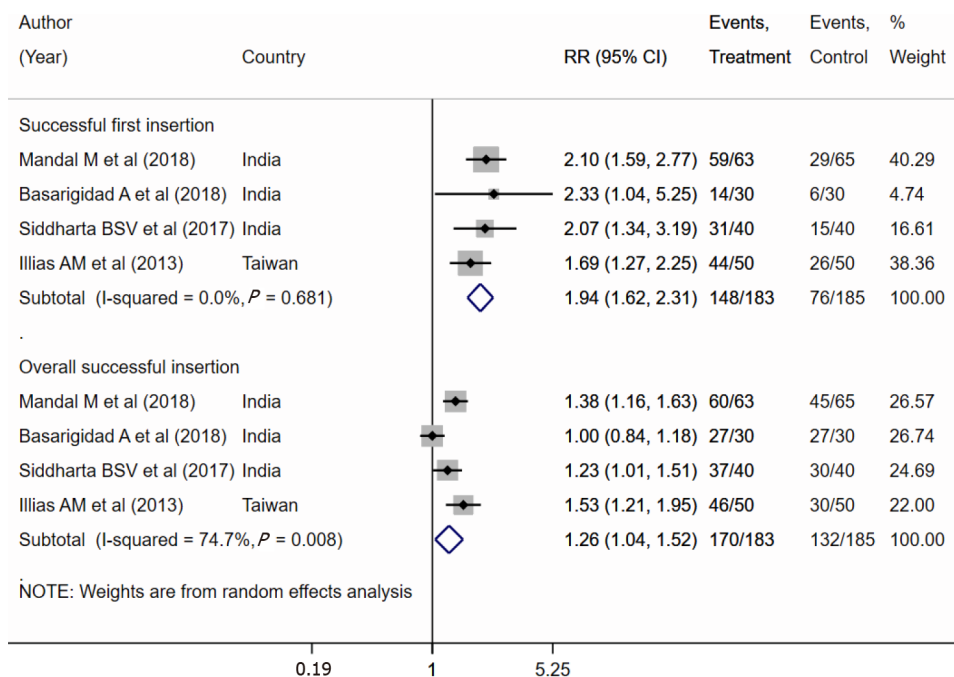


Figure 2 Comparison between the conventional technique and the reverse Sellick's maneuver in terms of successful first and overall insertions. RR: Relative risk; CI: Confidence interval.

Comparison between conventional NGT placement technique and video-assisted NGT placement

The chances of successful insertion in the first attempt were 1.60 times higher (RR 1.60; 95%CI: 1.31-1.95) with video-assisted placement than with the conventional technique (Figure 6). Similarly, video-assisted placement led to a higher chance of overall successful insertion (RR 1.41; 95%CI: 1.20-1.64). The pooled mean time involved in NGT placement was comparatively less with the video-assisted technique than with the conventional technique (WMD: -22.71; 95%CI: -29.79 to -15.64) (Supplementary Figure 13). We found no differences in the risks of mucosal bleeding (RR 0.30; 95%CI: 0.05-1.74) between the two groups. The risk of coiling (RR 0.10; 95%CI: 0.01-0.75) was decreased with the use of video-assisted NGT placement (Supplementary Figures 14 and 15).

