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REVIEW

Summary of the Best Evidence for the Prevention and Management of Medical Adhesive-Related Skin Injuries in Patients with Tracheal Intubation

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Objective: The aim of this study was to summarize the best evidence for the prevention and management of medical adhesive-related skin injury and to provide a scientific basis for the facial skin care of healthcare professionals and patients undergoing tracheal intubation.
Methods: Following the "6S" pyramid model, the literature on the prevention and management of adhesive-associated skin lesions was searched from top to bottom of the guideline website, relevant professional association websites, and Chinese and English databases. The time frame of the search was from the creation of the repository to August 10, 2024. Evidence consolidation was completed in September 2024. The quality of the included studies was assessed, and key evidence was extracted and summarized.
Results: One guideline, five expert consensus reports, three evidence summaries, one cohort study, and two randomized controlled trials were included. Finally, 30 key evidence items were extracted from 7 areas: risk factor identification, skin assessment, selection and use of medical adhesives, skin care, use of skin protection products and removers, pain management, and education and training. The evidence base is characterized by a high proportion of expert consensus (Level 5, 20%) and case-series evidence (Level 4, 60%), reflecting the current lack of robust RCTs in MARSI prevention for intubated patients. However, 73.3% of recommendations carry Grade A strength, supported by either consistent expert consensus or at least one high-quality RCT, providing a solid foundation for clinical implementation. Future research should prioritize large-scale RCTs to validate interventions in diverse populations.
Conclusion: The best evidence for the prevention and management of medical adhesive-associated skin breakdown summarized in this study can be used as a scientific reference for practical nursing care and provide direction for healthcare teams as well as for the care of the facial skin of patients undergoing endotracheal intubation.

Plain Language Summary: risk factor identification, skin assessment, selection and use of medical adhesives, skin care, use of skin protection products and removers, pain management, and education and training. These 7 areas summarize the best evidence to guide healthcare professionals and facial skin care for tracheally intubated patients.

Keywords: medical adhesives, skin injuries, skin tears, medical adhesive, MARSI, prevention, evidence-based care, evidence summary

Introduction

In 2012, the International Skin Tear Advisory Panel (ISTAP) released a consensus reached by 23 experts at the Medical Adhesives and Patient Safety Summit, which for the first time defined skin injury following medical adhesive removal as medical adhesive-related skin injury (MARSI). Medical Adhesive-Related Skin Injury (MARSI) states that MARSI manifests as erythema of the skin lasting ≥30 minutes after removal of the adhesive, which may be accompanied by unusual symptoms such as blisters, vesicles, or lacerations.[1] The 2019 update of the International Consensus further simplified MARSI to include "skin injury caused by medical adhesive products or devices. (e.g, tapes, wound dressings, stoma sumps, electrode pads, medication patches, wound suture strips, etc)".[2] MARSI is quite common in the clinic, especially in critically ill patients, with

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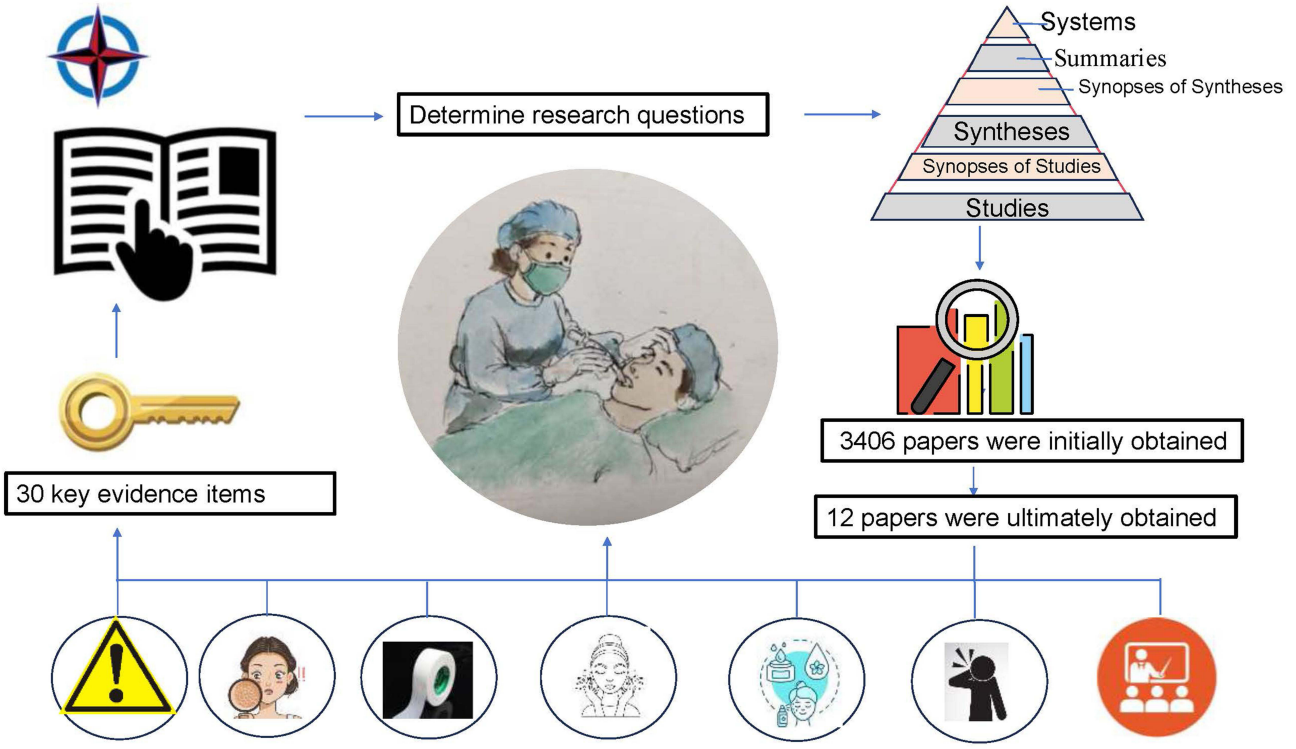
Graphical Abstract



an incidence rate of up to 31% in adult ICU patients, and most often involves the cheek and mandibular regions.[3] Notably, the incidence of facial MARSI is particularly prominent in patients with tracheal intubation, reaching 28.57%.[4]

