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Systematic Review

RETRACTED: Efficacy of Intermittent and Continuous Subglottic Secretion Drainage in Preventing the Risk of Ventilator-Associated Pneumonia: A Meta-Analysis of Randomized Control Trials

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Abstract: Ventilator-associated pneu[illegible]nia (VAP) is hospital-acquired pneumonia that develops 48 h or longer following mechanical vent[illegible]tion. However, cuf[illegible] pressure fluctuates significantly due to patient or tube movement, which mi[illegible] result in micr[illegible]aspiration. Subglottic secretion drainage (SSD) has been suggested as a method [illegible]AP p[illegible]ention bundles. This systematic review and meta-analysis aims to in[illegible]te the efficacy and safety of subglottic SSD in preventing VAP. The secondary outcomes of th[illegible]s study [illegible]o investigate the intensive care unit (ICU) stay length and mortality rate regarding VA[illegible] This study fo[illegible]owed the Preferred Reporting Item for Systematic Review and Meta-A[illegible]lysis guidelin[illegible] A thorough search of PubMed, Embase, and the Web of Science was conduct[illegible]d betw[illegible]en June and [illegible]ugust 2022. The study analysis used the Mantel–Haenszel method, and th[illegible] quality [illegible]f the include[illegible]tudy was assessed using the Cochrane Risk of Bias 2. Eighteen randon[illegible]d co[illegible]lled trials with a total of 2537 intubated patients were included. It was found that SSD was a[illegible]ciated with a lower risk of VAP (RR 1.44; 95% CI; 1.20–1.73; $p < 0.0001$). The subgroup analysis (utili[illegible] intermittent and continuous methods) found no statistically significant difference between the two [illegible]ups ($p = 0.28$). The secondary endpoints showed that there was no significant [illegible]ference in mo[illegible]tality (RR 1.02; 95% CI; 0.87–1.20; $p = 0.83$), but there were substantial differences in I[illegible] stays (mean difference, 3.42 days; 95% CI; 2.07–4.76; $p < 0.00001$) in favor of the SSD group. This w[illegible]s based on a very low certainty of evidence due to concerns linked to the risk of bias and inconsi[illegible]tency. The use of SSD was associated with a reduction in VAP incidence and ICU stay length, but there was no significant difference in the mortality rate.

Keywords: intensive care unit; ventilator-associated pneumonia; subglottic secretion drainage; mechanical ventilation; health risk; infectious diseases

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1. Introduction

Patients who are critically ill and frequently admitted to the intensive care unit (ICU) need invasive breathing support [1]. This invariably demands tracheal intubation to be performed to ensure free air admission. Additionally, an endotracheal cuff is wrapped around the tube's tip to seal the extraluminal airway and enable positive pressure ventilation [1]. Incorrect regulation of cuff pressure may contribute to the difficulties associated with the use of a ventilator [2,3]. Patients in ICUs who have been on a ventilator for more than 48 h may develop ventilator-associated pneumonia (VAP) at some point [4,5]. This has

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significant clinical and economic implications, particularly in terms of the accompanying ICU and hospital stay length and mortality rate [6,7].

The microbial invasion of the normally sterile lower respiratory tract and lung parenchyma that leads to VAP can overcome the host's defenses, allowing infection to spread. The aspiration of bacteria-tainted secretions that have accumulated above the endotracheal tube (ET) cuff is the most common way bacteria enter the lower respiratory tract because it is the route they take when they enter the body [5,8]. As a result, subglottic secretion drainage (SSD) is a technique that has been suggested for inclusion in VAP prevention bundles [1]. Additionally, earlier studies found that VAP was linked to greater mechanical ventilation time, longer hospital stays, consciousness issues, burns, comorbidities, prior antibiotic therapy, medication, and invasive procedures [9–12]. This study focuses on the causes of VAP due to SSD, which still lacks attention among health workers, especially nurses.

In preventing VAP, nurses have an important role during the treatment process. Regular patient monitoring and maintenance are necessary. Previous research stated that increasing the level of education would have an impact on the knowledge, attitudes, and practices of nurses in providing care and making optimal decisions [13]. However, comprehensive training on VAP is needed to increase the knowledge, compliance, and practice levels of critical care nurses [14]. Increasing the quality of care and preventing VAP can have an impact on improving patients' quality of life [15].

Although there is a recent meta-analysis regarding the effectiveness, the number of samples and years of study are limited [16]. In addition, the meta-analysis only looked at the results of VAP prevention and mortality. This study intends to update the meta-analysis and investigate not only the ICU stay outcome but also the risk of VAP and mortality.

2. Materials and Methods

2.1. Study Design

This systematic review followed the Preferred Reported Item for Systematic Review and Meta-Analysis guidelines [17]. This study has been registered in the PROSPERO with the ID registration number (CRD42022372723).

2.2. Eligibility Criteria

During the screening procedure, each of the articles that were discovered were categorized according to the eligibility, inclusion, and exclusion criteria that were used. The population, intervention, comparison, outcome, and study framework served as the basis for the inclusion criteria, which were as follows: (1) population: ICU patients with mechanical ventilators; (2) intervention: SSD; (3) comparison: standard care (standard ET); (4) outcome: VAP incidence, ICU stay, and mortality; (5) study: randomized controlled trials (RCTs).

In addition, studies were disregarded if they met any of the following criteria: (1) they were conducted on children; (2) the complete texts of the articles were unavailable; (3) the papers were written in a language other than English; and (4) the study did not provide total event, mean, standard deviation, and sample numbers.

2.3. Search Strategy

A comprehensive search of the databases MEDLINE, Embase, and the Web of Science was carried out between June and August 2022. In addition, the reference lists of pertinent publications, such as previous reviews, were carefully examined and manually screened. A comprehensive search was carried out to find all of the articles that described the use of the continuous aspiration of subglottic secretion in intubated patients or the prevention of pneumonia. Additionally, the reference lists of pertinent publications, such as prior reviews, were manually reviewed for relevance. Each scientific database's search technique and Boolean operators are detailed in Appendix A, and the details of the literature-searching process are depicted in Figure 1.

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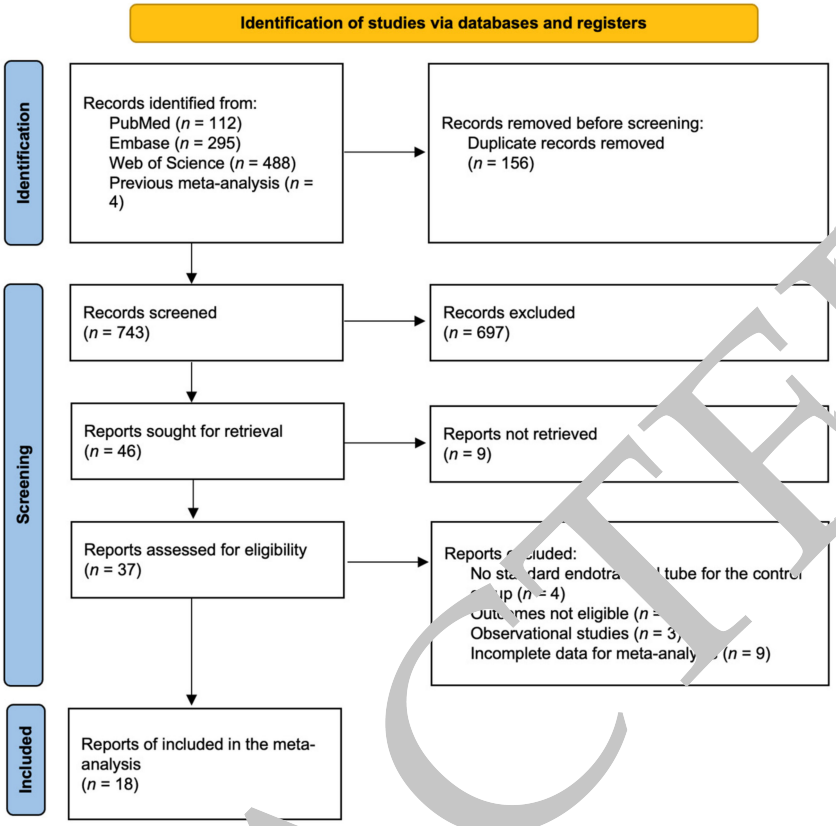


Figure 1. Preferred Repo ed for Systematic Review and Meta-Analysis flow diagram.