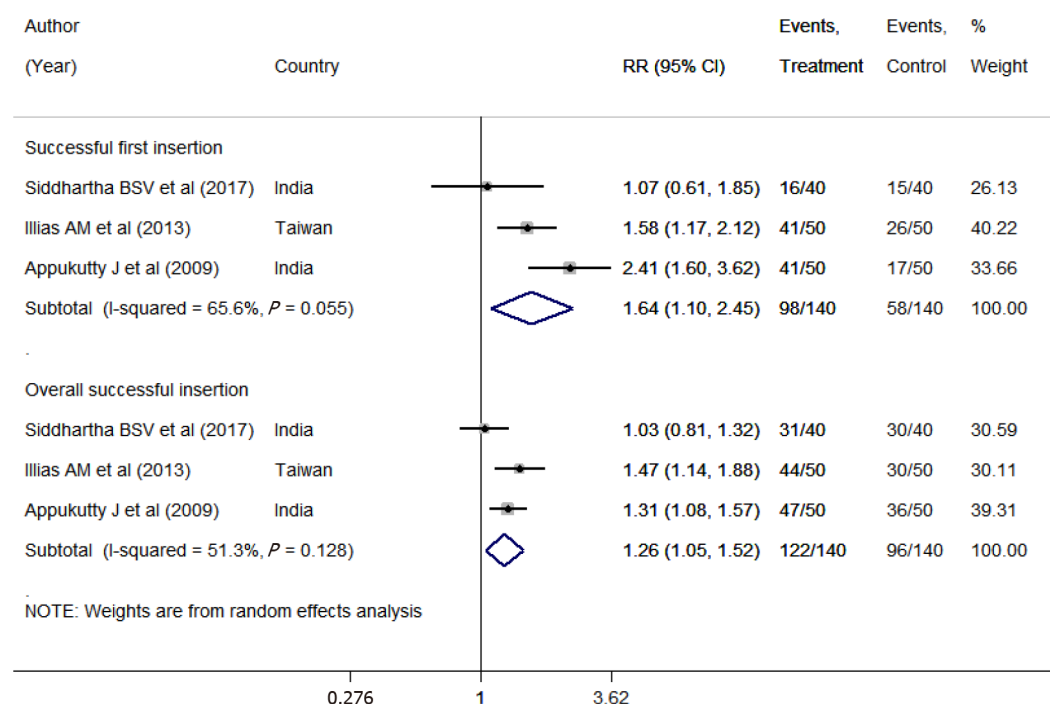


Figure 3 Comparison between the conventional technique and neck flexion with lateral neck pressure in terms of successful first and overall insertions. RR: Relative risk; CI: Confidence interval.

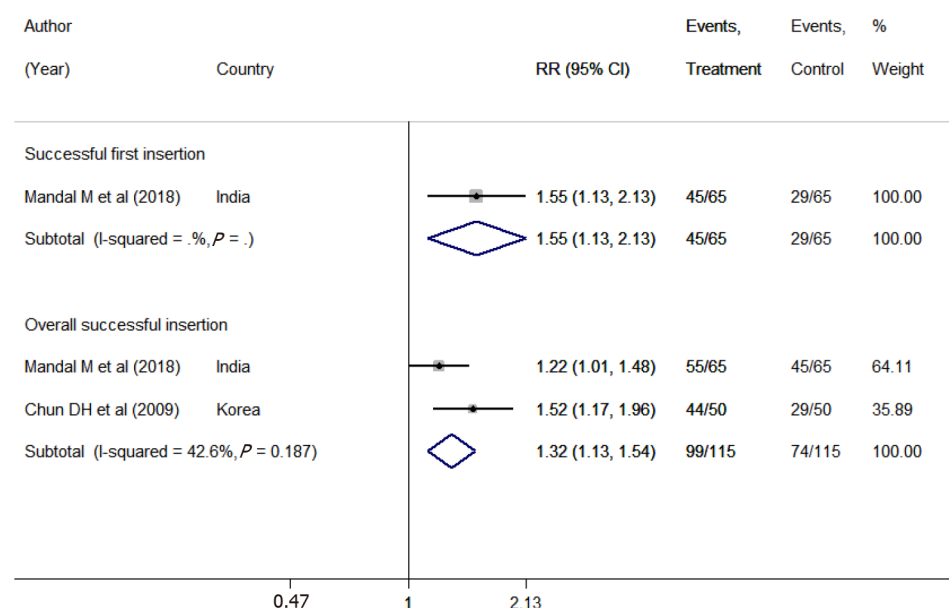


Figure 4 Comparison between the placement of a normal nasogastric tube and frozen nasogastric tube in terms of successful first and overall insertions. RR: Relative risk; CI: Confidence interval.

