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Effect of Safety Management Based on Feedforward Control on the Awakening Quality of Patients Undergoing General Anesthesia for Lung Cancer Surgery

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Abstract

Objective: To investigate the role of the safety management model based on feed-forward control in the anesthesia nursing of patients undergoing general anesthesia for lung cancer surgery. **Methods:** A total of 46 patients with lung cancer who underwent general anesthesia surgery and were admitted to the Anesthesiology Department from December 2024 to December 2025 were selected as the research subjects. They were divided into a control group and an observation group using the random number table method, with 23 patients in each group. The control group adopted the routine safety management model in the anesthesiology department, while the observation group adopted the safety management model based on feed-forward control. The recovery-related indicators, the incidence of adverse events during the recovery period, and nursing satisfaction were compared between the two groups. **Results:** The time for the observation group patients to recover spontaneous breathing, open their eyes, and have extubation was better than that of the control group, and the differences were statistically significant ($P < 0.05$). After resuscitation treatment, the recovery score of the observation group was higher than that of the control group, and the difference was statistically significant ($P < 0.05$). During the recovery period, the incidence of adverse events in the observation group was only 8.70% (2/23), which was lower than 39.13% (9/23) in the control group, and the difference was statistically significant ($P < 0.05$). The nursing satisfaction in the observation group reached 95.65% (22/23), which was higher than 65.22% (15/23) in the control group, and the difference was statistically significant ($P < 0.05$). **Conclusion:** The safety management model applying the feed-forward control mechanism can reduce the time for patients undergoing general anesthesia for lung cancer surgery to regain conscious-

ness, optimize the process of regaining consciousness, reduce the incidence of adverse events during the recovery period, and enhance patients' satisfaction with nursing services.

Keywords

Feedforward Control, Safety Management, Lung Cancer, General Anesthesia, Recovery Quality

1. Introduction

Lung cancer is one of the common clinical malignant tumors. Currently, general anesthesia surgery is one of the main treatment methods for lung cancer. The anesthesia recovery period is a crucial stage for patients to transition from the anesthetic state to the awake state. During this stage, the patients' physiological functions have not fully recovered, and they are prone to adverse events such as agitation, respiratory depression, and hypoxemia. These not only affect the patients' recovery quality but may also increase nursing risks and even endanger the patients' lives [1]. Nursing safety management in the anesthesiology department is an important part of ensuring the perioperative safety of patients undergoing general anesthesia surgery. The conventional safety management mode mainly focuses on feedback control, that is, intervening after problems occur, which has obvious lag and is difficult to effectively prevent the occurrence of adverse events [2]. Feed-forward control is an advanced control form proposed relative to feedback control. Its core is to predict possible future problems and take control measures in advance to nip potential problems in the bud, overcoming the defect of time lag in feedback control [3]. In recent years, feed-forward control has been widely applied in the field of medical safety management, but the application research in the anesthesiology department nursing of patients undergoing general anesthesia surgery for lung cancer is still relatively limited. In this study, 46 patients undergoing general anesthesia surgery for lung cancer were selected to explore the effect of safety management based on feedforward control on the patients' recovery quality. The results are reported as follows.

2. Materials and Methods

2.1. General Information

A total of 46 lung cancer patients who underwent general anesthesia for surgery and were admitted to the Department of Anesthesiology from December 2024 to December 2025 were divided into a control group (n = 23) and an observation group (n = 23) using the random number table method. In the control group, there were 13 males and 10 females, aged between 42 and 73 years, with an average age of (58.62 ± 7.35) years. There were 15 cases of lobectomy and 8 cases of segmentectomy. According to the American Society of Anesthesiologists (ASA) clas-

sification, 16 cases were of Grade II and 7 cases were of Grade III. Fifteen cases had a smoking history. The average operation duration was (128.45 ± 22.36) min. In terms of lung cancer staging, there were 10 cases of Stage I, 9 cases of Stage II, and 4 cases of Stage III. The surgical methods included 15 cases of lobectomy and 8 cases of segmentectomy. The anesthesia regimens were intravenous-inhalation combined anesthesia in 20 cases and total intravenous anesthesia in 3 cases.