Although MARSI is widely recognized in the medical literature, its impact on the management of patients under anesthesia has not been adequately appreciated.[5] Perioperative skin management often focuses on the prevention of stress injuries, with relatively little attention given to facial skin. However, in anesthesiology practice, the facial skin not only has the important function of observing the patient's condition but is also a common site for tracheal intubation catheter fixation. The lack of standardized extubation practices or insufficient awareness of protection by healthcare professionals can easily lead to facial MARSI caused by fixation tape; therefore, anesthesiology departments need to give more attention to MARSI and take effective measures to minimize this type of preventable injury.

As a common medical skin injury, MARSI has received increasing attention in terms of risk factors and protective strategies. Existing studies have focused on specific high-risk groups, such as neonates with immature skin barrier function,[6,7] older adults with degenerative changes in skin structure,[8,9] patients with PICC catheters requiring long-term intravenous access,[10–12] and critically ill patients with complex underlying diseases.[13,14] These studies have provided an important basis for understanding the general risk factors and population-specific protection against MARSI.

However, studies focusing on MARSI in the specific scenario of tracheal intubation catheter fixation are still insufficient. Although a variety of adhesive tapes are used in clinical practice, little is known about the relative likelihood of adhesives producing injury among patients undergoing general anesthesia.[15] The existing systematic studies on the occurrence characteristics, independent risk factors, and targeted protective measures for MARSI in patients undergoing tracheal intubation are relatively limited. Some studies failed to analyze the weight of tracheal intubation fixation as an independent risk factor in depth either because of an insufficient sample size or design limitations.[16]

Therefore, the present study is intended to focus on a group of patients who underwent tracheal intubation, aiming to explore in depth the unique risk factors for the occurrence of MARSI. By systematically searching the relevant literature

from China and abroad, we summarized the evidence for the prevention and management of MARSI using an evidence-based approach and applied it to the clinical practice of tracheal intubation patients in the Department of Anesthesiology, with the aim of providing scientific references for the standardization of the prevention strategy and management process of facial MARSI in this group of patients.

Materials and Search Methods

Defining the Research Question

The PICO model[17] was used to construct a structured evidence-based question to obtain the best evidence. The evidence was applied to the target population (population, P): intubated patients of all ages; intervention (intervention, I): a series of interventions to promote the prevention and management of MARSI, including the identification of risk factors for MARSI, standardized risk assessment, standardization of the selection and application of medical adhesives, skin care measures, skin protection products, and the rational use of medical deadhesives, as well as the development of relevant guidelines for the prevention and management of MARSI. The series of interventions included the identification of risk factors for MARSI, standardized risk assessment, standardized selection and application of medical adhesives, skin care measures, rational use of skin protection products and medical deadhesives, and training of relevant personnel; Comparison (C): Conventional adhesive use (acrylic tape without skin pre-treatment) Standard skin care (water cleansing without pH control) Usual removal method (vertical pulling without remover), Using the current routine tracheal intubation nursing program, which includes: (1) using a uniform size of medical tape to secure the catheter without selecting the type of adhesive based on the patient's skin condition; (2) reactive treatment of only visually visible skin injuries without implementation of a structured risk assessment; (3) Reliance on the operator's personal experience for adhesive application, replacement, and removal without a standardized process; (4) Skin protectants or medical adhesive removers were not routinely used; and Outcome (O): incidence rate of MARSI.

Literature Search Strategy

The 6S model, a hierarchical evidence classification system, guided the literature search strategy to prioritize high-quality evidence sources: Systems (eg, clinical decision support systems like UpToDate). Summaries (eg, evidence summaries from JBI, Cochrane Library). Syntheses (eg, systematic reviews and meta-analyses). Studies (eg, randomized controlled trials, cohort studies). Services (eg, expert consultation platforms). Sources (eg, primary research databases). Application in This Study: Searches began with "Systems" (UpToDate, BMJ Best Practice) and proceeded downward to "Sources" (PubMed, Embase) to ensure comprehensive coverage. When evidence conflicts arose across levels, higher-tier evidence (eg, systematic reviews) was prioritized over lower-tier evidence (eg, individual studies).

The English keywords used were 'degloving injuries/skin injury/medical adhesive/medical adhesive-related skin injury'. related skin injury/skin tear/medical adhesive-related skin injury' and "medical adhesive-related skin injury/skin tear/medical adhesive-related skin injury" as Chinese keywords and then searched UpToDate, BMJ Best Practice, Joanna Briggs Institute (JBI) Evidence-Based Institution (EBI), BMJ Best Practice and JBI Evidence-Based Institution (JBI) for evidence-based injuries and skin injuries. BMJ Best Practice, Joanna Briggs Institute (JBI) Centre for Evidence-Based Health Care Research database, Cochrane Library, International Federation of Library Associations and Institutions (IFLA), National Guideline Clearinghouse (NGC), and the National Guideline Library (NGL). National Guideline Clearinghouse (NGC), Agency for Healthcare Research and Quality (AHRQ), National Institute for Health and Care Excellence (NICE), National Institute for Health and Care Excellence (NICE). Health and Care Excellence (NICE), Scottish Intercollegiate Guidelines Network (SIGN), New Zealand Guidelines Group (NZGG), International Guidelines Collaboration Network (Guidelines), and the National Institute for Healthcare Research and Quality (NIHRQ). Guidelines International Network (GIN), College of Nurses of Ontario (CNO), Canadian Medical Association Infobase, guide medlive, Embase, PubMed, CINAHL, China Biomedical Literature Service System (CBLS), China Knowledge Network (CNN), Wanfang Data Knowledge Service Platform (WDKSP), Chinese Medical Journal Full Text Database (CMJFTD), World Association of Ostomy Therapists (WAOT), Wound Management Canada (WM Canada), International Skin Laceration Advisory Committee (ISLAC), Health Quality

Network (HQN), American Board of Wound Management (ABWM), National Coalition for Wound Care and Ostomy (NCOWCO), Wound Australia (WA), and European Wound Management Association.