Additional observations and findings from studies

A summary of the meta-analysis for the successful placement of NGT is presented in Table 2. Some studies could not be pooled in the meta-analysis because the insertion techniques tested were not used in other studies. Zhao *et al* [13] compared the conventional NGT insertion technique with NGT placement in the right lateral decubitus position and found a statistically significant difference in the rates of successful insertion in the first attempt, overall success, insertion time, and complications (gag reflex, cough, and mucosal bleeding) with the right lateral decubitus position. Ghaemi *et al* [25] compared Nelaton catheter-assisted NGT placement with the conventional technique and showed a higher rate of successful insertion with relatively shorter insertion duration in the Nelaton group. Wan Ibadullah *et al* [21] documented a higher,

Table 2 Summary of findings based on the pooling of available literature

Techniques compared/outcomes	Success on 1 st insertion	Overall success of insertion
Reverse Sellick's maneuver <i>vs</i> conventional technique	RR 1.94; 95%CI: 1.62-2.31	RR 1.26; 95%CI: 1.04-1.52
Neck flexion with lateral neck pressure <i>vs</i> conventional technique	RR 1.64; 95%CI: 1.10-2.45	RR 1.26; 95%CI: 1.05-1.52
Frozen nasogastric tube <i>vs</i> conventional technique	RR 1.55; 95%CI: 1.13-2.13	RR 1.32; 95%CI: 1.13-1.54
Endotracheal tube-guided <i>vs</i> conventional technique	RR 1.88; 95%CI: 1.52-2.32	RR 1.52; 95%CI: 1.29-1.79
Video-assisted <i>vs</i> conventional technique	RR 1.60; 95%CI: 1.31-1.95	RR 1.41; 95%CI: 1.20-1.64

Conventional technique implies head in a neutral position and nasogastric tube inserted through nostril. RR: Risk ratio; CI: Confidence interval.

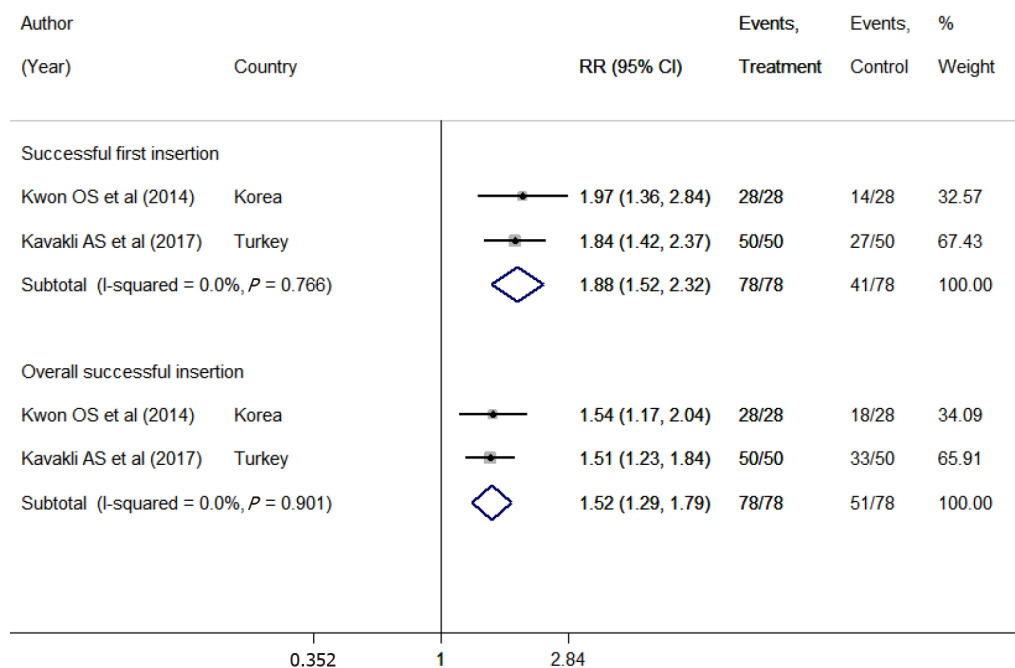


Figure 5 Comparison between the conventional nasogastric tube placement technique and endotracheal tube-assisted placement in terms of successful first and overall insertions. RR: Relative risk; CI: Confidence interval.

although non-significant, success rate of insertion for the GlideScope compared to the Macintosh laryngoscope. Appukutty *et al*[17] compared a slit endotracheal tube and guidewire with the conventional method and showed similar success rates. Kirtania *et al*[23] showed that the esophageal guidewire-guided technique with a manual shift of the larynx resulted in correct NGT placement in anesthetized patients and had a low incidence of complications and comparatively shorter insertion times.

