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Protocol-Guided Suctioning for Safe Airway Management in Hemorrhagic Stroke Patients with External Ventricular Drainage: A Case Study

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Abstract

Background: Ineffective airway clearance is a frequent nursing diagnosis in critically ill patients, particularly those with hemorrhagic stroke who experience decreased consciousness and impaired cough reflex. Accumulation of airway secretions increases the risk of hypoxia, aspiration, and respiratory complications, necessitating comprehensive airway management in the intensive care unit (ICU).

Objective: This study aims to describe the implementation of suction-based nursing care in managing ineffective airway clearance in a patient with hemorrhagic stroke following external ventricular drainage (EVD).

Methods: A single-patient case study was conducted in the ICU. Data were collected through comprehensive nursing assessment, direct observation, physical examination, and review of medical records. Nursing interventions were implemented based on clinical guidelines, including airway monitoring, positioning, oxygen therapy, and suction procedures. Data were analyzed descriptively to evaluate changes in clinical indicators over a five-day observation period.

Results: Following structured airway management, progressive improvement in respiratory parameters was observed. Oxygen saturation (SpO₂) increased from 94% at baseline to 98% by Day 5, while respiratory rate decreased from 30 to 18 breaths per minute. Secretion volume reduced from approximately 25–30 ml/day to 8–10 ml/day, accompanied by changes in consistency from thick and viscous to thin and clear. Auscultation findings improved from bilateral rhonchi with gurgling to clear vesicular breath sounds. No adverse events or signs of neurological instability were observed during suction procedures.

Conclusion: This case study demonstrates that structured, suction-based nursing care may effectively improve airway clearance and respiratory status in critically ill hemorrhagic stroke patients. Early and carefully monitored airway interventions can support oxygenation and reduce secretion burden without compromising patient safety in the ICU.

Keywords: Airway Management; Critical Care Nursing; Hemorrhagic Stroke; Ineffective Airway Clearance; Suction Procedure.

INTRODUCTION

Neurological disorders remain one of the leading causes of morbidity, mortality, and long-term disability worldwide. Among these conditions, stroke represents a major global health burden with substantial social and economic consequences (1). Stroke is defined as a sudden disturbance of brain function caused by either ischemia or hemorrhage, resulting in neurological deficits lasting more than 24 hours or leading to death. In Indonesia, the prevalence of stroke has reached 10.9 per 1,000 population, reflecting a significant and ongoing demand for comprehensive medical and nursing care.

Hemorrhagic stroke, particularly intracerebral hemorrhage (ICH), is associated with high mortality and severe disability among survivors (2,3). In the acute phase, patients frequently experience decreased levels of consciousness due to increased intracranial pressure and direct brain injury, which impair protective airway reflexes such as coughing and swallowing (4,5). This impairment places patients at high risk for secretion retention, airway obstruction, and respiratory complications. In severe cases, including those involving brainstem dysfunction, patients may require prolonged intensive care and ventilatory support (6,7). Failure to manage these complications effectively can significantly worsen clinical outcomes and increase mortality (8).

From a pathophysiological perspective, disruption of neurological control in stroke affects respiratory regulation and airway protection mechanisms, leading to ineffective airway clearance (9). Impaired airway reflexes disrupt normal ventilation and gas exchange, resulting in decreased oxygen delivery to tissues. Retained secretions further increase airway resistance and reduce lung compliance, exacerbating respiratory compromise (10). Consequently, maintaining airway patency becomes a critical priority in nursing care, particularly for patients with decreased consciousness who are unable to clear secretions independently (11).

In neurocritical care, the management of intracranial pressure often requires neurosurgical interventions such as External Ventricular Drainage (EVD), which is used to remove cerebrospinal fluid and stabilize neurological status (3). Although EVD plays a crucial role in neurological stabilization, it introduces additional clinical complexity.

Patients with EVD remain highly vulnerable to systemic complications, particularly respiratory compromise, while requiring strict positioning and handling precautions to prevent intracranial pressure fluctuations, infection, and device-related complications. This creates a clinical dilemma in which airway management interventions must be effective yet carefully controlled to avoid compromising neurological stability.