2.4. Data Extraction and Quality Assessment

The primary aim was to investigate the efficacy of SSD in preventing VAP incidents. The secondary aim was to investigate the ICU stay lengths and mortality rate. Using a qualitative technique, the results were tabulated with descriptions. Information such as the author and year, study design, country of the study, participant characteristics, intervention, mean or median age, number of participants, outcome with the total event and sample data (for VAP and mortality outcome), and mean standard deviation (for ICU stays) are shown.

The final included studies were assessed for their potential for bias with the help of the revised tool for Risk of Bias in randomized trials 2, which comprises five different domains for initiative studies. The author conducted an analysis of the potential for bias using the formula that was developed by the Cochrane Collaboration. Heterogeneity was evaluated using I^2 statistics with categories as insignificant, low, moderate, and high (cut-off limits of 0%, 25%, 50%, and 75%, respectively) [18].

2.5. Pooled Analysis

Using the Review Manager 5.4 statistical program, a meta-analysis was conducted (Cochrane Collaboration, Oxford, UK). The dichotomous data clinical result was expressed as a risk ratio (RR) for VAP, and continuous data were expressed as a mean difference for ICU stays. An appropriate 95% confidence interval was determined.

2.6. Subgroup Analysis

An additional analysis—a subgroup analysis—was carried out because the studies reported different methods of SSD. The information was partitioned into intermittent and continuous groups. Following the same methodology as the prior pooled analysis, subgroups were evaluated to determine the RR for VAP incidents.

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3. Results

3.1. Characteristics of Included Studies

Eighteen RCTs yielding 2537 intubated patients in the ICU were included for quantitative analysis (see Figure 1). The included studies were conducted in several locations: Turkey (n = 1), China (n = 4), Iran (n = 8), Belgium (n = 1), the United States (n = 1), the United Kingdom (n = 1), India (n = 1), and France and Tunisia (n = 1). They were published between 2012 and 2022. The mean age of participants was >36, and they were further randomized into the intervention group and control group or several follow-up intervention groups. The setting of the studies in the ICU included surgical, medical, neurological, anesthesiology ICU, and surgical-cardiac ICU. Detailed literature search procedures are presented in Table 1. Most studies' distribution was conducted in Asian countries; therefore, this study's conclusion is highly biased.

Table 1. Characteristics of included studies.

Study	Design	Location	Setting	Age (Mean SD)	Gender (Male %)	Intervention of Treatment Group	Method of SSD
Akdogan et al. (2017) [19]	RCT	Turkey	Anesthesiology ICU	IG: 60.32 (21.55) CG: 61.4 (19.7)	IG: 28 (75.68) CG: 52 (54.17)	Endotracheal tube with subglottic drainage and cuff pressure monitorization	Continuous
Chai et al. (2022) [20]	RCT	China	ICU	-	CG: 24 (40%) IG: 6 (10.66%)	suction with 0.9% normal saline with 5% inhaled eucalyptus	-
Chen et al. (2016) [21]	RCT	China	ICU	I: 8 (12.0) CG: 8 (12.1)	IG: 16 CG: 25	subglottic secretion drainage	-
Chow et al. (2012) [22]	Pilot RCT	Iran	Surgical ICU	IG: 70.3 (14.3) CG: 79.4 (12.5)	56	SSD with the saliva ejector tube	Continuous
Damas et al. (2015) [23]	RCT	Belgium	ICU	IG: 66 (55–75) CG: 65 (55–75)	IG: 107 CG: 127	Subglottic secretion suctioning	-
Deem et al. (2016) [24]	Pilot RCT	USA	ICU	IG: 55 (17) CG: 53 (16)	10	Polyurethane-cuffed tube equipped with a port for continuous aspiration of subglottic secretions (PUC-CASS-ETT)	Continuous
Gopal et al. (2015) [25]	RCT	UK	Surgical and Cardiac ICU	IG: 72.4 (8.2) CG: 72.1 (7.4)	n = 699	SSD with Venner-PneuX tube	Intermittent
[illegible] et al. (2017) [26]	Pilot RCT	India	Neurological ICU	IG: 36.9 (12.8) CG: 42.2 (17.9)	32	Suction above cuff endotracheal tube (SACETT)	-
Mahmoodpoor et al. (2015) [27]	RCT	Iran	Surgical ICU	IG: 54.00 (19.49) CG: 55.71 (19.39)	67.2	Taperguard-Polyurethane cuff with the continuous aspiration of subglottic secretions	-
Mahmoodpoor et al. (2013) [27]	RCT	Iran	Surgical ICU	IG: 57.31 (19.77) CG: 55.71 (19.39)	64	Sealguard-Polyurethane cuff with continuous aspiration of subglottic secretions	-

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Table 1. *Cont.*

Study	Design	Location	Setting	Age (Mean SD)	Gender (Male %)	Intervention of Treatment Group	Method of SSD
Mahmoodpoor et al. (2017) [28]	A prospective random-ized trial	Iran	ICU	IG: 54.0 (19.2) CG: 54.5 (18.1)	IG: 102 CG: 84	Evac tube	Interm[illegible]
Mahmoodpoor et al. (2020) [29]	RCT	Iran	ICU	55	72.8	Polyurethane cuff[illegible]h continuou[illegible]spiratio[illegible] of subg[illegible]ttic secretions En[illegible]otrachea[illegible] tube w[illegible]bglottic[illegible]tion [illegible]or[illegible]	-
Mansoor et al. (2016) [30]	RCT	Iran	ICU	IG: 38.24 (24.71) CG: 43.35 (24.71)	IG: 27 CG: 1[illegible]	(Mali[illegible]rodt™ TaperGuard[illegible]ac Or[illegible] Trachea[illegible] Tube; Covid[illegible]en, Mexico)	Intermittent
Naghibi et al. (2019) [31]	A random-ized, double-blind, placebo-controlled trial	Iran	ICU	IG: 38 ([illegible]4) CG: 4[illegible]57 (14.5[illegible])	IG: 10 CG: 9	SSD with sodium chloride	Intermittent
Philippart et al. (2015)-a [32]	A multicenter, prospec-tive, open-label RCT	France and Tunisia	medical-surgical ICUs	[illegible] (52.0–77.2)	IG: 83 CG: 92	PVC, Cylindrical	Continuous
Philippart et al. (2015)-b [32]	a multicenter, prospec-tive, open-lab[illegible] RC[illegible]	Fra[illegible] and Tunisia	[illegible]edical-surg[illegible] ICUs	63.2 (53.4–76.4)	IG: 91 CG: 96	PVC, Conical	Continuous
Seyfi et al. (2013) [33]	[illegible]CT	Iran	[illegible]CU	-	-	SSD	-
Tao et al. (2014) [34]	RCT	Chi[illegible]	ICU	-	-	SSD	Intermittent and continuous
Qiao et al. (2018) [35]	RCT	China	ICU	IG: 65.1 (5.6) CG: 64.6 (7.6)	IG: 25 CG: 23	Bronchoscopic sputum suction	Continuous