In the observation group, there were 12 males and 11 females, aged between 40 and 75 years, with an average age of (59.17 ± 7.52) years. There were 14 cases of lobectomy and 9 cases of segmentectomy. According to the ASA classification, 15 cases were of Grade II and 8 cases were of Grade III. Thirteen cases had a smoking history. The average operation duration was (127.65 ± 21.65) min. In terms of lung cancer staging, there were 11 cases of Stage I, 8 cases of Stage II, and 4 cases of Stage III. The surgical methods included 14 cases of lobectomy and 9 cases of segmentectomy. The anesthesia regimens were intravenous-inhalation combined anesthesia in 19 cases and total intravenous anesthesia in 4 cases.

A comparative analysis of the baseline data of the two groups showed no significant differences in the above-mentioned indicators between the two groups ($P > 0.05$). The study was approved by the hospital ethics committee (Ethics No.: G2023-238).

Inclusion criteria: (1) Meeting the diagnostic requirements for lung cancer [4] and confirmed by pathological examination; (2) Planning to undergo radical resection of lung cancer under general anesthesia; (3) The age of the patients ranging from 40 to 75 years old; (4) The patients and their families are required to provide written informed consent, clearly stating their willingness to participate in this study.

Exclusion criteria: (1) Patients with severe impairment of critical organ function; (2) Patients accompanied by coagulation disorders and immune system diseases; (3) Individuals with a history of mental illness or drug dependence problems; (4) Patients who have developed respiratory failure or severe infection before surgery; (5) Patients who encounter urgent and severe complications such as massive hemorrhage and cardiac arrest during the surgery.

2.2. Methods

2.2.1. Control Group: Routine Safety Management Mode in the Anesthesiology Department

(1) Conduct pre-operative anesthesia consultation, inform patients of precautions, complete pre-operative examinations, and make preparations for anesthesia. (2) During the operation, follow the anesthesia operation standards, perform anesthesia induction and maintenance, and monitor the patient's vital signs to respond promptly to emergencies. (3) After the patient recovers in the anesthesia recovery room, receive nursing care such as vital sign monitoring, oxygen inhalation, and sputum suction. After the patient is awake and meets the extubation criteria, perform extubation and observe for 30 - 60 minutes. If there are no abnormal conditions, transfer the patient back to the ward, and provide post-oper-

ative pain management, complication prevention, and health education.

2.2.2. Observation Group: Safety Management Model Based on Feedforward Control

Through literature review, case review, and group discussion, the high-risk factors during the awakening period were identified: age ≥ 65 years, long-term smoking, moderate to severe pulmonary function decline, ASA Grade Ⅲ, operation duration > 150 min, intraoperative hypotension, insufficient analgesia, etc. High risk: ≥ 3 high-risk factors, with extremely high risks of agitation, respiratory depression, and hypoxemia; Medium risk: 1 - 2 high-risk factors, with certain risks during the awakening period; Low risk: no high-risk factors, with smooth awakening and low risk of complications.

Specific measures:

(1) For high-risk patients: Immediately initiate a special monitoring and intensive intervention plan. Conduct comprehensive respiratory function training and psychological intervention before surgery, enforce smoking cessation and perform nebulization inhalation therapy. The head of the anesthesiology department formulates an individualized anesthesia plan. During the operation, use BIS to accurately monitor the depth of anesthesia, warm the infusion throughout the process, strictly control the infusion speed and volume, and maintain circulatory stability. After the operation, the patient is transferred to the recovery room and is under 24-hour dedicated care. The modified Aldrete score [5] is used to evaluate the awakening state. The consciousness, respiration, analgesia, and agitation are evaluated every 5 minutes. The patient is given continuous oxygen inhalation and the airway is kept unobstructed. When the pain score is ≥4, intravenous analgesics are immediately given to prevent agitation. When weak breathing or a decrease in blood oxygen occurs, assisted breathing is immediately provided. The tracheal tube is removed as early as possible and the patient is transitioned to mask oxygen inhalation. At the same time, keep the patient warm, monitor blood gas, prevent high-risk events such as respiratory depression, hypoxemia, and severe agitation, and ensure that the patient meets the Steward score criteria before being transferred out of the recovery room.

