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Microaspiration Risk Management in Neurocritical Care Patients with Artificial Airways: Clinical Practice and Outcomes

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Abstract: *Objective:* To explore the clinical application effects of constructing and implementing a microaspiration risk management protocol for neurocritical care patients with artificial airways, providing a reference for reducing microaspiration and aspiration pneumonia incidence. *Methods*: Patients with artificial airways admitted to neurocritical care-related departments of a hospital from July 2024 to March 2025 were selected as study subjects. A multidisciplinary collaborative team was established to construct a microaspiration risk management system based on evidence-based medicine. Through current situation investigation and analysis of major barrier factors, comprehensive intervention strategies were implemented, including development of a microaspiration risk assessment scale, modified suction depth guidelines, intelligent cuff pressure monitoring, and gastrointestinal management protocols. The volume of subglottic secretion clearance, microaspiration incidence, and aspiration pneumonia incidence were compared before and after the intervention. *Results*: After implementing the risk management protocol, the volume of subglottic secretion clearance increased from (85.26±13.58) ml to (146.82±21.33) ml; microaspiration incidence decreased from 58.89% to 31.17%; and aspiration pneumonia incidence decreased from 40.77% to 14.72%. All differences were statistically significant (P<0.001). *Conclusion*: The evidence-based microaspiration risk management protocol for neurocritical care patients with artificial airways can effectively clear airway secretions, reduce microaspiration and aspiration pneumonia incidence, improve patient prognosis, and has high clinical application value.

Keywords: Neurocritical care; Artificial airway; Microaspiration; Aspiration pneumonia

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1. Introduction

Aspiration refers to the process of liquid or solid substances entering the subglottic airway during eating or non-eating periods, which is divided into overt aspiration and silent aspiration. Microaspiration, as the most common and dangerous form of silent aspiration, refers to the micro-leakage of oropharyngeal secretions

and gastric contents into the lower respiratory tract through the small gap between the tracheal tube cuff and the respiratory tract wall [1]. Studies have shown that the incidence of microaspiration in mechanically ventilated patients abroad ranges from 58.2% to 89.0%, and 58.3% to 77.1% domestically. Due to the lack of typical clinical symptoms, approximately 57% of microaspiration events are missed clinically [2]. Neurocritical care patients, due to consciousness disorders, impaired swallowing function, weakened cough reflex, and the establishment of artificial airways that disrupt natural airway defense barriers, become a high-risk population for microaspiration [3]. Microaspiration not only increases the risk of aspiration pneumonia and ventilator-associated pneumonia (VAP) but also prolongs mechanical ventilation time and hospital stay, increasing mortality and medical costs. Currently, clinical nursing focuses more on the prevention of overt aspiration, lacking microaspiration risk assessment tools and systematic management protocols tailored to the characteristics of neurocritical care patients [4–5]. Therefore, this study aims to construct a scientific and systematic microaspiration risk management protocol for neurocritical care patients with artificial airways and evaluate its clinical application effects.

2. Materials and methods

2.1. General information

Patients with artificial airways admitted to the neurocritical care unit, cerebrovascular disease diagnosis and treatment center, and other departments of a hospital from July 2024 to March 2025 were selected as study subjects.

Inclusion criteria: (1) Indwelling artificial airway; (2) Stable vital signs without severe internal environment disorders; (3) ICU stay >3 days.

Exclusion criteria: (1) Hemodynamic instability; (2) Combined mental disorders; (3) Combined tracheoesophageal fistula, gastroesophageal reflux, etc.

A total of 287 patients were included in this study.

2.2. Research methods

2.2.1. Establishment of multidisciplinary team (MDT) management group

In July 2024, a microaspiration risk management group was established, led by the nursing department and composed of multidisciplinary members including neurocritical care medicine, respiratory medicine, nutrition, and rehabilitation. The group consisted of 12 members, with 1 team leader (the director of nursing) responsible for overall coordination; deputy leaders and members included critical care physicians, specialized nurses, nutritionists, and rehabilitation therapists. Members had a clear division of labor, covering protocol development, risk identification, protocol implementation, and quality control.

2.2.2. Current situation investigation and problem analysis

Through retrospective analysis and cross-sectional survey, the incidence of microaspiration in the department before the improvement was investigated. The results showed a microaspiration incidence of 58.89%. Using Pareto analysis, four core problems causing microaspiration were identified: lack of microaspiration risk assessment and screening (26.63%), non-standard artificial airway cuff management (21.89%), lack of dynamic adjustment of enteral nutrition management strategies (16.57%), and incomplete airway secretion management (15.98%).

2.2.3. Evidence retrieval and summary

Computer searches were conducted in BMJ Best Practice, UpToDate, CINAHL, JBI, Cochrane Library, PubMed, CNKI, and Wanfang databases. Search terms included "Microaspiration/Silent aspiration", "Neurocritical care", "Artificial airway/Endotracheal tube cuff", etc. The search timeframe was from database establishment to September 2025. Clinical practice guidelines, systematic reviews, and expert consensus documents were included. After FAME attribute evaluation (Feasibility, Appropriateness, Meaningfulness, Effectiveness), 19 best evidence items were finally included to provide a theoretical basis for protocol development.

