Int J Clin Exp Med 2020;13(6):3883-3891
www.ijcem.com /ISSN:1940-5901/IJCEM0107740

Review Article

Risk factors for postoperative pulmonary infection in elderly cancer patients and countermeasures

Ben Niu[1*], Ran An[1*], Tao Feng[1], Xiaofeng Qin[2], Jian Zhang[1], Yadong Yang[2]

[1]Respiratory medicine of Shengli Oilfield Central Hospital, Dongying, Shandong Province, China; [2]Emergency of Shengli Oilfield Central Hospital, Dongying, Shandong Province, China. [*]Equal contributors.

Received January 12, 2020; Accepted March 23, 2020; Epub June 15, 2020; Published June 30, 2020

Abstract: Objective: This study aimed to explore the risk factors for postoperative pulmonary infection in elderly cancer patients and countermeasures. Methods: We enrolled 107 elderly cancer patients admitted to Shengli Oilfield Central Hospital from February 2017 to February 2019 and randomly assigned them to either receive the targeted intervention for preventing pulmonary infection (54 cases, the research group) or to receive the routine intervention (53 cases, the control group). We compared the nursing satisfaction and VAS scores before and after the intervention between the two groups, and explored the risk factors for pulmonary infection, as well as the relevant countermeasures. Results: The nursing satisfaction and postoperative VAS scores in the research group were superior to those in the control group ($P<0.050$). Multivariate analysis suggested that smoking, degree of differentiation, type of surgery, and intraoperative blood loss were independent risk factors for postoperative complications in elderly cancer patients ($P<0.050$). The intervention by the automatic vibrating sputum excretion machine could effectively improve the sputum excretion of infected patients ($P<0.050$). Conclusion: Risk factors for postoperative pulmonary infection in elderly cancer patients include smoking, degree of differentiation, type of surgery, and intraoperative blood loss. Corresponding interventions can essentially enhance the nursing satisfaction and improve and the sputum excretion of infected patients.

Keywords: Cancer, elderly patients, postoperative pulmonary infection, risk factors, intervention

Introduction

Cancer refers to a malignant tumor developing from epithelial tissue and is the most common type of malignant tumors [1]. Cancer is featured with abnormal differentiation and proliferation, uncontrolled growth, infiltration, and metastasis of cells, and its occurrence and development is a complicated process [2]. At present, cancer is the principal threat to human life and health, with a high incidence around the world [3]. According to statistics, 1,762,450 new cancer cases were reported in the United States in 2019 [4]. The clinically common cancers include gastric cancer, lung cancer, esophageal cancer, colon cancer, breast cancer, cervical cancer, etc. [5], all of which are with high mortality. The study of Torre et al. [6] revealed a constant ramp-up in the mortality of cancer patients. The study of Malvezzi et al. [7] showed that the current cancer death rate is approximately 128.9/100,000 in Europe. Usually, the middle-aged are the most susceptible to cancers. However, the aging of the population in recent years makes the elderly population a large portion of cancer patients [8]. The existing treatment methods for cancer are mainly surgery and surgery combined with radiotherapy and chemotherapy. In elderly cancer patients whose physical functions are weakened, the risk of various stress syndrome and infections after the surgery is greatly increased [9]. Because of the endotracheal intubation and ventilation during surgery, pulmonary infection is the most common postoperative risk event in elderly cancer patients [10]. The prevention from postoperative pulmonary infection to effectively improve the postoperative rehabilitation and prognosis in elderly cancer patients is a major research focus and difficulty in the clinic. A previous study has revealed that nursing intervention can proficiently reduce postoperative pulmonary infection in cancer patients [11]. But no study has been reported on the postop-

erative nursing intervention for elderly cancer patients. Therefore, this study explored the risk factors for postoperative pulmonary infection in elderly cancer patients and conducted corresponding intervention measures, aiming to provide clinical reference and guidance for future studies.

Materials and methods

Basic information

A prospective analysis was performed on 107 elderly cancer patients admitted to Shengli Oilfield Central Hospital from February 2017 to February 2019. Among them, 54 patients were assigned to the research group to receive the targeted intervention for preventing pulmonary infection, while the other 53 patients were assigned to the control group to receive the routine intervention. This study has been approved by the ethics committee of Shengli Oilfield Central Hospital and obtained informed consent from all subjects.

