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Study on Targeted Interventions to Reduce the Incidence of Delayed Recovery in Patients Undergoing General Anesthesia

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Abstract: *This study aimed to implement targeted interventions based on baseline data regarding delayed recovery from anesthesia in our institution and to evaluate their effectiveness, as well as to explore their potential for clinical application. An observational study design with a pre-and-post comparison was employed. The period from February to July 2023 served as the baseline for the pre-intervention phase, during which a retrospective analysis of the incidence of delayed recovery in 5,742 patients undergoing general anesthesia was conducted. A systematic literature review was performed to identify key risk factors, which informed the development and implementation of a comprehensive intervention program. This program included enhanced preoperative assessments and optimization, precise administration and antagonism of anesthetic agents, and active intraoperative warming. Data from the same period (February to July) in the subsequent years were used as outcome measures to compare the changes observed in 2024 (n=6,116) and 2025 (n=5,789). Following the implementation of the intervention measures, the incidence of delayed recovery (>2 hours) showed a decreasing trend, from 1.93% in the pre-intervention year (2023) to 1.86% in 2024, and significantly decreased to 1.59% in the second year post-intervention (2025) (P<0.05). This study confirms that targeted interventions based on evidence-based medicine can effectively reduce the incidence of delayed recovery in patients undergoing general anesthesia, thereby optimizing the quality of anesthetic recovery. The proposed intervention program demonstrates scientific validity, effectiveness, and good operability, indicating its potential for broader application in similar healthcare institutions.*

Keywords: *General anesthesia; Delayed recovery; Quality improvement; Targeted intervention; Application value*

1. Introduction

Delayed awakening after general anesthesia is one of the common complications observed during the anesthesia recovery period [1]. This condition not only directly impacts the turnover efficiency of the operating room but is also closely associated with the risk of adverse events such as postoperative pulmonary infections, hypoxemia, and cognitive dysfunction. Therefore, it serves as a key indicator for measuring the quality and safety of perioperative medical care [2]. The reported incidence of delayed awakening varies depending on the definition used, the type of surgery, and the patient population, with rates reaching as high as 8.1% in specific groups [3]. Consequently, implementing effective measures to prevent and reduce the occurrence of delayed awakening has become an important and urgent issue in the field of anesthesia quality management.

In recent years, numerous studies have focused on delayed awakening, identifying factors such as advanced age, the presence of multiple comorbidities, prolonged surgery duration, intraoperative hypothermia, and the accumulation of anesthetic agents as significant determinants affecting the recovery time and quality of patients [4, 5, 6]. A retrospective analysis of anesthesia data quality control conducted at our institution revealed that from February to July 2023, the incidence of delayed awakening (>2 hours) in patients undergoing general anesthesia was 1.93%. Although this figure is below the industry-recognized standard for high-quality anesthesia care (defined as <2%) as per the 2022 version of the anesthesia quality control indicators, there remains room for improvement.

In response, our research team conducted an in-depth literature review to identify key risk factors and implement targeted interventions. We developed a comprehensive intervention strategy that

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includes enhanced preoperative assessments, precise anesthetic dosing, and proactive intraoperative warming measures. This study aims to evaluate the effectiveness of this intervention process in reducing the incidence of delayed awakening in patients undergoing general anesthesia, as well as to assess its feasibility and potential value for broader application, ultimately enhancing the quality of medical care.

2. Materials and methods

2.1 Study design

Data collected from February to July 2023 served as the baseline for pre-intervention analysis and current status assessment. Comprehensive intervention measures were initiated on a point-to-point basis. The same months in 2024 and 2025 were designated as post-intervention evaluation periods to assess the effectiveness of the intervention measures.

2.2 Study subjects

Inclusion Criteria: The study included patients who underwent elective or emergency surgeries requiring general anesthesia at our institution, received tracheal intubation for general anesthesia, and were transferred to the Post-Anesthesia Care Unit (PACU) postoperatively.

Exclusion Criteria: Patients were excluded if they had incomplete clinical data, presented with severe altered consciousness (e.g., coma) prior to surgery or were directly transferred to the Intensive Care Unit (ICU) following surgery.