3.2. The Outcome of Included Studies

3.2.1. Ventilator-Associated Pneumonia Outcomes

The results of a meta-analysis that evaluated the efficacy of SSD VAP prevention by comparing the usual care group and the SSD group are depicted in Figure 2 as a forest plot. The results indicate that there is a significant effect ($p < 0.0001$), and the RR was 1.44 (95% CI: 1.20–1.73). It was discovered that SSD could dramatically reduce VAP incidents in ICU patients with mechanical ventilation. It was also discovered that there was heterogeneity ($I^2 = 30\%$; $p = 0.10$).

According to the findings of the subgroup analysis, studies utilized intermittent and continuous methods in terms of both usual care and SSD intervention. The difference between the two groups was not statistically significant ($p = 0.93$). It was also discovered that there was heterogeneity ($I^2 = 0\%$). The results indicate that there is a significant effect

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between the intermittent (RR 1.54; 95% CI; 1.14–2.08; $p = 0.0005$; $I^2 = 0\%$) and continuous groups (RR 1.57; 95% CI; 1.19–2.07; $p = 0.001$; $I^2 = 0\%$). The details of the subgroup analysis are shown in Figure 3.

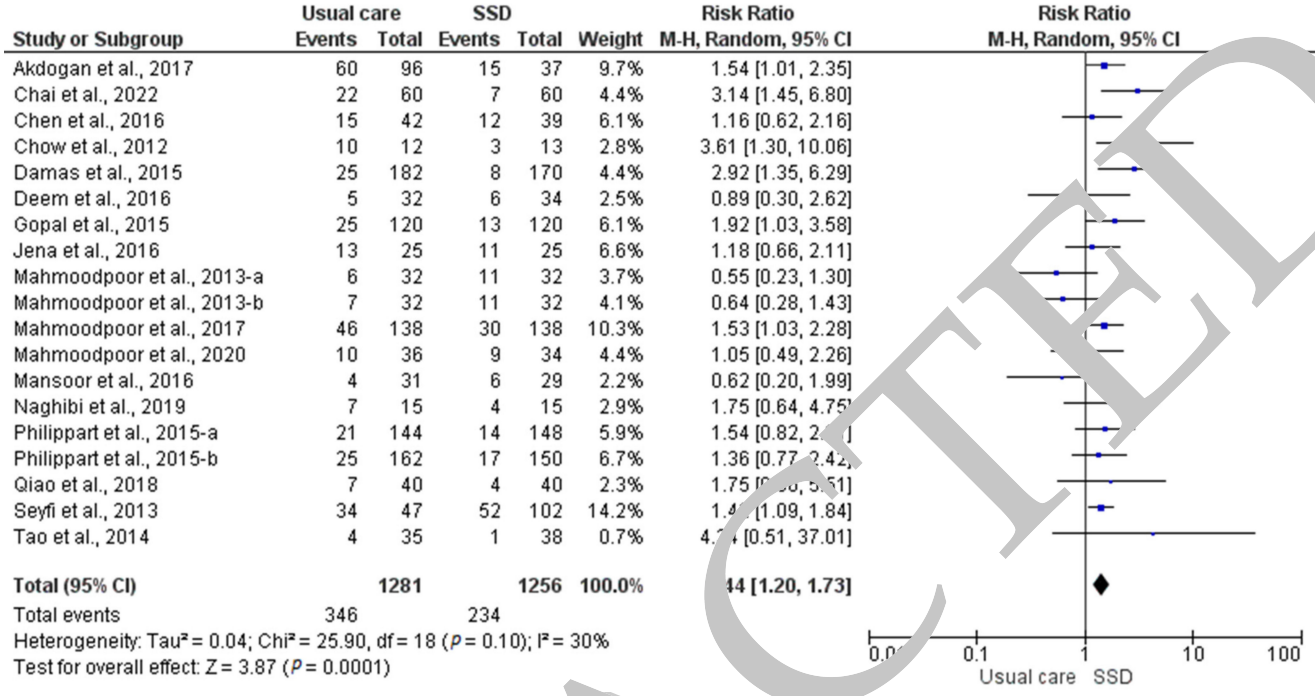


Figure 2. Risk of VAP in the usual care group vs. the SSD group.