Inclusion and Exclusion Criteria

Inclusion criteria were: (1) inpatients of all ages; (2) risk factors, assessment tools, and intervention strategies related to skin injuries associated with medical adhesives; and (3) English or Chinese language. Exclusion criteria: Duplicated documents, research proposals or reports, incomplete content information, and evidence that did not pass the quality assessment.

Literature Quality Assessment

The literature from UpToDate and BMJ Best Practice was located at the top of the evidence resource pyramid, with a high level of evidence, and was directly included. Guidelines were evaluated using the Appraisal of Guidelines for Research and Evaluation of Clinical Guidelines (AGREE II).[18] Expert consensus was used with the JBI Centre for Evidence-Based Health Care Expert Consensus Evaluation Criteria (2016).[19] The evidence summaries were traced back to the original literature and evaluated according to the nature of the original literature. Cohort studies were evaluated on the basis of the Newcastle–Ottawa Scale (NOS) recommended by the Cochrane Collaboration.[20] Randomized controls were conducted using the CONSORT 2010 Statement List entries, including title, abstract, scientific background, trial purpose, inclusion criteria, exclusion criteria, intervention, outcome evaluation, sample size estimation, randomization method, allocation concealment, blinding, adverse events, trial registration, and funding, among 25 others.[21] Guidelines were individually assessed by four researchers, while two researchers individually assessed other relevant literature. When the assessments diverged, a third researcher made adjustments and reached a consensus. All fellows involved in the assessment underwent a comprehensive study of evidence-based nursing. The literature search was conducted between August 10, 2024 and September 2024, with the database search scope spanning from the inception of each database to August 10, 2024. This timeframe was chosen to ensure inclusion of the most recent evidence while maintaining consistency across all sources. Database-Specific Search Strategies: While the core keywords and inclusion criteria were uniform across all databases, minor adjustments were made to accommodate database-specific search functionalities: For structured databases (eg, PubMed, Embase), Boolean operators (AND/OR) and MeSH terms were used (eg, "medical adhesive-related skin injury" AND "tracheal intubation"). For grey literature sources (eg, guidelines repositories), keyword searches were combined with manual browsing of relevant categories (eg, "skin injury" or "wound care" subsections). A standardized search log was maintained to document all search strings and modifications, ensuring reproducibility.

PubMed search terms are listed in Table S1.

Evidence Extraction, Integration and Evaluation

Relevant evidence from the included literature was extracted and integrated independently by 2 researchers and verified by a third researcher. The following principles of evidence integration were followed in this process:[17] if the integration content was consistent, evidence with the same content was summarized in a logical, clear, concise and easy-to-understand statement; if the integration content was complementary, evidence with complementary content was integrated into a complete piece of evidence on the basis of the logical relationship of the language; and if the integration content was conflicting, priority was given to evidence-based evidence, priority was given to high-quality evidence, and priority was given to the most recently published authoritative literature. The 2014 version of the JBI evidence pregrading system[22] was used to grade the included evidence, which was classified from 1 to 5 from the highest to the lowest.

Results

Inclusion of Literature

After the search, 3406 papers were initially obtained, 423 duplicates were excluded, 2889 papers that did not match the subject matter were excluded by checking the titles and abstracts, 82 papers were excluded by reading the full text, and 12 papers were ultimately obtained[1,2,6,8,15,16,22–28]. The article screening process is shown in Figure 1. The general characteristics of the articles are shown in Table 1.