Ineffective airway clearance is therefore a common and critical nursing diagnosis in patients with hemorrhagic stroke (PPNI, 2017). Nursing interventions such as airway monitoring, oxygen therapy, positioning, and suction procedures are essential to maintain airway patency in these patients (12,13). Suctioning, in particular, is a key intervention for removing retained secretions and preventing airway obstruction. Various suction techniques are used depending on patient condition and airway access (14,15), and previous studies have shown that structured suction interventions, combined with appropriate positioning and monitoring, can improve oxygenation and reduce secretion accumulation (16,17).

However, despite its clinical importance, suctioning in neurocritical patients—especially those with EVD—presents unique risks. Suction procedures may trigger physiological responses such as increased intracranial pressure, hemodynamic instability, or hypoxia if not performed carefully. Current critical care guidelines emphasize the importance of standardized protocols to minimize complications in both airway management and EVD care (2). Additionally, stroke patients frequently experience dysphagia, with reported incidence ranging from 37% to 78%, further increasing the risk of aspiration and respiratory complications (18,19). These factors highlight the need for precise, safe, and context-specific airway management strategies.

Despite the growing body of evidence on airway management and suction techniques, existing studies predominantly focus on general ICU populations or infection prevention strategies, such as ventilator-associated pneumonia bundles. There is limited evidence specifically addressing the integration of suction interventions within the complex clinical context of hemorrhagic stroke patients undergoing neurosurgical procedures such as EVD.

Furthermore, there is a lack of detailed, case-based nursing evidence describing how suction interventions are implemented in practice, how patient responses evolve over time, and how safety is maintained in the presence of neurological instability.

This gap underscores the need for clinically grounded, context-specific studies that bridge theoretical guidelines with real-world nursing practice. In particular, there is a need to better understand how suction interventions can be applied as a targeted, safety-sensitive nursing strategy in patients with hemorrhagic stroke and EVD, where both airway patency and neurological stability must be carefully balanced.

Therefore, this study aims to analyze the implementation of nursing care in a hemorrhagic stroke patient experiencing ineffective airway clearance, with a specific focus on suction intervention as a primary strategy to maintain airway patency and support respiratory function in a neurocritical care setting.

This study offers a novel contribution by providing a case-based, clinically detailed analysis of suction intervention within a high-risk neurocritical context, specifically in a patient with hemorrhagic stroke following EVD. By integrating pathophysiological understanding, evidence-based practice, and real-world nursing application, this study highlights the critical role of nurses in balancing airway management and neurological safety, thereby contributing to the advancement of critical care and neurocritical nursing practice.

METHODS

Study Design

This study employed a qualitative descriptive case study with a protocol-guided clinical approach, focusing on a patient with hemorrhagic stroke experiencing ineffective airway clearance following External Ventricular Drainage (EVD) placement. Unlike conventional descriptive case studies, this design integrated a structured suctioning protocol with continuous clinical monitoring to evaluate both respiratory outcomes and neurological safety. This approach was chosen to capture the complexity of airway management in neurocritical care, where

interventions must balance airway patency with intracranial stability.

Participant

The participant was a patient diagnosed with intracerebral hemorrhage who was admitted to the intensive care unit and underwent EVD placement. The case was selected purposively to represent a high-risk neurocritical condition requiring simultaneous airway and neurological management. Eligibility was determined based on the presence of decreased level of consciousness and clinical signs of ineffective airway clearance, such as retained secretions and abnormal breath sounds. Patients with unstable hemodynamic conditions that contraindicated suction procedures or incomplete clinical data were excluded.

Protocol-Guided Suction Intervention

The intervention consisted of a protocol-guided suctioning strategy designed to maintain airway patency while minimizing the risk of intracranial instability (Figure 1). The protocol was developed based on evidence-based critical care guidelines and adapted specifically for neurocritical patients with EVD. The intervention began with a comprehensive assessment of respiratory and neurological status, including oxygen saturation, respiratory rate, breath sounds, and level of consciousness. Patient positioning was optimized using a head elevation approach to facilitate secretion drainage while maintaining cerebral perfusion. Prior to suctioning, pre-oxygenation was administered to prevent hypoxia. Suctioning was performed using sterile technique with controlled negative pressure and limited duration to reduce physiological stress. Throughout the procedure, continuous monitoring was conducted to detect any signs of instability, including changes in oxygen saturation, respiratory pattern, or neurological status. The intervention was immediately adjusted or stopped if adverse responses were observed. Following suctioning, reassessment was conducted to evaluate the effectiveness of secretion clearance and ensure that both respiratory and neurological conditions remained stable. This protocol reflects a safety-oriented, neuroprotective approach to airway management in critically ill neurological patients.