DISCUSSION

A meta-analysis of available data indicated that modified techniques of NGT insertion (use of reverse Sellick's maneuver, NFLNP, frozen NGT, endotracheal tube or video-assisted method) results in a significantly improved success on first attempt compared with the conventional technique of NGT placement. Similarly, all modified methods significantly improved the overall success rate of NGT insertion.

Failure of NGT insertion in patients who are unconscious and anesthetized frequently results due to impaction of the tube at the piriform sinuses and arytenoid cartilages or due to esophageal compression by the endotracheal tube cuff[16,17]. Therefore, as demonstrated by our results, techniques that aid in avoiding these obstructions result in better success as compared to the conventional method. The reverse Sellick's maneuver lifts the larynx and opens the esophagus for passage of the NGT. On the other hand, in the NFLNP technique, lateral pressure causes a collapse of

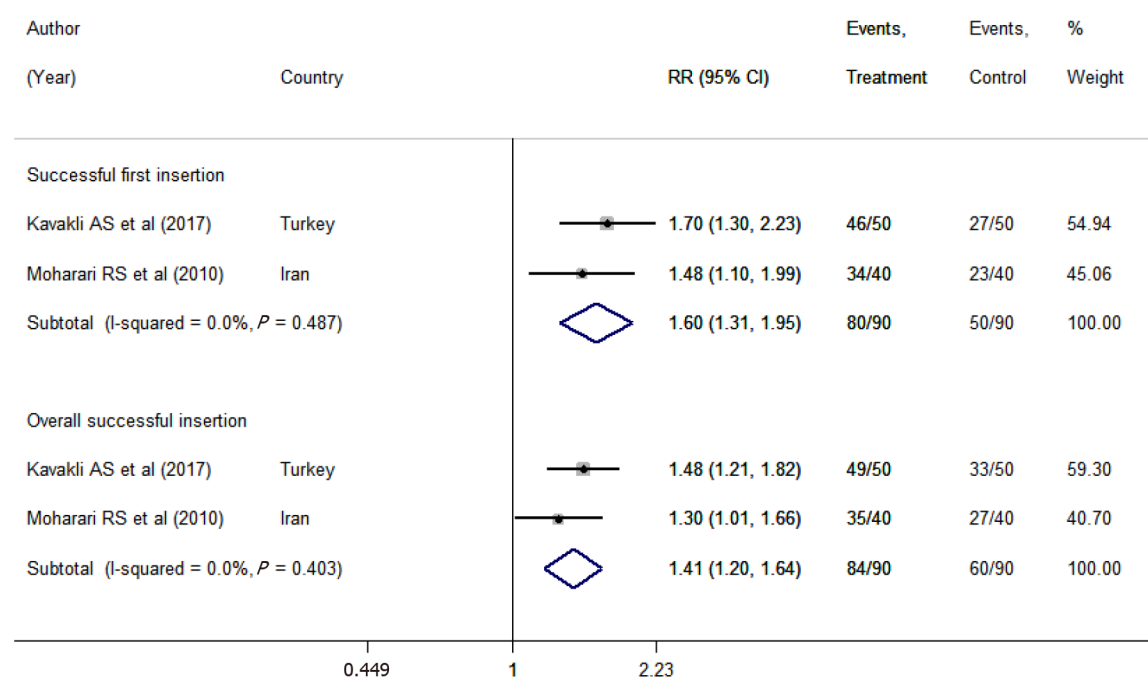


Figure 6 Comparison between the conventional nasogastric tube placement technique and video-assisted placement in terms of successful first and overall insertions. RR: Relative risk; CI: Confidence interval.

the pyriform sinus and lateral shifting of the arytenoid cartilage removing obstructions, while simultaneous neck flexion aids in keeping the NGT along the posterior pharyngeal wall[16]. The failure of NGT insertion is also correlated with the flexibility of the tube. As the distal portion of the NGT has multiple openings, the end is relatively flexible and prone to coiling or kinking[14]. Freezing the tube improves rigidity thereby reducing kinking and aiding successful insertion[15]. To improve passage, endotracheal tubes have also been used as a guide for inserting an orogastric or NGT[18,20]. The rigid endotracheal tube provides a conduit for NGT insertion resulting in better success as demonstrated by our results. While the majority of modified techniques, as well as the conventional method, are blind, the use of video-assisted techniques provides direct visualization of the larynx and the esophagus resulting in the improved success of NGT insertion[21].