(2) For medium-risk patients: Implement enhanced monitoring and preventive intervention. Improve pre-operative education and respiratory exercises, guide effective coughing, and provide smoking cessation supervision and psychological comfort to smokers. During the operation, standardly monitor vital signs, maintain an appropriate depth of anesthesia, and protect body temperature. After the operation, the patient is transferred to the recovery room and the awakening is evaluated every 10 minutes. The patient is given routine continuous low-flow oxygen inhalation and the airway is kept unobstructed. Preventive analgesics and anti-emetic drugs are given in advance to reduce the occurrence of agitation, nausea, and vomiting. Closely observe the respiratory rate and blood oxygen saturation, and promptly clear airway secretions. Extubation strictly follows the indications. After extubation, the patient is observed for 20 - 30 minutes. After the pa-

tient is stable, they are transferred to the general ward. At the same time, postoperative guidance on body position, diet, and activities is provided to reduce the risk of adverse events.

(3) For low-risk patients: Use routine monitoring and on-demand intervention. Conduct routine health education before surgery, inform the patient of the anesthesia and awakening process, and relieve their tension. During the operation, implement anesthesia and monitoring according to the standard process and maintain stable vital signs. After the operation, the patient is transferred to the recovery room and the awakening situation is evaluated every 15 minutes. The patient is given routine oxygen inhalation and basic nursing care. Symptomatic treatments such as analgesia and antiemesis are provided on demand according to the patient's complaints. After the patient regains consciousness, has stable breathing, and recovers muscle strength, the tracheal tube is smoothly removed. The patient can be transferred out after no abnormalities are observed. Throughout the process, comfort care is the main focus. Keep the environment quiet, guide relaxation techniques, and promote smooth and rapid awakening.

2.3. Observation Indicators

(1) Awakening-related indicators: Record the recovery time of spontaneous breathing (the time from the end of the surgery to stable spontaneous breathing), eye-opening time (the time from the end of the surgery to the patient's spontaneous eye opening), and extubation time (the time from the end of the surgery to the removal of the tracheal tube) in the two groups of patients. When leaving the recovery room, the Steward awakening score was used to evaluate the patients' awakening quality. The total score ranges from 0 to 6 points. A higher score indicates better awakening quality. Among them, patients with a score of ≥4 points can be considered for extubation, and those with a score of ≥6 points can be transferred out of the recovery room [5].

(2) Incidence of adverse events during the awakening period: Record the adverse events that occurred during the awakening period in the two groups of patients, including agitation (Richmond Sedation-Agitation Scale score ≥ +2 points), respiratory depression (spontaneous respiratory rate < 10 times/min), hypoxemia (oxygen saturation < 95% for more than 10 minutes), nausea and vomiting. Calculate the incidence of adverse events (number of cases with adverse events/total number of cases × 100%).

(3) Nursing satisfaction: Before patients are discharged from the hospital, the Newcastle Satisfaction with Nursing Scales (NSNS) [6] are used for evaluation. The total score is 95 points. A score of 90 points or above indicates high satisfaction, 85 - 89 points indicates satisfaction, and a score below 85 points indicates dissatisfaction. Nursing satisfaction = (Number of cases with high satisfaction + Number of cases with satisfaction)/Total number of cases × 100%.

2.4. Statistical Analysis

The SPSS 26.0 software was used for data analysis and processing. Count data were

expressed as percentages and analyzed using the χ^2 test. Measurement data were presented as ($\bar{x}$ ± s) and analyzed using the t-test. A P-value less than 0.05 was considered statistically significant.

3. Results

3.1. Comparison of Awakening-Related Indicators between the Two Groups

Compared with the control group, the time for the recovery of spontaneous breathing, eye-opening, and extubation in the observation group was shortened, and the Steward awakening score at the time of leaving the recovery room was increased. The differences were statistically significant (P < 0.05). See Table 1.

Table 1. Comparison of recovery-related indicators between the two groups ($\bar{x}$ ± s).

Group	Number of cases	Time to recovery of spontaneous breathing (min)	Eye-opening time (min)	Extubation time (min)	Steward score upon leaving the recovery room (Scores)
Control group	23	18.62 ± 4.35	22.35 ± 5.12	28.71 ± 6.24	4.87 ± 0.75
Observation group	23	12.35 ± 3.28	15.78 ± 4.26	20.42 ± 5.17	5.92 ± 0.68
t	-	5.519	4.731	4.906	4.974
P	-	<0.001	<0.001	<0.001	<0.001

3.2. Comparison of the Incidence of Adverse Events during the Recovery Period between the Two Groups

The incidence of adverse events during the recovery period in the observation group was 8.70%, which was lower than that of 39.13% in the control group, and the difference was statistically significant (P < 0.05). See Table 2.