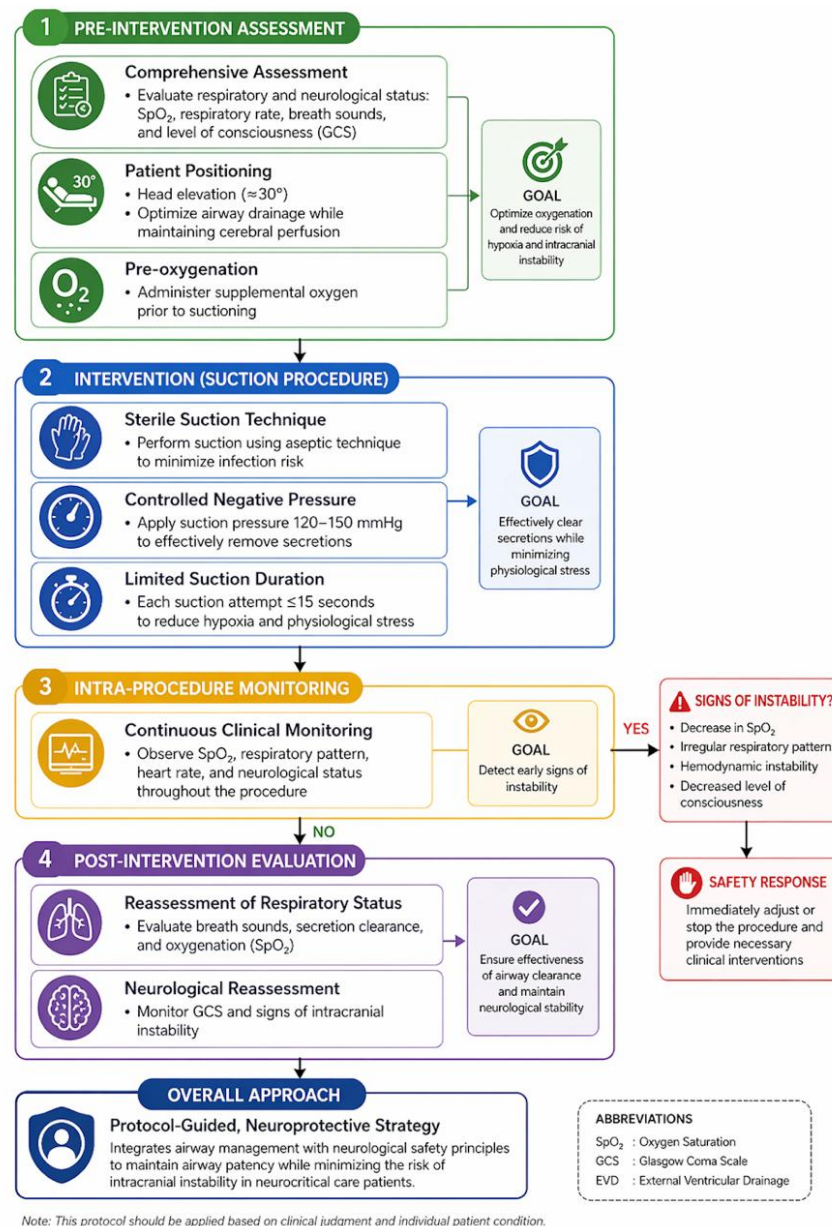


Figure 1. Protocol-Guided Suctioning Intervention for Neurocritical Patients with External Ventricular Drainage

Implementation of the Intervention

The intervention was delivered by ICU nurses trained in airway management and neurocritical care monitoring. Suctioning was performed based on clinical indications rather than fixed scheduling, allowing the intervention to be responsive to patient condition. The protocol was implemented over a five-day observation period, during which patient responses were continuously monitored and documented.

Adjustments to the intervention were made based on the patient's tolerance and clinical stability, reflecting individualized care in a neurocritical setting.