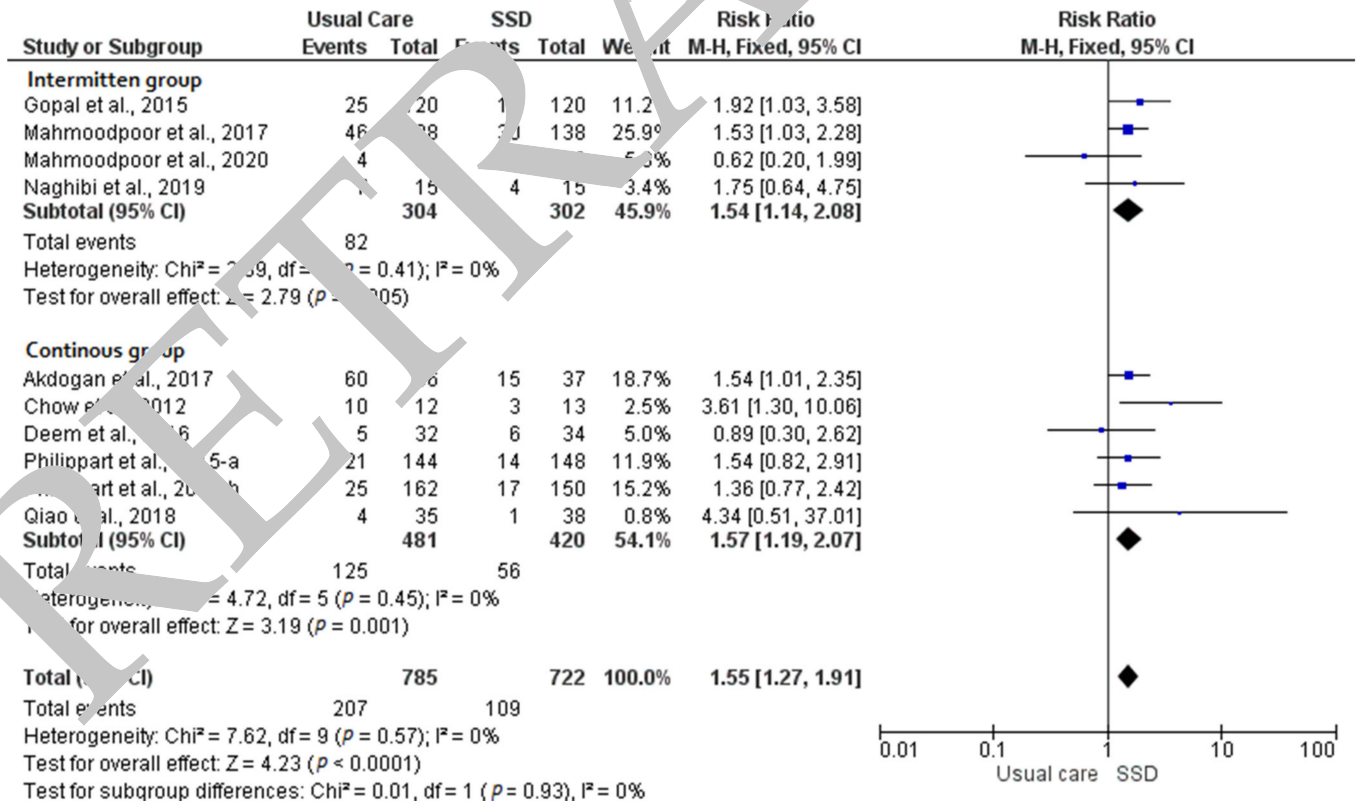


Figure 3. Subgroup analysis of VAP risk outcome between the usual care group and the SSD group [25,32].

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3.2.2. ICU Length of Stay Outcomes

The results of a meta-analysis that evaluated the efficacy of SSD on ICU length of stay outcomes by comparing the usual care group with the SSD group are depicted in Figure 4 as a forest plot. The results indicate that there is a significant effect ($p < 0.00001$), and the mean difference (MD) was 3.42 (95% CI: 2.07–4.76). It was discovered that SSD could dramatically reduce ICU length of stay among patients with mechani[illegible]ion. It was also discovered that there was heterogeneity ($I^2 = 0\%$; $p = 0.45$).

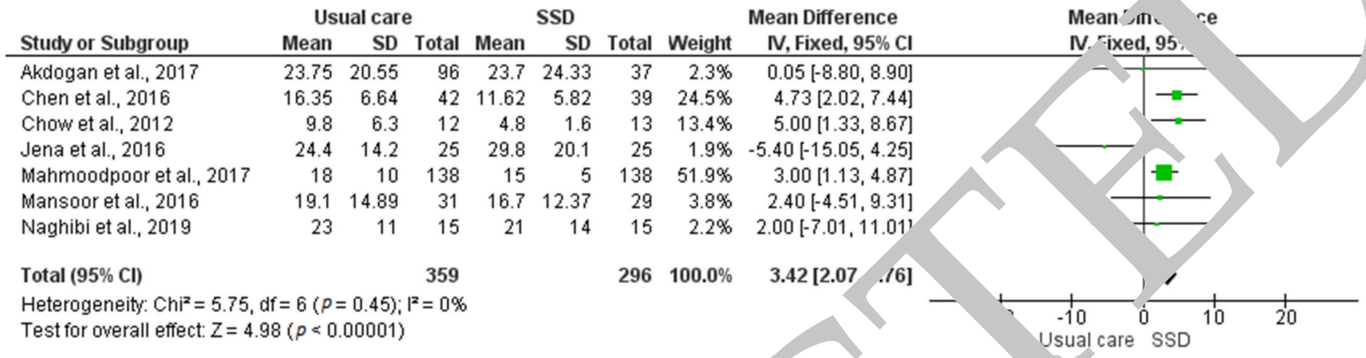


Figure 4. ICU length of stay in the usu[illegible] care group vs. the SSD gr[illegible]up.

3.2.3. Mortality Outcomes

The results of a meta-analysi[illegible]hat evaluated t[illegible]e efficacy of SSD mortality outcomes by comparing the usual care group v[illegible] the SSD g[illegible]up are depicted in Figure 5. The results indicate that there is n[illegible]ignificant effect[illegible].31), and the RR was 1.02 (95% CI: 0.87–1.20). It was discovered that [illegible]SD[illegible]no significant effect in reducing mortality incidents in ICU patients with mechanical venti[illegible]. It was also discovered that there was heterogeneity ($I^2 = 14\%$; $p = 0.83$).

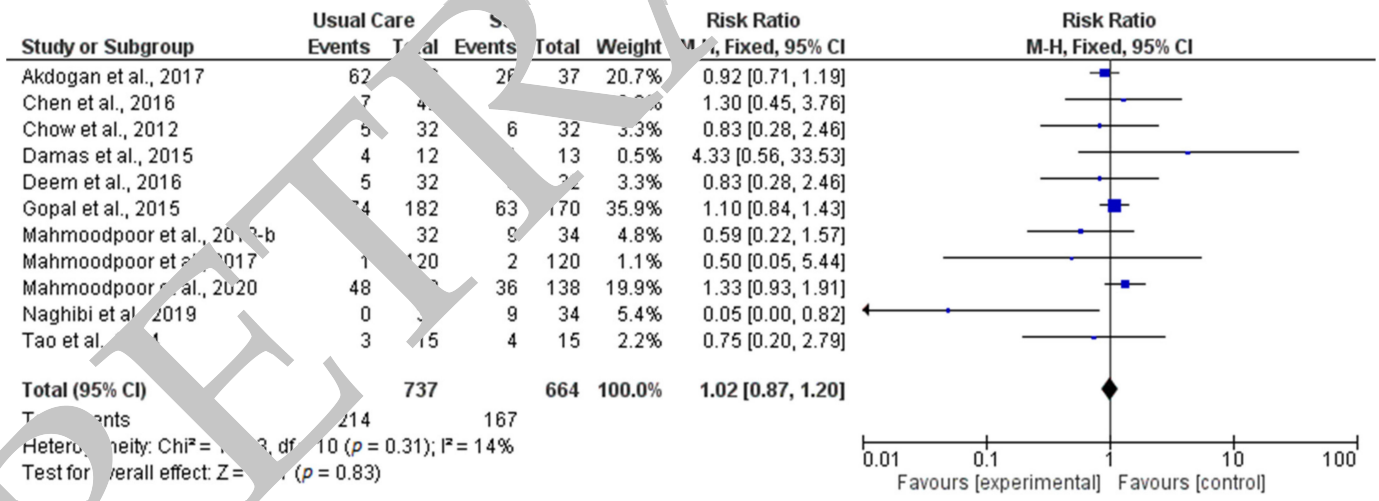


Figure 5. Mortality in the usual care group vs. the SSD group.

3.3. Quality of Included Studies

Most studies had moderate to low bias as individuals, and only two studies had high biases. Figure 6 shows the risk of bias in each included study. Overall, there was no blinding, and there were differences in the baseline preventive measures used in some studies. Figure 7 shows the summary risk of bias per component assessment.