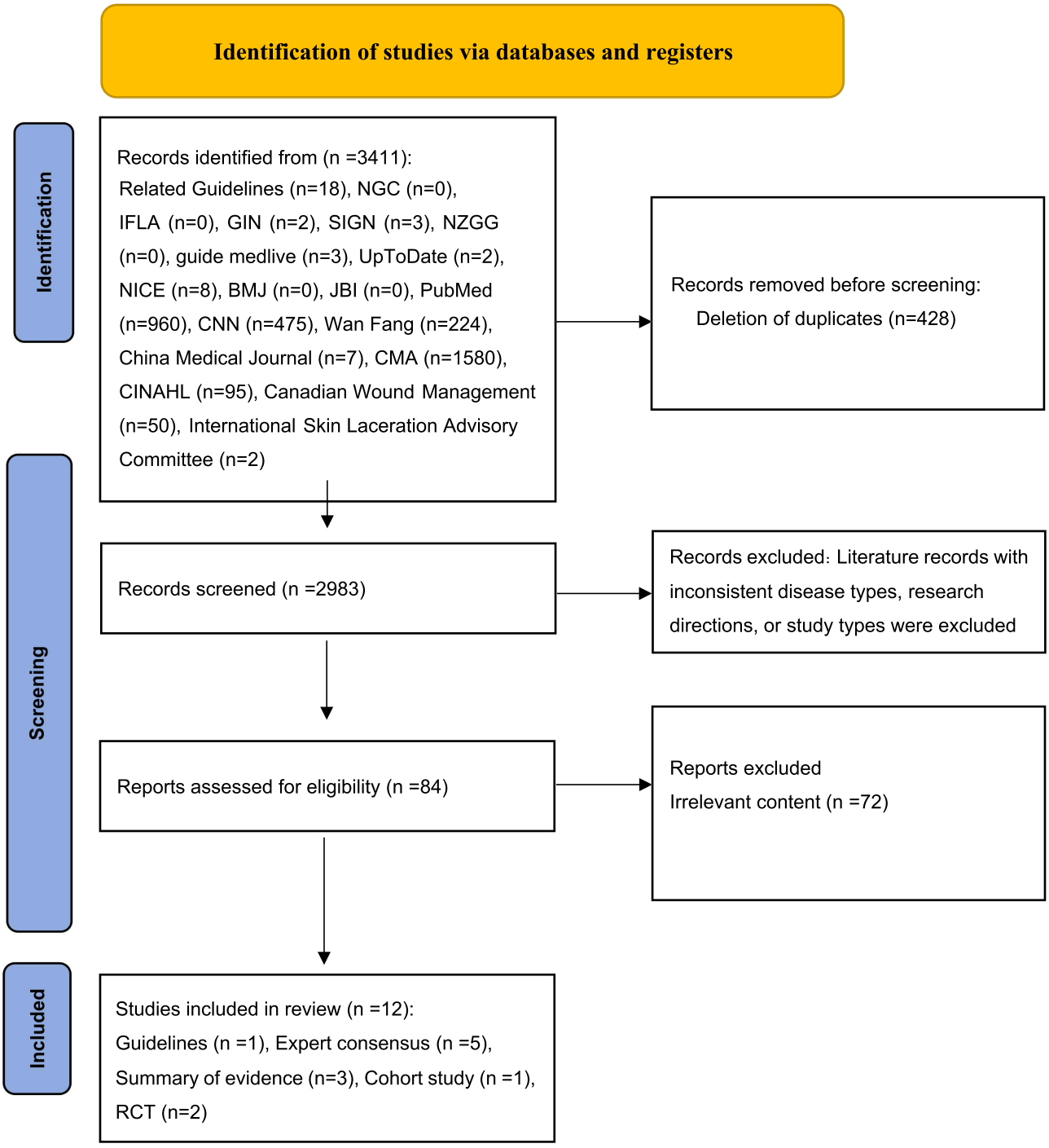


Figure 1 Screening flow chart for literature.
Abbreviations: NGC, National Guideline Clearinghouse; IFLA, International Federation of Library Associations and Institutions; GIN, Guidelines International Network; SIGN, Scottish Intercollegiate Guidelines Network; NZGG, New Zealand Guidelines Group; NICE, National Institute for Health and Care Excellence; JBI, Joanna Briggs Institute.

Results of the Literature Quality Evaluation

Quality Evaluation of the Guidelines

A total of 1 guideline was included,[8] and the evaluation results are shown in Table 2.

Quality Evaluation of Expert Consensus

A total of 5 expert consensus articles were included,[1,2,8,23,24] and the evaluation results are shown in Table 3.

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Table 1 General Information of the Included Studies (n =12)

Literatures	Source	Title	Nature	Year of Publication
Evidence-based Professional Committee of Neonatologists Branch of Chinese Physicians Association[11]	China Knowledge Network	Guidelines for skin management of neonates in intensive care unit (2021)	Guidelines	2021
Chinese Geriatrics Society, Burns and Trauma Branch[12]	Medlive	Expert consensus on skin laceration protection in elderly patients (2022)	Expert consensus	2022
Fumarola et al[2]	PubMed	Overlooked and underestimated: medical adhesive-related skin lesions	Expert consensus	2020
McNichol et al[1]	PubMed	Consensus statement on the evaluation, prevention, and treatment of adhesion-related skin injuries	Expert consensus	2013
LeBlanc et al[13]	PubMed	Adhesive skin lesions: results of an international consensus conference	Expert consensus	2019
Yang Tongling et al[14]	China Knowledge Network	Expert consensus on the key points of assessment and anticipatory care of medically induced skin injuries in neonates	Expert consensus	2020
Gu Mengqian et al[15]	China Knowledge Network	Summary of the best evidence for the prevention and management of medical adhesive-associated skin injury in adult patients	Summary of evidence	2023
Guo Weiting et al[16]	China Knowledge Network	Evidence-based practice for the prevention and management of medical adhesive-related skin injury in elderly patients	Summary of evidence	2020
Zhang Juan et al[17]	China Knowledge Network	Summary of the best evidence for the prevention and management of medical adhesive-related skin injuries in neonates	Summary of evidence	2022
Deng Xingyue et al[18]	China Knowledge Network	Preventive interventions for medical adhesive-associated skin injuries in children in the perioperative period	Cohort study	2022
Bahadori et al[19]	PubMed	Durapore vs Hy-Tape for securing endotracheal tubes during general anesthesia: a prospective randomized controlled non-inferiority trial	Randomized controlled trial	2022
Shi, Jinmei et al[20]	China Knowledge Network	Application and study of a method for preventing medical adhesive-related skin damage on the face of patients undergoing tracheal intubation	Randomized controlled trial	2020

Quality Evaluation of Original Studies of Evidence Summaries

Three evidence summaries were included in this study,[25–27] and the evaluation results are shown in Table 4.

Quality Evaluation of Cohort Studies

One cohort study was included,[28] and the evaluation results are shown in Table 5.

Table 2 Results of the Quality Assessment of the Guidelines (n=1)

Guidelines	Percentage of Domain Standardization (%)							≥30%	≥60%	Are they Recommended?	Recommended Level
	Scope and Purpose	Persons Involved	Guideline Development Rigor	Guidelines Present Clarity	Recommended Level	Guide to Editorial Independence	Overall Quality Rating of the Guide	Number of Fields	Number of Fields	Testimonials	
Evidence-based Professional Committee of Neonatologists Branch of Chinese Physicians Association[11]	95.83	95.83	89.06	95.83	51.04	91.67	6	6	5	Yes	A

Notes: By calculating the standardized percentage for each domain (domain score / domain maximum score × 100%), we statistically determine the number of domains with ≥30% (to assess whether the guideline is generally usable) and the number of domains with ≥60% (to assess whether the guideline is of high quality and recommended for use). This is combined with the overall quality rating (1–7 points, with 7 being the highest), the final recommendation level of the guideline is determined (eg, "Grade A" in the text indicates high-quality guidelines recommended for application).