A total of 5,742 patients were included in the pre-intervention group (2023), while the post-intervention group comprised 6,116 patients in 2024 and 5,789 patients in 2025. Baseline characteristics of the three groups are compared in the Table 1.

Table1. Baseline characteristics of the three groups are compared

year	Object	cases with delayed resuscitation	Recovery delay (>2 hours) rate	p value
2023	5,742	111	1.93	-
2024	6,116	114	1.86	0.378
2025	5789	92	1.59	0.049

Data indicate that following the implementation of the intervention, the incidence of delayed awakening (>2 hours) in patients undergoing general anesthesia decreased from 1.93% prior to the intervention (in 2023) to 1.86%, and further declined to 1.59% in the second year post-intervention (2025), compared to the baseline in 2023 ($P<0.05$). This demonstrates a sustained improvement in outcomes.

3. Development and implementation of targeted interventions

Delayed awakening from anesthesia poses a significant threat to perioperative safety and is a critical focus of anesthesia quality control. This study adheres to the principles of evidence-based medicine and, based on a systematic literature review, combines the practical work conditions of our hospital's anesthesia department to establish a comprehensive set of multidimensional intervention strategies addressing various risk factors associated with delayed awakening in patients undergoing general anesthesia. This strategy emphasizes three key areas: the identification of high-risk populations, management of critical control points, and continuous quality improvement. The goal is to reduce the incidence of delayed awakening in patients undergoing general anesthesia and to enhance anesthesia quality and patient outcomes through standardized and refined perioperative management.

3.1 Strengthening preoperative assessment and individualized anesthesia plans for high-risk patients

Elderly patients, characterized by physiological decline, multiple comorbidities, and slower drug metabolism, represent a high-risk group for delayed awakening[7,8,9]. To accurately identify risks, we designed a standardized preoperative assessment and risk evaluation form for patients undergoing general anesthesia. This assessment form enhances the evaluation of key factors, including advanced

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age (>65 years), liver and kidney function, cardiopulmonary status, baseline cognitive function (using a simple cognitive screening tool), and medication history. For patients with chronic conditions such as diabetes and hypertension, we collaborate with the ward team to optimize the internal environment preoperatively, maintaining fasting blood glucose levels between 6.1-10.0 mmol/L and controlling blood pressure fluctuations within ±20% of baseline values[10,11,12].

Based on the assessment results, we develop individualized anesthesia plans. For elderly patients and those with hepatic or renal insufficiency, we aim for smooth induction of anesthesia using a slow induction approach and accurately calculate drug dosages based on ideal body weight or lean body weight, typically administering 1/2 to 2/3 of the standard adult induction dose. In terms of drug selection, we prioritize agents with rapid metabolism and minimal accumulation, such as propofol, etomidate, and remifentanil, to construct a "fast-track anesthesia" plan that reduces reliance on hepatic and renal metabolism and lowers the risk of drug accumulation.

3.2 Implementation of comprehensive temperature management strategies

Inadvertent hypothermia during the perioperative period (core temperature <36°C) can inhibit drug metabolism, reduce organ perfusion, and suppress central nervous system function, making it an independent risk factor for delayed awakening. To address this, we have established an active temperature management protocol that spans the entire surgical procedure.

Specific measures include: preheating the operating room to 24-26°C for 30 minutes prior to surgery; immediately covering non-surgical areas of the patient with a pre-warmed, inflatable warming blanket upon entry into the operating room; ensuring all intravenous fluids and blood products are heated to 37°C before administration; and continuously monitoring core temperature (using nasopharyngeal or bladder temperature) during surgery, recording it every 15 minutes. For patients undergoing procedures lasting more than 2 hours or with significant exposure of body cavities, we employ a dual warming strategy using both an inflatable warming blanket (set at 38-40°C) and a circulating water warming blanket to maintain core temperatures above 36.5°C. During patient transport to the Post-Anesthesia Care Unit (PACU) and throughout the recovery period in the PACU, we continue to use warming blankets until the patient's temperature stabilizes above 36.5°C.