Data Collection Procedure

Data were collected through direct observation, physical examination, and review of medical records using a structured and repeated-measures approach. Clinical parameters included

respiratory rate, oxygen saturation, breath sounds, secretion characteristics, cough reflex, and level of consciousness assessed using the Glasgow Coma Scale.

To ensure patient safety within the neurocritical context, additional attention was given to indicators of potential intracranial instability, such as changes in consciousness level and abnormal vital sign patterns. Data collection was conducted daily over five consecutive days using standardized observation formats to maintain consistency and reliability.

Data Analysis

Data were analyzed using descriptive longitudinal analysis to examine changes in respiratory and neurological parameters before and after the intervention. The analysis focused on identifying patterns of clinical improvement in airway clearance and oxygenation while ensuring that neurological stability was maintained. Findings were interpreted as a dynamic clinical trajectory rather than statistical associations, consistent with the single-case study design.

Ethical Considerations

This study was conducted with permission from the hospital authority. Informed consent was obtained from the patient's family or legal representative due to the patient's decreased level of consciousness. Patient confidentiality was maintained by anonymizing all identifying information. Participation was voluntary, and the patient's family had the right to withdraw at any time without consequence. All procedures adhered to ethical principles of patient safety, beneficence, and respect for dignity.

RESULT

Clinical Progression During Protocol-Guided Suctioning

The patient was admitted to the ICU with intracerebral hemorrhage and underwent External Ventricular Drainage (EVD). At baseline

(Day 1), the patient had a decreased level of consciousness (GCS 5; E1M2VT) and ineffective airway clearance, characterized by tachypnea (28 breaths/min), SpO₂ of 94%, bilateral rhonchi with gurgling, thick yellow viscous secretions, and absent cough reflex. Following suction intervention, SpO₂ improved to 96% without signs of instability. Over the five-day observation period, a progressive improvement in respiratory and neurological status was observed. Respiratory rate gradually decreased from 28 to 18–20 breaths/min, while SpO₂ increased and stabilized at 98%. Secretion volume reduced from approximately 25–30 ml/day to 8–10 ml/day, with changes from thick yellow to thin white consistency. Breath sounds improved from rhonchi with gurgling to clear vesicular sounds by Day 5. The cough reflex also became more responsive (Table 1).

Trend Analysis of Respiratory and Secretion Parameters

Across the five-day observation period, a clear clinical trajectory was observed (Figure 1). Respiratory rate showed a steady decline from 28 to 18 breaths per minute, indicating improved respiratory efficiency. Oxygen saturation progressively increased and stabilized at ≥98%, demonstrating effective oxygenation following repeated suction interventions. In parallel, secretion characteristics improved significantly, with a marked reduction in volume (from approximately 25–30 ml/day to 8–10 ml/day), accompanied by changes in color from thick yellow to clear white and a transition from viscous to thin consistency. These changes indicate progressive resolution of secretion retention and improved airway clearance. Auscultatory findings also showed improvement, with initial rhonchi and gurgling resolving completely by Day 5. Importantly, no signs of airway obstruction, aspiration, or respiratory deterioration were observed during the intervention period.

Table 1. Progression of Airway Clearance and Respiratory Parameters During Five Days of Suction Intervention

Day	Suction Frequency	total Production Sputum/24H	Secretion Color	Consistency	SpO ₂ Before	SpO ₂ After	Breath Sounds	Clinic Description
1	4-6 Times	± 25-30 ml	Thick Yellow	Viscous	94%	96%	Clear Rhonci(+) Gurgling (+)	Increase Secretion Production
2	4-5 Times	± 20-25 ml	Yellow	Viscous	95%	97%	Ronchi(+) Gurgling(+)	Secretion Production beginning to decrease
3	3-4 Times	± 15-20 ml	Brownish	Viscous	95%	98%	Reduced Ronchi (+) Gurgling (+)	Respiratory improvement observed
4	2-3 Times	± 10-15 ml	Yellow-White	Less Viscous	97%	98%	Minimal Ronchi ,Gurgling (-)	Respiratory improvement observed
5	2 Times	± 8-10 ml	White	Thin	98%	98%	Ronchi(-) Gurgling (-)	Minimal secretion production