Table 3 Quality Evaluation Results of Expert Consensus (n=5)

Expert Consensus	①	②	③	④	⑤	⑥
Chinese Geriatrics Society, Burns and Trauma Branch[12]	Yes	Yes	Yes	Yes	Yes	No
Fumarola et al[2]	Yes	Yes	Yes	Yes	Yes	No
McNichol et al [1]	Yes	Yes	Yes	Yes	Yes	No
LeBlanc et al[13]	Yes	Yes	Yes	Yes	Yes	No
Yang Tongling et al[14]	Yes	Yes	Yes	Yes	Yes	No

Notes: ① Is the source of the idea clearly labeled? ② Are the ideas derived from influential experts in the field? ③ Are the ideas presented centered on the interests of the people concerned by the study? ④ Are the conclusions stated based on the results of the analyses, and are the ideas expressed logically? ⑤ Are there references to other literature? ⑥ Are there any inconsistencies between the proposed ideas and those in the previous literature?

Quality Evaluation of Randomized Controlled Trials

Two randomized controlled trials were included,[15,16] Bahadori et al. The study by Shi Jinmei et al[29] was evaluated as 'yes' except for entry 1, 'The title identifies the trial as a randomized clinical trial', and entry 2, 'The title identifies the trial as a randomized clinical trial'. The study of Shi Mei et al[16] was evaluated as 'yes' except for entry 1, 'The title of the study identifies it as a randomized clinical trial'; 6, 'A complete and precise description of the predetermined primary and secondary outcome indicators, including when and how they were measured'; 'Whether any changes were made to the outcome indicators after the start of the trial, and why'—Entry 9, 'Mechanisms used to implement the randomization sequence, describing the steps taken to hide the sequence numbers prior to allocation of the intervention'; Entry 11, 'If blinding was implemented, who was blinded after allocation of the intervention (eg, when the subjects, health care providers, Entry 11, 'Who is blinded after allocation of the intervention (eg, subjects, healthcare providers, outcome assessors) and how the blinding is implemented'; Entry 15, 'Baseline data, including demographics and clinical characteristics, for each group of subjects in a single table'; and Entry 17, 'Outcomes and Estimates'; Entry 20, 'Limitations of the trial, reasons for reporting potential bias and imprecision, and reasons for multiple analyses'; Entry 25 'Sources of funding and other support (eg, provision of medicines), role of funders' rated 'No', and Entry 26 'Sources of funding and other support (eg, provision of medicines), role of funders' rated 'No', with 'No'. 'The overall quality of the two randomized controlled trials was high, and they were accepted for inclusion.

Summary and Description of Evidence

This study used the 'JBI 2014 version of the evidence pregrading and recommendation level system',[22] and two researchers graded the evidence from levels 1 to 5 according to the type of literature. The level of evidence recommendation was determined by the research team through a meeting, which accounted for the pros and cons of the interventions shown in the evidence, the impact on resource allocation, whether to consider the patient's willingness and experience, and the quality of the evidence to determine whether the evidence was Grade A (strong recommendation) or Grade B (weak recommendation). A total of 30 items of MARSI-related evidence are summarized in Table 6.

Discussion

This Study Demonstrated a High Degree of Scientific Rigor in the Evidence Summary Phase, Ensuring that the Evidence Consolidated was of High Quality and Could Inform the Prevention and Management of Facial MARSI in Patients Undergoing Tracheal Intubation Within the Field of Anesthesiology

Through extensive and systematic collection of multidimensional literature covering guidelines, evidence summaries, systematic evaluations, expert consensus, evidence summaries, and clinical studies, this study implemented rigorous screening criteria and quality assessment processes, aiming to distill the most reliable and applicable body of evidence.

Table 4 Results of the Quality Assessment of the Evidence Summaries (n=3)

Summary of Evidence	Scope and Target Specific	Clear and Transparent Authorship	Reviews are Clear and Transparent	Searches are Transparent and Comprehensive	Evidence Grading is Clear	Recommendations are Clear	Recommendations are Appropriately Cited	Recommendations are Time-Sensitive	Conflict of Interest Declaration	Applicable to the Study Population
Gu Mengqian et al[15]	Yes	Yes	Yes	Partial Yes	Yes	Yes	Yes	Yes	Yes	Yes
Guo Weiting et al[16]	Yes	Yes	Yes	Partial Yes	Yes	Yes	Yes	Partial Yes	No	Yes
Zhang Juan et al[17]	Yes	Yes	Yes	Partial Yes	Yes	Yes	Yes	Yes	Yes	Yes

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Table 5 Results of the Quality Assessment of the Cohort Studies (n=1)

Cohort Study	Representativeness of the Exposed Group	Representativeness of the Non-Exposed Group	Determination of Exposure Factors	Comparability of the Two Groups	Comparability of the Two Groups	Evaluation of Ending Indicators	Sufficient Length of Follow-up	Completeness of Follow-Up in Both Groups	Total Score
Deng Xingyue et al[18]	1	1	1	0	2	1	1	1	8

Notes: The specific content of the NOS scale includes the following: ① 4 entries for the selection of the study population: the representativeness of the exposed group (1 point), the representativeness of the non-exposed group (1 point), the determination of the exposure factors (1 point), and the certainty that there is no outcome indicator to be observed at the beginning of the study (1 point); ② 1 entry for comparability between groups: the comparability of the exposed and non-exposed groups is considered in the design and the statistical analyses (2 points); ③ 3 entries for the measurement of the results: evaluation of outcome indicators (1 point), sufficiently long follow-up (1 point), and completeness of follow-up in exposed and non-exposed groups (1 point), totaling 9 points, the higher the score, the better the quality.