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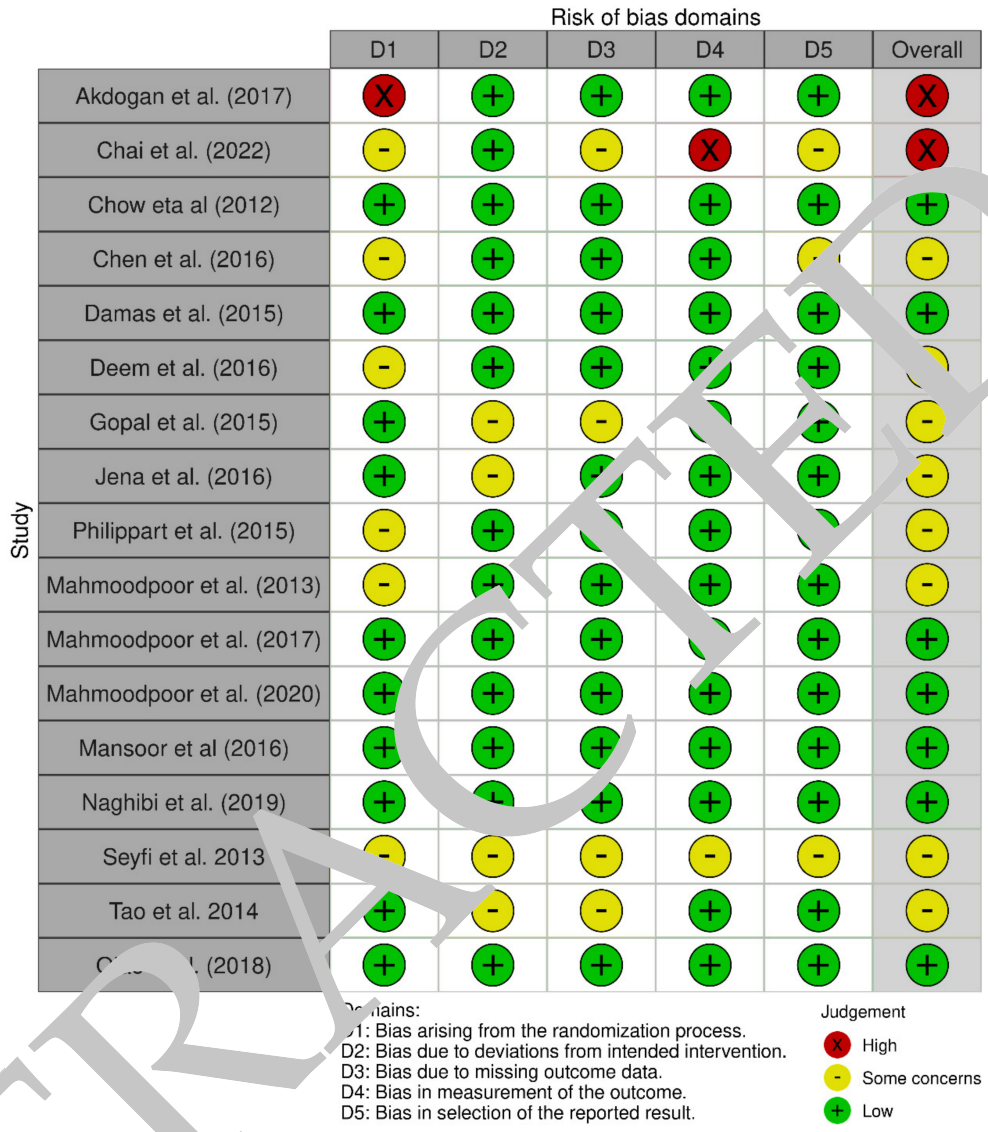


Figure 6. Traffic l t plot risk of bias.

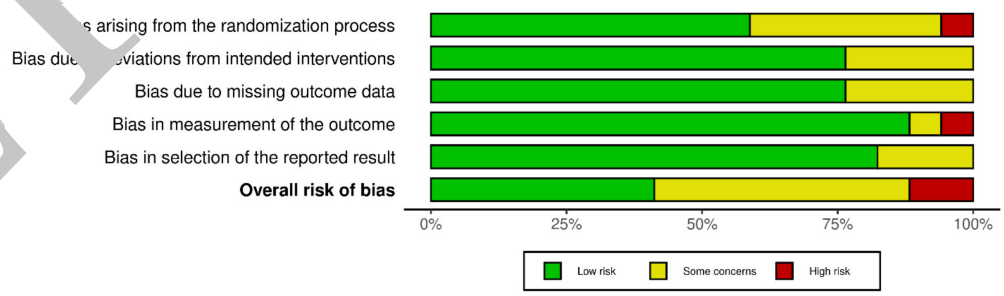


Figure 7. Summary of risk of bias.

4. Discussion

This study conducted a meta-analysis to investigate SSD compared with the standard ET used as usual care on ICU patients who are intubated with a mechanical ventilator. The risks of VAP, ICU length of stay, and mortality were also evaluated. This study is important and provides valuable information for nurses on preventing VAP. SSD is an important indicator that needs attention from nurses who may be missing SSD events, which can cause VAP [36,37]. It was found that SSD reduced the risk of VAP and ICU length of stay

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but did not significantly reduce the risk of mortality. This result is consistent with previous studies that reported reductions in VAP and ICU length of stay outcomes [1,16,38,39].

Ventilator-associated pneumonia is responsible for a considerable rise in the duration of mechanical ventilation, the length of stay in the ICU, the expense of that time, the need for antibiotic therapy, and patient mortality [40,41]. The accumulation of secretions in the gap between the glottis and the cuff during intubation, which cannot be removed by coughing, is the primary cause of VAP. Therefore, germs are more likely to spread throughout the lower respiratory tract [42].

In most cases, the treatment of VAP is carried out by a multidisciplinary team, including an ICU nurse [4]. When it comes to VAP, the most important thing is to lower the risk by requiring preventative practices in patient care. It is important to address all of the modifiable risk factors, one of which is endotracheal and tracheostomy positioning through SSD equipment [4]. It is also necessary to pay attention to the observation of the cuff pressure because low cuff pressure allows bacteria to enter the body [36,43,44]. Strengthening nurses through regular training needs to be done to improve knowledge, attitude, skills, and practice levels.

The efficacy of SSD in the VAP prevention bundle has been demonstrated through this meta-analysis. The incidence of VAP was observed to be correlated with ICU length of stay in observational studies [45–47], and this meta-analysis suggests that SSD may decrease ICU length of stay, possibly due to a reduced risk of VAP. Guidelines for the prevention of VAP have been developed in a number of countries [48]. These guidelines urge the use of an ET that is equipped with a subglottic suctioning lumen. However, there are still certain restrictions associated with using this method. For instance, expensive specialist tubes are necessary, and the treatment is frequently followed by problems such as mucosal injury to the airway [49,50].

This highlights that the generalization of the meta-analysis is very important. This meta-analysis showed insignificant heterogeneity; it only showed moderate heterogeneity in the risk of VAP outcome and low heterogeneity in the mortality outcome. This is mirrored by a clear symmetry in the funnel plot, which may show low bias. The protocol for this study was submitted to PROSPERO to strengthen the robustness and transparency of this systematic review and meta-analysis. Furthermore, a sub-group analysis was conducted for intermittent and continuous methods to minimize the bias of this study.

However, there are some limitations to this study. First, the clinical setting in which those trials were carried out may not have been representative of the overall ICU population, as most of the studies were conducted on the Asian population. Second, some interventions caused confounding in several of the studies that were included, namely polyurethane, sand and semi-recumbent positions. Finally, the primary problems with most of the included studies' bias were that there was no blinding, the study authors may have had potential commercial conflicts of interest, there were differences in the baseline preventive measures that were applied, there was a potentially high level of heterogeneity as a result of differences in methodology between studies, and there were differences in the devices used for SSD.