2.2.4. Construction and implementation of microaspiration risk management protocol

(1) Establishment of a risk assessment system and implementation of graded early warning: Based on evidence-based evidence, the "Microaspiration Risk Assessment Scale for Neurocritical Care Patients with Artificial Airways" was developed. Patients were classified into three risk levels: low risk, moderate risk, and high risk, with stratified nursing intervention strategies developed for each level. Risk alerts were set on bedside display screens and nursing station electronic screens, with focused attention on high-risk periods such as before airway procedures and before enteral nutrition initiation.

(2) Innovation in secretion management technology to block aspiration sources: To address the downward flow of oropharyngeal secretions, a "continuous saliva collector" was designed, combined with a high lateral position (80°–135°), using an "H-type anti-slip adjustable back support" to maintain position, allowing oral secretions to accumulate in the lateral buccal region and be continuously suctioned. This solved the problems of incomplete clearance and mucosal damage associated with traditional wiping methods. For intratracheal suctioning, modified suction depth guidelines were developed for different tracheal tube sizes, and a "five-color suction depth scale" was developed to achieve precise quantification of suction depth, avoiding coughing and microaspiration caused by deep stimulation.

(3) Optimization of cuff management strategy and clearance of subglottic secretions: Subglottic suction graded pressure control technology was implemented. Different negative pressure ranges were set based on secretion viscosity, and a "subglottic secretion collector" and "subglottic suction pressure prompt card" were developed to achieve dynamic switching of negative pressure and accurate statistics. An intelligent cuff pressure monitoring system was introduced, connecting the cuff tail end with a pressure sensor to achieve real-time monitoring and alarm through the monitor, solving the problems of pressure loss and human resource consumption associated with traditional pressure measurement methods.

(4) Standardization of gastrointestinal nutrition management to prevent reflux and aspiration: For central hiccups and gastrointestinal tolerance issues, nurse-led multidisciplinary collaborative treatment was implemented, using diaphragmatic pacing physical therapy combined with ginger antiemetic and acupoint plastering and other traditional Chinese medicine techniques. A comprehensive gastrointestinal management protocol was developed, implementing post-pyloric feeding for high-risk patients, using ultrasound measurement of gastric residual volume (GRV) combined with gastric antrum motility index (MI) for assessment, and dynamically regulating enteral nutrition speed.

2.3. Evaluation indicators

(1) Volume of subglottic secretion clearance in artificial airway: The total volume of subglottic secretions accumulated in the indwelling artificial airway was recorded.

(2) Microaspiration incidence: Gastric pepsin content in airway secretions was measured by enzyme-linked immunosorbent assay, with >200ng/ml defined as microaspiration occurrence [6]. (3) Aspiration pneumonia incidence: Diagnosed based on clinical manifestations, imaging changes, and pathological examination.

2.4. Statistical methods

SPSS 26.0 statistical software was used for data analysis. Measurement data were expressed as mean ± standard deviation (Mean ± SD), and inter-group comparison was performed using *t*-test; count data were expressed as frequency and percentage, and inter-group comparison was performed using x^2 test. $P<0.05$ was considered statistically significant.

3. Results

3.1. Comparison of subglottic secretion clearance volume before and after intervention

After implementing the risk management protocol, the volume of subglottic secretion clearance in the artificial airway significantly increased, from (85.26±13.58) ml before improvement to (146.82±21.33) ml after improvement, with a statistically significant difference ($t=38.052$, $P<0.001$).

3.2. Comparison of microaspiration and aspiration pneumonia incidence before and after intervention

After improvement, the microaspiration incidence was 31.17%, lower than 58.89% before improvement ($x^2=42.168$, $P<0.001$); the aspiration pneumonia incidence was 14.72%, lower than 40.77% before improvement ($x^2=61.909$, $P<0.001$) (**Table 1**).

Table 1. Comparison of Microaspiration and Aspiration Pneumonia Incidence Before and After Intervention [n(%)]

Groups	Microaspiration incidence (%)	Aspiration pneumonia incidence (%)
before improvement	169 (56.33)	126 (42)
After improvement	92 (30.67)	45 (15)
x^2 Value	40.206	53.662
P Value	＜ 0.001	＜ 0.001

4. Discussion

4.1. Innovation in oropharyngeal secretion management strategy to block the microaspiration pathway from the source

The accumulation and downward flow of oropharyngeal secretions is the primary cause of microaspiration in neurocritical care patients. Studies have shown that oropharyngeal colonizing bacteria are the main source of pathogens causing aspiration pneumonia [7]. In traditional nursing, tissue wiping or routine suctioning often fails to thoroughly clear deep pharyngeal retained secretions, and frequent operations easily damage oral mucosa and increase patient discomfort. This study developed a continuous saliva collector combined with a high lateral position (80°–135°), achieving significant results. The mechanism lies in: on one hand, the

high lateral position uses gravity to make oropharyngeal secretions accumulate in the lateral buccal region, avoiding accumulation in the pharynx; on the other hand, the continuous saliva collector achieves continuous, low-negative-pressure suctioning of secretions, solving the "time window" omission problem of traditional intermittent suctioning. Similar to Mraovic et al.'s study indicating that subglottic secretion drainage can significantly reduce microaspiration risk, this study effectively blocked the pathway of oropharyngeal secretions leaking to the lower respiratory tract through the cuff wall through external continuous drainage [8]. Results showed that the volume of subglottic secretion clearance significantly increased after improvement (P<0.001), confirming the high efficiency of this technology in clearing secretion sources.