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Table 6 Best Evidence of Prevention and Management of Medical Adhesive-Associated Skin Injury in Patients Undergoing Tracheal Intubation

Classification	Evidence	Grading of Evidence	Recommended Level
Identifying Risk Factors	1. Risk factors for MARSI: (1) Intrinsic risk factors: extreme age (neonates and the elderly), dehydration, malnutrition, altered skin condition, underlying diseases affecting the skin (infections, renal insufficiency, diabetes mellitus, chronic venous insufficiency, immunosuppression, edema); (2) Extrinsic risk factors: dry skin, use of inappropriate cleansing products (pH <5 or pH >6), prolonged exposure to moisture, prolonged use of chemotherapeutic agents, anti-inflammatory and anticoagulant drugs, corticosteroids, radiation therapy, ultraviolet radiation or photodamage. Use of products that enhance or reduce adhesive properties.[1, 2, 13]	Level 5	A
Timing and content of skin assessment	2. Prior to applying and removing medical adhesives, all patient skin should be evaluated, and the patient skin condition should be assessed and documented, including medical history and overall skin condition (temperature, color, moisture, fullness, fragility, integrity, and degree of swelling), and observation of the skin for localized signs of irritation or injury.[2]	Level 5	A
	3. Skin evaluation should also be performed to check for increased edema.[15]	Level 4	A
	4. Assess the integrity of the skin under and around the endotracheal tube, skin color, and skin tone every 4 to 6 h. Lower birth weight and gestational age are associated with a greater likelihood of medical skin injury, so the assessment interval for such patients can be shortened. Assess the patient's local skin and the use of dressings during the shift handover and before the change of adhesive dressings.[12, 14]	Level 5	A
	5. Recommends that warning cards be provided to patients at high risk for MARSI based on risk assessment results.[2]	Level 5	A
	6. Assess the severity of skin injuries when they occur, assessing wound location, size, degree of necrosis, type and amount of exudate, and the integrity of the surrounding skin.[1, 17]	Level 4	A

(*Continued*)

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Table 6 (Continued).

Classification	Evidence	Grading of Evidence	Recommended Level
Selection, use and removal of medical adhesives	7. Select medical adhesives that are biocompatible, non-sensitizing, non-irritating, and non-cytotoxic, and use adhesives according to the manufacturer's instructions.[2]	Level 5	A
	8. Select the most suitable medical adhesive with the results of risk assessment, purpose of use, anatomical location, skin environment of the adhesive site, patient skin type, frequency of replacement, adhesion needs and environmental conditions of the application site.[2]	Level 5	B
	9. Select the appropriate adhesive with careful consideration of patient age and risk factors that may predispose him or her to skin damage.[20]	Level 1	A
	10. Use anti-allergic dressings for those who are allergic to dressings; for patients who develop skin tension damage, switch to sterile gauze. Silicone dressings minimize damage to the skin stratum corneum and are suitable for fragile skin. Silicone products are recommended for elderly patients with extremely fragile skin.[12, 16]	Level 5	B
	11. The following steps should be followed when applying medical adhesives: (1) prepare the skin; (2) avoid products that cause skin dryness (eg, ethanol) when sterilizing; (3) apply and secure the adhesive when the skin is dry; (4) apply the adhesive tension-free; (5) ensure proper adhesive orientation and use a ductile adhesive in areas of mobility or possible swelling; (6) apply gentle pressure without creasing; (7) assess the appropriate border and apply adhesive only to the desired area. (8) follow the texture of the skin; (9) consider using a tracheal tube fixation bracket to secure the transtracheal intubation, reducing pressure on the orofacial area and increasing the stability of the tracheal tube.[2, 13]	Level 5	A
	12. The following steps are followed when removing medical adhesives: (1) loosen the edges of the adhesive; (2) use one hand to press down on the skin while the other hand lifts the adhesive; (3) slowly remove the adhesive in the direction of hair growth; (4) place the adhesive at a low angle to the skin during removal, and the index finger is placed along the line of peeling to support the skin; (5) move the hand that is pressing down on the skin slowly in the direction of removal toward the detached skin to the point where the adhesive is completely separated from the skin; (6) remove borderless transparent dressings by first removing one corner of the dressing and peeling back the dressing; wound dressings can be removed by first removing the surrounding edges and then lifting the center. (6) Borderless transparent dressings can be removed by removing one corner of the dressing and reversing the direction of removal; wound dressings can be removed by removing the surrounding edges first and then from the center.[2]	Level 4	A
	13. The skin of the paste area should be well moistened before removal to minimize the risk of skin damage.[17]	Level 4	A
	14. The use of adhesive removers: ① for children with particularly fragile skin (such as herpetic epidermolysis bullosa) recommend the use of silicone-based removers ② special cases can be replaced by mineral oil, petroleum jelly; ③ with sterile saline or sterile water to clean the skin with residual product.[17]	Level 4	A
	15. Avoid rapid, vertical pulling forces that generate more force than slow, horizontal removal of adhesives close to the skin surface.[19]	Level 1	A