3.3 Enhanced monitoring of anesthetic depth and rational drug administration

An overdose of anesthetic agents is a common cause of delayed recovery. To accurately control the depth of anesthesia, we have implemented a multi-faceted monitoring and management approach. All patients undergoing general anesthesia are routinely monitored using the Bispectral Index (BIS), with target values maintained between 40 and 60. This provides anesthesiologists with an objective basis to prevent excessive anesthesia.

For high-risk patients, including those with prolonged surgical times, advanced age, obesity, or concurrent organ dysfunction, we employ a goal-directed drug infusion strategy. The infusion rates of propofol and remifentanil are dynamically adjusted based on the intensity of surgical stimuli and real-time BIS values, allowing for on-demand administration and reducing drug accumulation. Additionally, we implement a goal-directed fluid therapy approach, controlling the volume of crystalloid fluid administered while ensuring hemodynamic stability to prevent tissue edema and dilution of drug concentrations. Prior to the conclusion of the surgery, we routinely assess the recovery of neuromuscular function and utilize neuromuscular antagonists as necessary.

3.4 Establishment of a data-driven quality control improvement mechanism

To ensure the effective implementation of these measures, we have established a regular training and assessment mechanism. Anesthesiologists and nurses participate in specialized training sessions covering critical aspects such as temperature management, BIS monitoring, and drug antagonism. Monthly assessments of theoretical knowledge and technical skills are conducted.

In terms of data management, PACU nurses are responsible for meticulously recording the admission time, surgery completion time, extubation time, periods with a Steward score ≥ 5, and any related complications for each patient undergoing general anesthesia. Data is compiled and analyzed monthly, with findings discussed in departmental quality and safety meetings to identify issues and implement timely improvements, thus creating a continuous cycle of quality enhancement through planning, implementation, evaluation, and action.

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4. Discussion

This study identified issues through anesthesia quality control, followed by evidence-based tracking, and developed targeted point-to-point interventions for risk factors, with the aim of effectively reducing the incidence of delayed recovery in patients undergoing general anesthesia. Quality control data indicated that the effectiveness of the interventions continued to improve in the second year of implementation [13], with the rate of delayed recovery decreasing from 1.93% in 2023 to 1.59%. This significant reduction demonstrates not only the effectiveness of the intervention program but also its considerable potential for ongoing optimization. The continuous refinement of the program provides strong evidence for its widespread application in clinical practice.

The targeted intervention program developed in this study has been validated through its application in anesthesiology practice[14]. This protocol is characterized by a high degree of structure and standardization, making it less dependent on specific individuals and easier for medical teams to understand and adopt. With a low technical threshold, it can be rapidly implemented across hospitals of various levels, including primary care facilities. Any healthcare institution can adapt the framework provided by this program to align with regional patient characteristics and optimize existing resources, enabling localized replication of the process, thus demonstrating significant potential for dissemination across healthcare systems. The core intervention measures are based on established techniques widely used in practice [15]. These procedural standards have been incorporated into anesthesia nursing guidelines, and the establishment of a structured nursing team with clearly defined responsibilities can systematically enhance the management of the anesthesia recovery unit. This program does not require substantial financial investment in new equipment; rather, it promotes more effective utilization of existing resources and a more rational allocation of healthcare personnel. By effectively reducing the incidence of delayed recovery, it can directly shorten patient stay in the anesthesia recovery unit, thereby significantly improving the turnover efficiency of operating rooms. Furthermore, by minimizing complications associated with the recovery period (such as hypoxemia, shivering, and agitation), it reduces the subsequent medical costs associated with managing these complications and improves the quality of postoperative recovery, indirectly alleviating the overall burden on the healthcare system. This aligns with the modern values of healthcare management, enhancing quality and operational efficiency while demonstrating high economic feasibility.

5. Conclusion

This study confirms that evidence-based targeted interventions can significantly reduce the incidence of delayed recovery in patients undergoing general anesthesia. The program exhibits favorable clinical benefits and possesses substantial potential for broader application, providing new insights for enhancing the quality of perioperative anesthesia care.

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