Table 2. Comparison of the incidence of adverse events during the awakening period between the two groups (n, %).

Group	Number of cases	Restlessness	Respiratory depression	Hypoxemia	Nausea and vomiting	Total incidence
Control group	23	4 (17.39)	2 (8.70)	1 (4.35)	2 (8.70)	9 (39.13)
Observation group	23	1 (4.35)	0 (0.00)	1 (4.35)	0 (0.00)	2 (8.70)
χ^2	-	-	-	-	-	5.855
P	-	-	-	-	-	0.016

3.3. Comparison of Nursing Satisfaction between the Two Groups

The nursing satisfaction rate in the observation group was 95.65%, which was significantly higher than 65.22% in the control group, and the difference was statistically significant (P < 0.05). See Table 3.

Table 3. Comparison of nursing satisfaction between the two groups (n, %).

Group	Number of cases	Highly satisfied	Satisfied	Dissatisfied	Nursing satisfaction
Control group	23	7 (30.43)	8 (34.78)	8 (34.78)	15 (65.22)
Observation group	23	15 (65.22)	7 (30.43)	1 (4.35)	22 (95.65)
χ^2	-	-	-	-	6.769
P	-	-	-	-	0.009

4. Discussion

The recovery period after general anesthesia for lung cancer surgery is a high-risk period for nursing safety. Traditional safety management in the anesthesiology department mainly relies on feedback control, which intervenes in problems that have already occurred. It lacks foresight and is difficult to effectively prevent adverse events. Feedforward control, as an advanced control mode, emphasizes preventing problems before they happen. By identifying risks in advance, predicting problems and formulating intervention measures, it can eliminate risks in the bud.

The results of this study showed that the recovery time of spontaneous breathing, eye-opening time, and extubation time in the observation group were all shorter than those in the control group, and the Steward awakening score was higher. This suggests that safety management based on feed-forward control can effectively accelerate the awakening process and improve the quality of awakening. Pre-operatively, the pre-operative state of patients was optimized through risk stratification assessment, smoking cessation guidance, respiratory function training, and psychological intervention. Intra-operatively, anesthesia depth monitoring, body temperature protection, and precise drug administration were adopted to reduce excessive anesthesia and delayed awakening. Post-operatively, graded monitoring, analgesia, and airway management were implemented according to the risk level, realizing the transformation from passive treatment to active prevention and control, thus promoting the smooth and rapid awakening of patients [7] [8]. In terms of adverse events, the total incidence rate during the awakening period in the observation group was only 8.70%, lower than 39.13% in the control group, indicating that feed-forward control can effectively prevent events such as agitation, respiratory depression, nausea, and vomiting. By identifying high-risk factors and implementing graded interventions, intensive monitoring, early analgesia, and dedicated care were provided for high-risk patients, and preventive nursing was carried out for medium-and low-risk patients, reducing the risks related to respiration, circulation, and agitation and improving the safety of resuscitation [9]. Meanwhile, the nursing satisfaction in the observation group was higher, indicating that the personalized, refined, and humanized feed-forward management model can improve the patients' medical experience and enhance the trust between nurses and patients [10]. This study has certain limitations. Firstly, it is a single-center study with a sample size of only 46 cases. Secondly, double-blinding and strict allocation concealment were not adopted, resulting in certain perfor-

mance bias and detection bias. Thirdly, nursing satisfaction is a subjective indicator, which is easily affected by factors such as emotions and the environment, lacking objectivity. Finally, the observation indicators mainly focus on short-term awakening quality, and long-term follow-up was not conducted. In the future, multicenter, large-sample, prospective randomized controlled studies can be carried out, the blinding design can be improved, and the follow-up time can be extended to further verify the long-term application effect of feed-forward control in patients with lung cancer under general anesthesia.

5. Conclusion

In conclusion, the safety management model based on feed-forward control can effectively shorten the awakening time of patients undergoing general anesthesia for lung cancer surgery, improve the quality of awakening, reduce the incidence of adverse events during the awakening period, and enhance patients' satisfaction with nursing, thus making up for the deficiencies of the conventional safety management model.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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