Despite all modified methods achieving better success rates of NGT insertion as compared to the conventional technique, a statistically significant difference in the mean time to tube insertion was found with only two techniques in our study. The mean intubation times were significantly reduced only in the case of the reverse Sellick's maneuver and with video-assisted placements. It is important to note that, only a few studies were available for meta-analyses for each comparison and results may have been skewed due to the limited data. Also, there was wide variation in the time to insertion of the NGT in the included studies. This may be attributed to the varied sample of the included trials, study settings, methodological differences, operator expertise, *etc.*

NGT insertion in an anesthetized and intubated patient can also cause trauma leading to patient complications. The incidence of complications increases with multiple attempts of insertion and instrumentation[3]. Therefore, strategies that increase the first attempt success rate and ease of NGT placement could also reduce the complication rate. However, in contrast, the results of our study indicate that none of the modified techniques were able to reduce the risk of mucosal bleeding as compared to the conventional method. This may be attributed to the methodological differences of the included studies such as variation of outcome definition, differences in patient population (use of anticoagulants or presence of bleeding disorders) and the limited data pooled in the meta-analysis. Our results showed that the risk of NGT coiling was significantly reduced with all techniques, except with frozen NGTs. The risk of NGT kinking during placement was reduced only with the NFLNP technique.

We are aware of the limitations of this meta-analysis. Firstly, while the quality of the studies included was good, most of them were conducted on a limited study population; and therefore, the strength and generalizability of the evidence are limited. Also, due to the limited studies on some techniques, not all insertion methods were

compared in the meta-analysis and comparisons of some techniques were only presented in a descriptive format. Secondly, since our study included only RCTs, it is possible that other techniques of NGT insertion described in non-randomized or retrospective studies could have been missed. Thirdly, successful NGT placement largely depends upon the skill of the medical personnel. Different practitioners with a variable level of expertise were involved in the insertion of NGTs in the included trials and this may have influenced outcomes.

CONCLUSION

To conclude, our study indicates that the use of modified techniques of NGT insertion such as the reverse Sellick's maneuver, NFLNP, frozen NGT, endotracheal tube-guided or video-assisted method result in a significantly better chance of successful tube insertion at first attempt as compared to the conventional technique. All modified techniques also significantly improve the overall chances of successful NGT placement as compared to the conventional method. Insertion times were significantly reduced with the use of the reverse Sellick's maneuver and with video-assisted placements. None of the modified techniques were able to reduce the incidence of mucosal bleeding as compared to the conventional method. However, strong conclusions cannot be drawn due to the lack of coherent studies and limited data available. Further homogenous large-scale RCTs comparing multiple techniques of NGT insertion are needed to strengthen the evidence on this important subject.

ARTICLE HIGHLIGHTS

Research background

Several techniques of nasogastric tube (NGT) insertion have been described in the literature with different success rates. The best NGT insertion method is still unclear.

Research motivation

No meta-analysis has summarized the evidence with the intent to provide reliable information both in terms of relative advantages of the techniques and their associated complication rates.

Research objectives

To compare the success rates, insertion time, and complications associated with different techniques of NGT insertion in anesthetized and intubated patients.

Research methods

An electronic search of the PubMed, Scopus, CENTRAL (Cochrane Central Register of Controlled Trials), and Google Scholar databases was performed up to October 31, 2019.

Research results

Seventeen randomized controlled trials (RCTs) featuring data on 2500 patients showed that successful insertion of the NGT on the first attempt was higher with modified techniques such as the reverse Sellick's maneuver, use of a frozen NGT, adopting neck flexion and lateral neck pressure, as well as endotracheal tube-assisted and video-assisted placements. All modified techniques also led to comparatively higher overall insertion success rates.

Research conclusions

The use of modified techniques of NGT insertion appears superior to conventional methods. However, limited available data makes drawing a strong conclusion difficult.

Research perspectives

Further homogenous large-scale RCTs comparing multiple techniques of NGT insertion are needed to strengthen the evidence on this important subject.

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