Based on this meta-analysis, there is moderate evidence that SSD can be used as an intervention in preventing VAP. SSD is one of several interventions in the VAP prevention bundle, including the administration of antibiotics [51]. However, adverse events, especially tracheal mucosal injury due to SSD administration, need to be considered. This meta-analysis did not observe an adverse event related to the administration of SSD, so a further meta-analysis is expected to add to these outcomes. In addition, adverse events and risk of death between intermittent and continuous methods were not observed in this meta-analysis because many of the included studies did not report the SSD method used or combined analysis of both in one group study.

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5. Conclusions

Subglottic secretion drainage has a reasonable amount of evidence supporting its usage as an intervention for the prevention of VAP. Moreover, SSD could reduce ICU length of stay but not the mortality rate. However, further studies are required to compare intermittent and continuous SSD, and more high-quality research is needed to determine SSD's potential role in medical care. Furthermore, a study to evaluate the cost-effectiveness of SSD usage needs to be conducted.

Author Contributions: Conceptualization, Y.S.D., H.A., R.O.P. and A.Q.; methodology, Y.S.D. and H.A.; software, R.O.P.; validation, A.Q., R.R. and C.N.G.; formal analysis, H.A.; investigation, Y.S.D.; data curation, H.A. and R.O.P.; writing—original draft preparation, Y.S.D., H.A., R.O.P. and A.Q.; writing—review and editing, Y.S.D., H.A., R.O.P., A.D.K.G. and A.Q.; project administration, A.Q., R.R. and C.N.G. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: This study has been registered in the PROSPERO with the ID registration number (CRD42022372723).

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

PubMed

#1 ((“ventilated”[All Fields] OR “ventilates”[All Fields] OR “ventilating”[All Fields] OR “ventilation”[MeSH Terms] OR “ventilation”[All Fields] OR “ventilate”[All Fields] OR “ventilations”[All Fields] OR “ventilate”[All Fields] OR “ventilators, mechanical”[MeSH Terms] OR (“ventilators”[All Fields] AND “mechanical”[All Fields]) OR “mechanical ventilator”[All Fields] OR “ventilator”[All Fields] OR “ventilators”[All Fields] OR “ventilation”[All Fields])

#2 ((“subglottal”[All Fields] OR “subglottic”[All Fields]) AND (“suction”[MeSH Terms] OR “suction”[All Fields] OR (“mechanical”[All Fields] AND “aspiration”[All Fields]) OR “mechanical aspiration”[All Fields]))

#3 (“pneumonia, ventilator associated”[MeSH Terms] OR (“pneumonia”[All Fields] AND “ventilator associated”[All Fields]) OR “ventilator-associated pneumonia”[All Fields] OR (“ventilator”[All Fields] AND “associated”[All Fields] AND “pneumonia”[All Fields]) OR “ventilator associated pneumonia”[All Fields]))

Embase:

#1 “subglottic mechanical aspiration” OR “subglottic mechanical suction” OR “mechanical aspiration” OR suction OR subglottic

#2 “ventilator-associated pneumonia” OR “ventilator associated pneumonia” OR pneumonia

Web of Science

#1 ((((ALL=(Ventilator-Associated Pneumonia)) OR ALL=(Pneumonia)) OR ALL=(Respiratory Tract Infections)) OR ALL=(Healthcare-Associated Pneumonia)) OR ALL=(Hospital Acquired Pneumonia)

#2 (((((ALL=(Mechanical Aspiration)) OR ALL=(Suction)) OR ALL=(mucus)) OR ALL=(secretion)) OR ALL=(secret)) OR ALL=(subglottic)