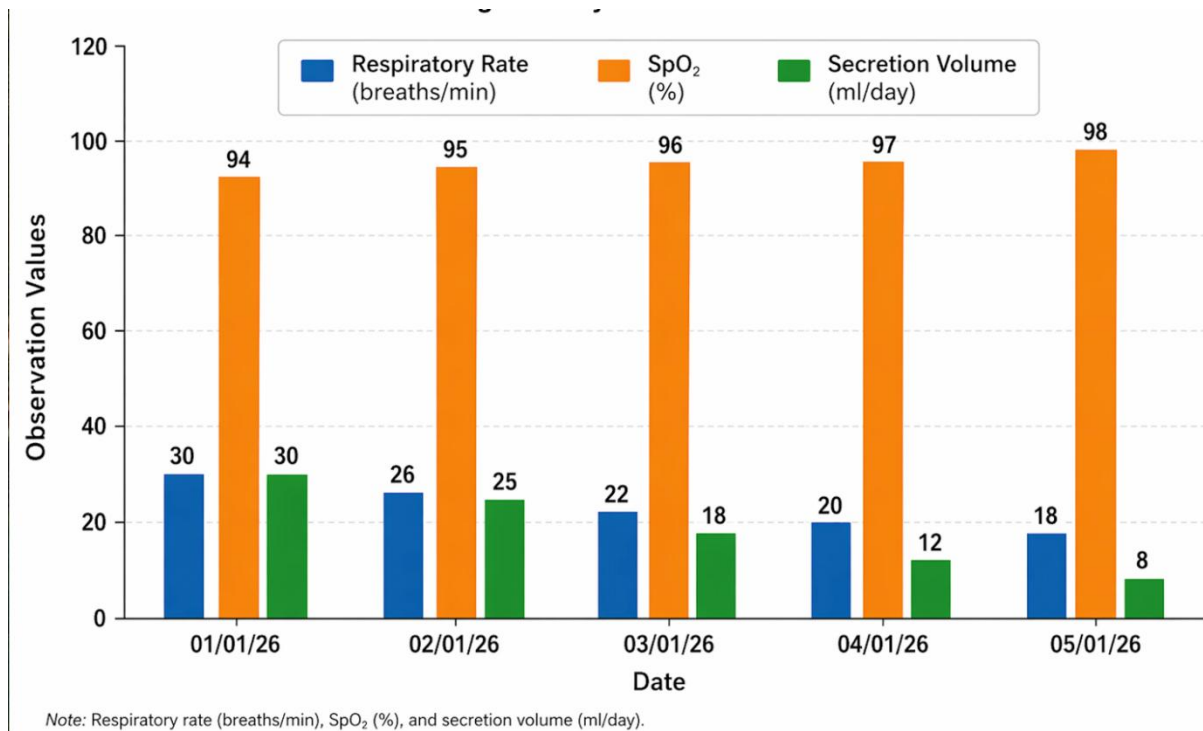


Figure 2. Trend of respiratory rate, oxygen saturation (SpO₂), and secretion volume during five days of protocol-guided suction intervention.

DISCUSSION

Respiratory complications are common among patients with hemorrhagic stroke, particularly in those with decreased levels of consciousness and impaired airway protective reflexes. Previous studies have reported that patients with intracerebral hemorrhage requiring neurocritical interventions, including EVD placement, are at increased risk of respiratory compromise due to impaired neurological regulation of breathing and secretion retention (4,6). This condition reflects the complex interaction between neurological injury and respiratory function, where disruption of central respiratory control mechanisms contributes to ineffective airway clearance and increased vulnerability to complications.

From a physiological perspective, impaired neurological function leads to reduced airway reflexes, diminished cough effectiveness, and compromised mucociliary clearance, resulting in the accumulation of secretions within the airway (4,5). This accumulation increases airway resistance, interferes with ventilation and gas exchange, and may produce abnormal breath sounds such as rhonchi (8). In neurocritical patients, these changes can rapidly progress to hypoxia and respiratory failure if not managed appropriately.

In the present case, the patient demonstrated gradual improvement in respiratory parameters over a five-day observation period, including increased oxygen saturation, reduced secretion retention, and clearer breath sounds. While these findings indicate a favorable clinical progression, it is important to recognize that such improvements cannot be attributed solely to suction interventions. The patient received comprehensive ICU management, including oxygen therapy, positioning, and neurological care, all of which likely contributed to the observed outcomes. This highlights the multifactorial nature of recovery in critically ill patients, where multiple interventions interact to produce clinical improvement (20,21).