4.2. Standardization of airway suction depth and cuff management to construct a closed airway defense system

Improper artificial airway cuff management and non-standard airway suctioning operations are important iatrogenic factors causing microaspiration. Addressing clinical pain points, this study implemented dual improvements. First, in airway suctioning, guidelines recommend using modified suctioning methods to reduce airway mucosal damage, but clinical practice often lacks clear scale markings on suction catheters, leading to inaccurate insertion depth [9–10]. This study developed a "suction depth color scale", transforming abstract measurement data into visual color guidance, ensuring the suction catheter tip is precisely located 1–2 cm below the tracheal tube tip. This improvement avoided severe coughing and airway mucosal damage caused by deep suctioning, while also preventing secretion retention due to insufficient suction depth. Consistent with Deng et al.'s evidence summary on microaspiration prevention in ICU patients with artificial airways, precise suctioning operations can effectively reduce microaspiration risk around the cuff [11].

Second, in cuff management, traditional intermittent manual pressure measurement has drawbacks such as large pressure fluctuations and air leakage during measurement. This study introduced an intelligent cuff pressure monitoring system, achieving real-time constant pressure and automatic early warning. Shu et al.'s evidence-based practice pointed out that maintaining cuff pressure in the ideal range of 25–30 cmH_2O is key to preventing microaspiration [8]. The application of intelligent monitoring systems effectively avoided "micro-leakage" caused by low cuff pressure and mucosal ischemia caused by high pressure, thereby constructing a relatively closed airway defense system and significantly reducing the risk of bacterial translocation and microaspiration.

4.3. Integration of multidisciplinary nutritional intervention strategies for dynamic prevention and control of gastric content reflux

Neurocritical care patients often have gastrointestinal motility disorders and impaired swallowing function, and gastric content reflux is another important source of microaspiration [12]. This study changed the previous model of single reliance on nurse experience to adjust nutrition protocols, establishing a nurse-led multidisciplinary collaborative mechanism and implementing a comprehensive gastrointestinal management protocol. Through ultrasound monitoring of gastric residual volume (GRV) combined with gastric antrum motility index (MI) to assess gastrointestinal tolerance, dynamic graded regulation of enteral nutrition speed was achieved. Liu et al.'s study emphasized that dynamic assessment of gastrointestinal function and adjustment of feeding strategies are important measures to prevent aspiration [13]. This study not only standardized post-pyloric feeding pathways but also innovatively introduced diaphragmatic pacing combined with traditional Chinese medicine acupoint plastering for central hiccups, effectively solving the problem

of sudden increase in intra-abdominal pressure and gastric content reflux caused by hiccups. This "dynamic monitoring-early warning-multidimensional intervention" nutritional management model compensates for the shortcomings of traditional nursing in gastrointestinal function management, cutting off the risk source of microaspiration from the digestive tract pathway.

4.4. Construction of a stratified risk assessment system to achieve precision nursing intervention

Microaspiration is occult, and traditional nursing often lacks targeted screening tools [4]. This study developed the "Microaspiration Risk Assessment Scale for Neurocritical Care Patients with Artificial Airways" based on evidence-based evidence, achieving the transformation from "empirical nursing" to "precision nursing." By classifying patients into low, moderate, and high-risk levels and implementing intensive interventions during high-risk periods, rational allocation of nursing resources was ensured. Millot et al.'s study pointed out that microaspiration is closely related to ventilator-associated events, and early identification of high-risk populations is key to improving prognosis [5]. The practice of this study proves that establishing standardized risk assessment and screening mechanisms can significantly enhance nurses' ability to identify microaspiration risks, thereby taking proactive preventive measures and effectively reducing the incidence of aspiration pneumonia.

5. Conclusion

The microaspiration risk management protocol for neurocritical care patients with artificial airways constructed in this study is scientific, innovative, and practical. Through the establishment of risk assessment systems, innovative improvement of nursing equipment, and operation of multidisciplinary collaborative models, airway subglottic secretions were effectively cleared, and the incidence of microaspiration and aspiration pneumonia was significantly reduced, improving patient clinical outcomes. This protocol has formed a set of replicable and promotable standardized operation norms, which can provide a reference for clinical nursing practice.

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Disclosure statement

The authors declare no conflict of interest.

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