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References

1. Maertens, B.; Lin, F.; Chen, Y.; Rello, J.; Lathyris, D.; Blot, S. Effectiveness of continuous cuff pressure control in preventing ventilator-associated pneumonia: A systematic review and meta-analysis of randomized controlled trials. *Crit. Care Med.* **2022**, *50*, 1430–1439. [CrossRef] [PubMed]
2. Blot, S.; Ruppé, E.; Harbarth, S.; Asehnoune, K.; Poulakou, G.; Luyt, C.-E.; Rello, J.; Klompas, M.; Depuydt, P.; Eckmann, C.; et al. Healthcare-associated infections in adult intensive care unit patients: Changes in epidemiology, diagnosis, [illegible] and contributions of new technologies. *Intensive Crit. Care Nurs.* **2022**, *70*, 103227.
3. Blot, S.; Koulenti, D.; Dimopoulos, G.; Martin, C.; Komnos, A.; Krueger, W.A.; Spina, G.; Armaganidis, A[illegible]Rello, J. Prevale[illegible], risk factors, and mortality for ventilator-associated pneumonia in middle-aged, old, and very old critica[illegible]l patients. *Crit. Ca[illegible] Med.* **2014**, *42*, 601–609. [CrossRef]
4. Ranzani, O.T.; Niederman, M.S.; Torres, A. Ventilator-associated pneumonia. *Intensive Care Med.* **2[illegible]**, *48*, 1222[illegible]26. [CrossR[illegible]]
5. Jain, V.; Vashisht, R.; Yilmaz, G.; Bhardwaj, A. *Pneumonia Pathology. StatPearls*; StatPearls Publi[illegible]ning LLC.: Treas[illegible]Island[illegible], FL, USA, 2022.
6. Luo, W.; Xing, R.; Wang, C. The effect of ventilator-associated pneumonia on the prognosis o[illegible]nsive [illegible]are unit patie[illegible]nts within 90 days and 180 days. *BMC Infect. Dis.* **2021**, *21*, 684. [CrossRef]
7. Heredia-Rodríguez, M.; Peláez, M.T.; Fierro, I.; Gómez-Sánchez, E.; Gómez-Pesqu[illegible]ra, E.; Lorenzo[illegible]; Álvare[illegible]-González, F.J.; Bustamante-Munguira, J.; Eiros, J.M.; Bermejo-Martin, J.F.; et al. Impact of ven[illegible]r-associated pne[illegible]onia on mortality and epidemiological features of patients with secondary peritonitis. *Ann. Intensiv[illegible] Care* 2[illegible]6, 34. [CrossRe[illegible]]
8. Spapen, H.; Suys, E.; De Regt, J.; Troubleyn, J.; Jonckheer, J.; De Waele, E. An e[illegible]ndotrache[illegible]tube providing "pressurized sealing" prevents fluid leakage in mechanically ventilated critically ill patients: [illegible]a pilot study. *J. An[illegible]* **2020**, *34*, 144–148. [CrossRef]
9. Wang, F.; Bo, L.; Tang, L.; Lou, J.; Wu, Y.; Chen, F.; Li, J.; Deng, X. Subg[illegible]ottic secretion drainage [illegible]reventing ventilator-associated pneumonia: An updated meta-analysis of randomized controlled t[illegible]als. *J. Trauma Acute Care Su[illegible]g.* **2012**, *72*, 1276–1285. [CrossRef] [PubMed]
10. Wu, D.; Wu, C.; Zhang, S.; Zhong, Y. Risk Factors of Ventilator-Ass[illegible]iated Pneumonia in Critically Ill Patients. *Front. Pharm.* **2019**, *10*, 482. [CrossRef]
11. Teng, G.; Wang, N.; Nie, X.; Zhang, L.; Liu, H. Analysis of risk fa[illegible]s for earl[illegible]onset ventilator-associated pneumonia in a neurosurgical intensive care unit. *BMC Infect. Dis.* 2[illegible]22, 66. [CrossRe[illegible]]
12. Xu, Y.; Lai, C.; Xu, G.; Meng, W.; Zhang, J.; Hou, H.; [illegible]k factors of ventilator-associated pneumonia in elderly patients receiving mechanical ventilation. *Clin. Interv. Aging* 2[illegible]**19**, *14*, [illegible]Ref] [PubMed]
13. Rababa, M.; Bani-Hamad, D.; Hayajneh, A.A.; Al Mughe[illegible]d, K. Nurses' knowledge, attitudes, practice, and decision-making skills related to sepsis assessment and manag[illegible]nt. *Electron. J. Gen. Med.* **2022**, *19*, em420. [CrossRef] [PubMed]
14. Al-Mugheed, K.; Bani-Issa, W.; Ra[illegible]aba, [illegible] Hayajneh, [illegible].A.; Al Syouf, A.; Al-Bsheish, M.; Jarrar, M. Knowledge, practice, compliance, and barriers toward [illegible]ntilator-a[illegible]sociated pneu[illegible]nia among critical care nurses in eastern mediterranean region: A systematic review. *Healthcare* 2[illegible]. 1852[illegible]CrossRef]
15. Alkhazali, M.; Bayraktar, [illegible] Al-M[illegible]eed, K[illegible]dge and Barriers of Critical Care Nurses Regarding Evidence-Based Practices in Ventilator-A[illegible]ociated Pneu[illegible]nia Prevention. *Cyprus J. Med. Sci.* **2021**, *3*, 185–191. [CrossRef]
16. Pozuelo-Carrascosa, D[illegible] Herráiz-Adillo, A[illegible]lvarez-Bueno, C.; Añón, J.M.; Martínez-Vizcaíno, V.; Cavero-Redondo, I. Subglottic secretion drainage [illegible]or pr[illegible]nting ventilator-[illegible]sociated pneumonia: An overview of systematic reviews and an updated meta-analysis. *Eur. Respir. Rev.* 20[illegible]29, 190107. [CrossRef] [PubMed]
17. Page, M.J.; M[illegible]Kenzie, J.E.; Bo[illegible]yt, P.M.; Boutron, I.; Hoffmann, T.C.; Mulrow, C.D.; Shamseer, L.; Tetzlaff, J.M.; Akl, E.A.; Brennan, S.E.; et al. The PRISMA [illegible]20 statement: An updated guideline for reporting systematic reviews. *Syst. Rev.* **2021**, *10*, 1059[illegible]6. [Crossr[illegible]f]
18. Higgins, J.P.; Thompson, S.G.; Deeks, J.J.; Altman, D.G. Measuring inconsistency in meta-analyses. *BMJ* **2003**, *327*, 557–560. [CrossRef]
19. [illegible]logan, O.; [illegible]soy, Y.; K[illegible]zucu, C.; Gedik, E.; Togal, T.; Yetkin, F. Assessment of the effectiveness of a ventilator associated pne[illegible]monia prev[illegible]on b[illegible]undle that contains endotracheal tube with subglottic drainage and cuff pressure monitorization. *Braz. J. Infec[illegible]. Dis.* **2017**, *21*, [illegible]6–281. [CrossRef]
20. Ch[illegible]; C.; Liu, X.; Zhao, Y. The effect of different solutions in tracheal suctioning on the incidence of pneumonia in patients on the ventilator. [illegible]*Mol. Biol.* **2022**, *68*, 197–202. [CrossRef]
21. [illegible]en, G.; Wang, J.; Liu, C.; Xu, R.; Li, Q.; Zhou, X.; Gan, X. Subglottic secretion drainage and semi-recumbent position for pr[illegible]nting ventilator associated pneumonia. *Int. J. Clin. Exp. Med.* **2016**, *9*, 5193–5198.
22. Chow, M.C.; Kwok, S.-M.; Luk, H.-W.; Law, J.W.; Leung, B.P. Effect of continuous oral suctioning on the development of ventilator-associated pneumonia: A pilot randomized controlled trial. *Int. J. Nurs. Stud.* **2012**, *49*, 1333–1341. [CrossRef] [PubMed]
23. Damas, P.; Frippiat, F.; Ancion, A.; Canivet, J.L.; Lambermont, B.; Layios, N.; Massion, P.; Morimont, P.; Nys, M.; Piret, S.; et al. Prevention of ventilator-associated pneumonia and ventilator-associated conditions: A randomized controlled trial with subglottic secretion suctioning. *Crit. Care Med.* **2015**, *43*, 22–30. [CrossRef] [PubMed]
24. Deem, S.; Yanez, D.; Sissons-Ross, L.; Elrod Broeckel, J.A.; Daniel, S.; Treggiari, M. Randomized pilot trial of two modified endotracheal tubes to prevent ventilator-associated pneumonia. *Ann. Am. Thorac. Soc.* **2016**, *13*, 72–80. [CrossRef] [PubMed]