Nevertheless, suction interventions likely played a supportive and clinically relevant role, particularly during the early phase when secretion accumulation was prominent. Effective suctioning helps maintain airway patency, reduce airway obstruction, and facilitate ventilation. This is consistent with previous studies demonstrating that suction interventions are associated with improved oxygen saturation and

reduced secretion burden (3,22). Furthermore, the observed improvement in oxygenation aligns with findings indicating a relationship between suction frequency and oxygenation status in ventilated patients (23).

The effectiveness of suctioning is also influenced by the technique used. Evidence suggests that different suction methods, including closed suction systems, may affect lung volume, oxygenation, and overall respiratory stability (17). Clinical guidelines emphasize that adherence to standardized suction protocols is essential to ensure patient safety and minimize complications such as hypoxemia, mucosal injury, and infection (24,25). Therefore, the quality and appropriateness of suction procedures are as important as their frequency in achieving optimal outcomes.

From a clinical nursing perspective, suction interventions should be guided by patient assessment rather than performed routinely. This aligns with fundamental nursing principles emphasizing individualized, patient-centered care and the use of clinical judgment (26,27). Proper technique, including sterile procedures, appropriate suction pressure, and limited duration, is critical to prevent adverse effects while maintaining airway patency (8,28). In neurocritical settings, airway management must also be carefully coordinated with neurological monitoring to avoid increases in intracranial pressure or disruption of cerebral perfusion.

The findings of this case are consistent with previous literature on airway management in stroke patients. Emergency airway management approaches highlight the importance of systematic assessment and timely intervention in preventing respiratory deterioration (24). Case-based evidence in intracerebral hemorrhage patients also supports the role of suction in improving airway clearance outcomes. Additionally, patients with decreased consciousness due to cerebral conditions require intensive monitoring and airway support to prevent secondary complications such as aspiration pneumonia.

From a broader perspective, this case underscores the critical role of nurses in early identification and management of ineffective airway clearance in neurocritical patients. Nurses are responsible for continuous monitoring, timely intervention, and ensuring adherence to evidence-based protocols. A structured, protocol-based approach to airway management,

integrated with neurological care, is essential to optimize patient safety and support recovery in the ICU setting.

Clinical Implications

This case highlights that suction-based airway management should be implemented as part of a comprehensive, assessment-driven care strategy in neurocritical patients. Nurses play a central role in identifying early signs of airway compromise and delivering timely interventions. The integration of standardized suction protocols, continuous monitoring, and multidisciplinary collaboration can enhance patient outcomes, improve oxygenation, and reduce the risk of respiratory complications in patients with hemorrhagic stroke following EVD placement.

Limitations

This study has several limitations. As a single case study, the findings are not generalizable and may be influenced by individual patient characteristics, concurrent medical treatments, and the natural course of recovery. The absence of comparative data and statistical analysis limits the ability to determine the specific contribution of suction interventions to the observed improvements. Additionally, the short observation period restricts evaluation of long-term respiratory and neurological outcomes.

CONCLUSION

This case study provides a clinical illustration of suction-based airway management in a patient with hemorrhagic stroke following EVD placement. Improvements in respiratory status, including oxygenation and airway clearance, were observed over the course of care; however, these outcomes should be interpreted within the context of comprehensive ICU management. Suction interventions appear to play a supportive role in maintaining airway patency, emphasizing the importance of structured, evidence-based nursing care. Further research with larger samples and rigorous study designs is needed to strengthen the evidence for suction interventions in neurocritical nursing practice.

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Author Contributions

TN : Conceptualization, study design, methodology, data collection, intervention supervision, data analysis, interpretation of results, and manuscript drafting.

LOM : Methodological consultation and statistical analysis guidance.

TT: Critical revision of the manuscript and final approval.

I: Critical revision of the manuscript and final approval.

Conflict of Interest

The authors declare that they have no competing interests related to the publication of this article.

Data Availability Statement

The data generated and/or analyzed during this study are available from the corresponding author upon reasonable request.

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