Avoiding pain	16. Check for patient comfort during procedures, reduce anxiety, routinely assess pain, and incorporate pain minimization strategies into daily practice.[2]	Level 5	B
Skin care	17. Be gentle and thorough in skin care: (1) keep the skin clean, recommend the use of pH 5~6 cleaning products; (2) keep the skin moist; (3) avoid rubbing dry skin, avoid sharp objects; (4) avoid stimulating the skin of the clothing; (5) pay attention to sunscreen.[15]	Level 4	B
	18. Engage in dynamic observation of the skin, including color, temperature, wetness, integrity, fragility of the adhesive site, and palpation if necessary; observation of the integrity of the adhesive bond to determine whether there are signs of loosening and rubbing of the skin.[18]	Level 3	B
	19. Choose appropriate cleansers for newborns: Use warm water and pH-neutral cleansers for skin cleansing. For elderly individuals, use cleansers containing phospholipids or use no-wash and mild cleansers, avoid irritating or alkaline soaps for cleansing, and after cleansing, use moisturizers with nutrients, skin restorative lotions, or skin protectants to apply to the skin! Or choose a neutral, all-natural skin moisturizer to apply to the skin twice daily.[12, 17]	Level 5	A
	20. Use accelerated rehabilitation surgical concepts for early extubation to reduce time with tube; and extubation adhesive removal feedback on the MARSI assessment scale and uploading of the skin at the place of adhesion.[18]	Level 3	B
Skin barrier products and medical gel removers	21.Prior to the use of medical adhesives, skin barrier products (liquid dressings that are easily film-forming or silicone-containing creams, foam spout dressings, hydrocolloid dressings) should be considered to prevent skin damage caused by increased adhesion of the adhesive to the skin. Skin protection by spraying with a protective agent prior to the use of an adhesive product in elderly patients older than 65 years.[11, 12]	Level 5	A
	22.Consider using a sterile skin barrier product (with instructions labeling the product sterile) for patients at high risk of infection, including those with open wounds, surgical wounds, intravenous access or central venous catheters, or immunodeficiency.[2]	Level 5	A
	23. Use oil or medical adhesive remover to aid in the removal of medical adhesives.[11]	Level 5	A
	24. After wiping the facial skin with a sterile cotton ball in warm water, apply a skin protection film to the patient's face and the skin around the mouth where the adhesive tape needs to be affixed.[20]	Level 1	B

(*Continued*)

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Table 6 (Continued).

Classification	Evidence	Grading of Evidence	Recommended Level
Training and education	25. Medical staff, including purchasing staff and pharmacists, should be educated on MARSI, skin preparation, medical adhesive application and removal methods, and the use of skin barrier products and or medical adhesive removers.[13]	Level 5	A
	26. Patients and families should be educated about MARSI so that patients can proactively recognize symptoms that threaten their skin integrity.[2]	Level 5	A
	27. All pre- and post-registration education on wound management and skin care should include MARSI-related content.[2]	Level 5	A
	28. MARSI consultation with a wound care specialist or dermatologist should be considered when conservative treatment has not been effective for 7 d or when wound deterioration has occurred.[15]	Level 4	A
	29. All MARSI should be documented in the patient's medical record and should include photographs of the injury at the time of the injury or when it was first viewed and inform the patient and family of the injury.[2]	Level 5	A
	30. Consideration of the etiology of skin injury is relevant to planning and developing strategies to prevent MASI. Developing a stratified risk care program based on risk assessment.[18]	Level 3	B

Notes: The Joanna Briggs Institute (JBI) evidence grading system was used to classify the quality of evidence for the recommendations, where Level 1 represents the highest quality evidence, including high-quality systematic reviews (including meta-analyses) and "all-or-nothing" case series (such as observations of the natural course of rare diseases); Level 2 denotes evidence of moderate quality, including single randomized controlled trials (RCTs), prospective or retrospective cohort studies; Level 3 denotes moderate-quality evidence, including case-control studies and cross-sectional studies analyzing the association between exposure and outcomes; Level 4 denotes lower-quality evidence, including uncontrolled case series, case reports, and expert consensus not based on systematic research; Level 5 denotes the lowest-quality evidence, including basic research such as cell/animal experiments and opinion-based articles without empirical support. Grade A, strong recommendation: High quality evidence support, clear advantages outweigh disadvantages, applicable to most scenarios; Grade B, weak recommendation: The quality of evidence is moderate or uncertain, and individualized decision-making should be based on patient preferences and clinical context.

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Specifically, one[6] guideline prepared by the Evidence-Based Professional Committee of the Neonatologists Branch of the Chinese Medical Doctors' Association and five[1,2,8,23,24] expert consensus papers were included, all of which originated from authoritative organizations or teams; their contents were closely related to the core topics of MARSI prevention and management, and the overall quality assessment revealed that they possessed high scientific value and practical guidance significance. In addition, three[26–28] high-quality evidence summary studies and the included clinical studies further enriched the research database, and the research process effectively reduced the influence of personal bias on the interpretation of the results through the mechanism of two-person independent review, which enhanced the objectivity and credibility of the conclusions. The entire quality evaluation process followed scientific principles and was strictly controlled, reflecting the high standards and strict requirements of the study. In the evidence integration process, this study not only carefully weighed the strengths and limitations of each piece of evidence but also closely integrated them with the actual clinical operational situation and finally condensed 30 best practice recommendations, which not only laid a solid foundation for the translation of clinical practice but also provided clear, scientific operational guidelines for healthcare professionals when dealing with facial skin care for patients with endotracheal intubation, which is highly useful for the development of targeted and highly effective strategies that are highly valuable for guiding the development of targeted and effective MARSI prevention strategies.

Through a Comprehensive and Detailed Summary of Evidence, this Study Provides a Valuable Basis for Guiding the Development of Effective Strategies for the Prevention of Medical Adhesive-Related Skin Injury in Patients Undergoing Tracheal Intubation

Timely Identification of Risk Factors is Essential for the Prevention of Skin Injuries Associated with Facial Medical Adhesives in Patients Undergoing Tracheal Intubation

The prediction and prevention of MARSI remain the basis of MARSI management, and the identification of risk factors is the starting point for the prevention of medical adhesive-related skin injury. The internal and external factors of the first evidence MARSI summarized in this paper refer to the 2013 expert consensus,[1] which has long-term guiding significance for subsequent research. Domestic and international research MARSI risk assessment scales, such as the MARSI risk assessment tool for children[30] and elderly patients[29] and the risk assessment scale for medical adhesive-associated skin injuries at the peripheral insertion site of central catheters in oncology patients[31,] are produced by combining the internal and external factors of MARSI.