RETRACTED

25. Gopal, S.; Luckraz, H.; Giri, R.; Nevill, A.; Muhammed, I.; Reid, M.; Bickerton, S.; Jenkins, D. Significant reduction in ventilator-associated pneumonia with the Venner-PneuX System in high-risk patients undergoing cardiac surgery: The Low Ventilator-Associated-Pneumonia study. *Eur. J. Cardio-Thorac. Surg.* **2015**, *47*, e92–e6. [CrossRef]
26. Ravikumar, R.; Masapu, D.; Jena, S.; Kamath, S.; Veenakumari, H.B.; Ramesh, V.J.; Bhadrinarayan, V. Comparison of suction above cuff and standard endotracheal tubes in neurological patients for the incidence of ventilator-associated pneumonia and in-hospital outcome: A randomized controlled pilot study. *Indian J. Crit. Care Med.* **2016**, *20*, 261. [CrossRef]
27. Mahmoodpoor, A.; Peyrovi-Far, A.; Hamishehkar, H.; Bakhtyiari, Z.; Mirinezhad, M.M.; Hamidi, M.; Golzari, S. Comparison of prophylactic effects of polyurethane cylindrical or tapered cuff and polyvinyl chloride cuff endotracheal tubes on ventilator-associated pneumonia. *Acta Med. Iran.* **2013**, *51*, 461–466.
28. Mahmoodpoor, A.; Hamishehkar, H.; Hamidi, M.; Shadvar, K.; Sanaie, S.; Golzari, S.E.; Khan, Z.H.; Nader, N.D. A prospective randomized trial of tapered-cuff endotracheal tubes with intermittent subglottic suctioning in preventing ventilator-associated pneumonia in critically ill patients. *J. Crit. Care* **2017**, *38*, 152–156. [CrossRef]
29. Mahmoodpoor, A.; Sanaie, S.; Parthvi, R.; Shadvar, K.; Hamishekar, H.; Iranpour, A.; Nuri, R.; Rahnemayan, S.; Nader, N.D. A clinical trial of silver-coated and tapered cuff plus supraglottic suctioning endotracheal tubes in preventing ventilator-associated pneumonia. *J. Crit. Care* **2019**, *56*, 171–176. [CrossRef]
30. Mansoor, M.; Farid, Z.; Golnar, S.; Behzad, M.; Mohsen, S. Early replacement of conventional endotracheal tube with endotracheal tube with subglottic suction port for the new intensive care patients; preventive or problematic against ventilator associated events? *J. Pure Appl. Microbiol.* **2016**, *10*, 2655–2662. [CrossRef]
31. Naghibi, T.; Akbari, Z.; Sabet, S.A.; Dobakhti, F. Effect of intermittent subglottic irrigation with 5% nacl on the prevention of ventilator associated pneumonia in critically ill patients. *Tanaffos* **2019**, *18*, 52.
32. Philippart, F.; Gaudry, S.; Quinquis, L.; Lau, N.; Ouanes, I.; Touati, A.; Nguyen, J.C.; Brange, A.; Faibis, F.; Mastouri, M.; et al. Randomized intubation with polyurethane or conical cuffs to prevent pneumonia in ventilated patients. *Am. J. Respir. Crit. Care Med.* **2015**, *191*, 637–645. [CrossRef]
33. Seyfi, S.; Latifi, S.; Shirkhani, Z. Effect of Subglottic Secretion Drainage on theVentilator-Associated Pneumonia in ICU Patients. *J. Babol Univ. Med. Sci.* **2013**, *15*, 58–62.
34. Tao, Z.; Zhao, S.; Yang, G.; Wang, L.; Zhu, S. Effect of two methods of subglottic secretion drainage on the incidence of ventilator-associated pneumonia. *Chin. J. Tuberc. Respir. Dis.* **2014**, *37*, 2.
35. Qiao, Z.; Yu, J.; Yu, K.; Zhang, M. The benefit of dynamic vacuum suction via bronchoscopy in patients of chronic obstructive pulmonary disease with ventilators: A randomized controlled trial. *Medicine* **2018**, *97*, e11631. [CrossRef] [PubMed]
36. Chair, S.Y.; Chan, D.W.K.; Cao, X. The interaction of subglottic drainage, cuff pressure, and oral care on endotracheal tube fluid leakage: A benchtop study. *Aust. Crit. Care* **2020**, *33*, 358–363. [CrossRef] [PubMed]
37. Caroff, D.A.; Li, L.; Muscedere, J.; Klompas, M. Subglottic Secretion Drainage and Objective Outcomes: A Systematic Review and Meta-Analysis. *Crit. Care Med.* **2019**, *44*, 830–840. [CrossRef] [PubMed]
38. Mao, Z.; Gao, L.; Wang, G.; Liu, Z.; Zhao, Y.; Gu, W.; Kang, H.; Zhou, F. Subglottic secretion suction for preventing ventilator-associated pneumonia: An updated meta-analysis and trial sequential analysis. *Crit. Care* **2016**, *20*, 353. [CrossRef]
39. Muscedere, J.; Rewa, O.; Mckechnie, K.; Jiang, X.; Laporta, D.; Heyland, D.K. Subglottic secretion drainage for the prevention of ventilator-associated pneumonia: A systematic review and meta-analysis. *Crit. Care Med.* **2011**, *39*, 1985–1991. [CrossRef]
40. Branch-Elliman, W.; Wright, S.B.; Howell, M.D. Determining the ideal strategy for ventilator-associated pneumonia prevention. Cost–benefit analysis. *Am. J. Respir. Crit. Care Med.* **2015**, *192*, 57–63. [CrossRef]
41. Melsen, W.G.; Rovers, M.M.; Koeman, M.; Bonten, M.J.M.; Oostenwold, R.; Bergmans, D.C.; Camus, C.; Bauer, T.T.; Hanisch, E.; Klarin, B.; Koeman, M.; Krueger, W.A.; et al. Attributable mortality of ventilator-associated pneumonia: A meta-analysis of individual patient data from randomised prevention studies. *Lancet Infect. Dis.* **2013**, *13*, 665–671. [CrossRef]
42. Powell, J.L.; Garnett, J.P.; Mather, M.W.; Cooles, F.A.H.; Nelson, A.; Verdon, B.; Scott, J.; Jiwa, K.; Ruchaud-Sparagano, M.-H.; Cumming, J.; Plant, P.; et al. Excess mucin impairs subglottic epithelial host defense in mechanically ventilated patients. *Am. J. Respir. Crit. Care Med.* **2018**, *198*, 343–349. [CrossRef] [PubMed]
43. Prabodo, A.; Sudiana, H.S.; Emaliyawati, E. The Implementation of Inspiratory Muscle Training to Enhance Weaning from Mechanical Ventilation: A Systematic Literature Review. *J. Plb. Nurs. Stud.* **2022**, *1*, 16–22. [CrossRef]
44. Gunawan, G.; Nihayati, H.E.; Puspitasari, L.; Machrus, M.A. Nurses Barrier: A Patient Safety Concern in The Intensive Care Unit. *J. Plb. Nurs. Stud.* **2022**, *1*, 25–27. [CrossRef]
45. Meier, S.; Martin-Loeches, I.; Povoa, P.; Metzelard, M.; Du Cheyron, D.; Lambiotte, F.; Tamion, F.; Labruyere, M.; Makris, D.; Boulle Geneste, L.; et al. Relationship between ventilator-associated pneumonia and mortality in COVID-19 patients: A planned ancillary analysis of the coVAPid cohort. *Crit. Care* **2021**, *25*, 177. [CrossRef]
46. Shamsizadeh, M.; Fathi Jouzdani, A.; Rahimi-Bashar, F. Incidence and Risk Factors of Ventilator-Associated Pneumonia among Patients with Delirium in the Intensive Care Unit: A Prospective Observational Study. *Crit. Care Res. Pract.* **2022**, *2022*, 4826933. [CrossRef]
47. He, Q.; Wang, W.; Zhu, S.; Wang, M.; Kang, Y.; Zhang, R.; Zou, K.; Zong, Z.; Sun, X. The epidemiology and clinical outcomes of ventilator-associated events among 20,769 mechanically ventilated patients at intensive care units: An observational study. *Crit. Care* **2021**, *25*, 44. [CrossRef]

RETRACTED

48. Klompas, M.; Branson, R.; Cawcutt, K.; Crist, M.; Eichenwald, E.C.; Greene, L.R.; Lee, G.; Maragakis, L.L.; Powell, K.; Priebe, G.P.; et al. Strategies to prevent ventilator-associated pneumonia, ventilator-associated events, and nonventilator hospital-acquired pneumonia in acute-care hospitals: 2022 Update. *Infect. Control. Hosp. Epidemiol.* **2022**, *43*, 687–713. [CrossRef]
49. Suys, E.; Nieboer, K.; Stiers, W.; De Regt, J.; Huyghens, L.; Spapen, H. Intermittent subglottic secretion drainage may cause tracheal damage in patients with few oropharyngeal secretions. *Intensive Crit. Care Nurs.* **2013**, *29*, 317–320. [CrossRef]
50. Yiating, L.; Yaochen, W. The association of subglottic secretion drainage and tracheal mucosa injury. *Eur. Respir. Soc.* **2020**, *6*, 27.
51. Righy, C.; do Brasil, P.E.A.; Vallés, J.; Bozza, F.A.; Martin-Loeches, I. Systemic antibiotics for preventing ventilator-associated pneumonia in comatose patients: A systematic review and meta-analysis. *Ann. Intensive Care* **2017**, *7*, 67. [CrossRef]

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