Comprehensive Assessment of Facial Skin in Patients Undergoing Tracheal Intubation to Inform the Development of Preventive Interventions

The skin of all patients should be assessed as all patients with medical adhesives are potentially at risk, ie, before the patient is admitted to the operating theatre, before anesthesia is started, before taping, at the end of the procedure, before extubation, and after extubation, as assessment nodes. The skin condition of the patient was assessed and recorded, and on the basis of the results of the assessment, warning cards were issued to patients at high risk of MARSI.[2] Detailed handover of the skin condition and risk level is performed during shift handover. A comprehensive assessment of all medical adhesive-related skin injuries should be performed to determine their severity and guide management.

Correct Selection of Medical Adhesives and Proficiency in Their Application and Removal Techniques to Minimize Pain and Avoid Skin Injury

The correct selection of adhesive materials is essential to avoid patient injury and potentially reduce healthcare costs. Medical elastic tapes are often preferred by anesthetists for securing tracheal tubes because of their strong adhesive properties, breathability and hypoallergenic nature. Medical tape backing materials are usually elastic fiber cloth, cotton cloth, nonwoven cloth, PE film, silk cloth, plastic-coated medical paper, etc. The paste of medical elastic tape is imported acrylic. Its adhesion increases over time. In prolonged procedures, the risk of skin damage during removal increases.[32] Zeng LA, 2016[33] compared the incidence of facial skin damage with different types of tape and reported that silicone tape resulted in less skin damage and greater patient satisfaction than acrylic tape. The selection of a suitable adhesive should be based on a thorough assessment of

the properties of the adhesive and the patient's specific situation. Fixation of tracheal tubes is achieved by tension-free adhesive fixation with a small amount of roll-up at the edges to facilitate removal. When removing the tape, it must be removed using a gradual, low-tilt, 0° or 180° removal method, with gentle, skin-following tugs, and if there is hair at the site, the tape should be slowly removed in the direction of the hair. When the edges of the tape are removed, it is difficult to use the low-angle method if the edges are completely stuck to the skin, especially when the adhesion is strengthened by using medical elastic tape for a long period, and there is a high risk of tearing off the tape. During extubation of the tracheal tube during the awakening period of general anesthesia, to reduce the degree of stimulation to the patient, medical personnel usually remove the tracheal tube quickly, but the rapid removal of the tracheal tube has a great MARSI safety risk. The use of tension stretching, vertical orientation, and rapid stripping of adhesives has been mentioned in several papers as risk factors for MARSI.[34–36] Patient comfort during the procedure should be checked, anxiety should be reduced, pain should be routinely assessed, and pain reduction strategies should be incorporated into daily practice. The use of skin barrier products and medical adhesive removers needs to be applied after assessment.

Standardize Continuing Education on Medical Adhesive-Related Skin Injury on the Face Of Tracheal-Intubated Patients

MARSI can be prevented by minimizing adhesive use, optimal adhesive use, appropriate adhesive attachment and removal techniques, and screening of susceptible populations but, most importantly, by increasing the awareness of the multidisciplinary team.[37] Medical adhesive-associated skin injuries (MARSIs) are common in clinical practice but are reported less frequently in health systems than in clinics. In many cases, MARSI should be considered a preventable injury. Therefore, training healthcare workers to increase their awareness of MARSI should be enhanced in all settings where medical adhesives are used. The content of the training is the knowledge of MARSI, the typology and clinical manifestations of MARSI, the assessment of high-risk factors, the assessment of the skin, the preventive measures of MARSI, the selection of adhesive tapes, the methods of adhesive application and removal, and the treatment methods of MARSI. Enhancing patients' and family members' knowledge about MARSI and motivating patients to actively participate in self-monitoring will increase their awareness of their participation and management ability.

Summary

In this study, a total of 30 key pieces of evidence were distilled through an evidence-based nursing approach from seven major areas: risk factor identification, skin condition assessment, selection and application of medical adhesives, skin care practices, use of skin protection products and adhesive removers, and pain management and education and training. These recommendations are intended to provide practical guidance to clinical staff on the prevention and management of facial MARSI in patients undergoing tracheal intubation. We emphasize that healthcare professionals should conduct a comprehensive skin assessment of patients with adhesives and develop an individualized process for the selection and application of adhesives, skin protection products and removers. The applicability and feasibility of the evidence should be fully considered in light of the characteristics of the department and the specific situation of the patient to develop a management plan that is most suitable for the department, thus providing better quality care to the patient. The limitation of this study is that for the MARSI, there are no validated and widely accepted prediction scales, such as the Braden, Norton, and Waterlow scales, for stress injuries. Only White's instrument has been suggested for the prediction of skin tears. However, it has not been validated, does not appear to be widely used, and is not specifically designed to predict MARSI.[38] Numerous clinical trials are yet to be conducted to develop a more accurate assessment tool, and it is recommended that future researchers explore this further to enrich the evidence to better guide clinical practice. The limitation of this study is that it does not provide differentiated guidance for different patients or different clinical settings, and in the future, we expect to conduct in-depth studies for different patients and different clinical settings, and it is recommended that future researchers explore this further to enrich the evidence in order to better guide clinical practice.

Data Sharing Statement

All the data generated or analyzed during this study are included in this published article.

Ethics Statement

In this study, all methods were performed in accordance with the relevant guidelines and regulations. Ethics approval and consent to participate are not necessary since our study was a meta-analysis.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Disclosure

All the authors declare that they have no conflicts of interest for this work.

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