Inclusion and exclusion criteria

Inclusion criteria: Patients in line with the clinical manifestations of cancer; patients diagnosed with malignant tumors by the pathology biopsy in Shengli Oilfield Central Hospital; patients with early or middle-staged cancers; patients with no tumor metastasis; patients older than 70 years; patients eligible for tumor resection; patients underwent surgeries in Shengli Oilfield Central Hospital; patients without coagulopathy before the surgery; patients with complete medical data; patients willing to cooperate with the investigation of medical staff in Shengli Oilfield Central Hospital. Exclusion criteria: patients with multiple tumors; patients with other cardiovascular or vital organ diseases; patients with pulmonary insufficiency; patients with mental disorders; patients with immunodeficiency diseases or other infectious diseases; patients with low compliance; patients with a death outcome during the treatment; patients with an estimated survival of less than 1 month; patients who received other surgeries, chemoradiotherapy, or antibiotics within six months before the admission; patients during pregnancy or lactation; patients who transferred to other hospitals; patients with long-term bedridden life or incapable of self-care due to physical disability.

Methods

Intervention measures for the control group: The routine intervention in the control group: We confirmed the basic information with patients before the surgery and then introduced the precautions and procedures of the surgery, the environment of the operating room, and related operations to all patients and their families. After the surgery, patients were escorted back to the ward and received daily regular examinations, with any changes in vital signs under monitoring.

Intervention measures for the research group: The targeted intervention for pulmonary infection in the research group: Based on the routine intervention, we guided the diet one week before the operation and recorded the vital signs of the patients. We also plotted the curve of body temperature to check if the temperature was normal. Close attention was required at the time of first surgery incision, anesthesia, and medication to check whether the vital signs were in the normal range. The use of antibiotics was in strict accordance with the requirements of the National Health Commission of the People's Republic of China. Blankets were prepared for patients to keep them warm, and the infusion was pre-heated. We taught patients about the importance of sputum excretion and used a disposable suction catheter to help with sputum excretion. Patients were required to keep clean, and the operating room and the ward were daily ventilated and sterilized. Caution must be required when moving the patient to prevent wound dehiscence. The airway of patients was kept smooth after surgery to prevent atelectasis. Patients were instructed to do simple bed movements and rolling over. The sputum excretion in patients with pulmonary infection was closely monitored, and the automatic vibrating sputum excretion machine was used as a help. With a mastery of the machine performance, we decided the most appropriate body position for sputum excretion according to the specific location of the patient's pulmonary infection. Set at a frequency of 20 Hz, the sputum excretion machine slowly moved from the fore breast, to the side of the body, and then to the back, from bottom to top. After percussion by the machine on the surface of the infected part for 2 minutes, the nursing staff tapped the surface of the infected part to help with the sputum excretion, followed by postural drainage.

Outcome measures

Nursing satisfaction: The assessment of nursing satisfaction of all patients referred to the methods used by McNicholas et al. [12]. The satisfaction score ranged from 0 to 100 points. Scores >80 points indicated satisfaction; scores from 60 to 80 points indicated expectations for improvements; scores <60 points indicated dissatisfaction. Nursing satisfaction = (cases of satisfaction + expectations for improvements)/total cases × 100%.

Pain intensity: The pain intensity of patients was evaluated by the visual analog scale (VAS), which was performed 3 days before or after the surgery.

Risk factors for pulmonary infection: We recorded the occurrence of postoperative pulmonary infection in patients and then employed the Logistic regression analysis to identify risk factors for postoperative pulmonary infection.

Effect of the intervention: We took interventions for patients with lung infections. The sputum excretion was compared between before and after the intervention. We compared the 5 d amount of sputum (collected in a measuring cup) and the SpO_2 after the sputum excretion between before and after the intervention, and analyzed the difference in sputum excretion performance. Excellent sputum excretion performance: the sputum was easy to cough up and its amount was reduced after 5 days of intervention, with no mosist crackles nor coarse rales, and the breathing was normal; moderate sputum excretion performance: the sputum amount was reduced, with decreased mosist crackles and coarse rales after 5 days of intervention; poor sputum excretion performance: the sputum was thick and hard to cough up, with still heavy mosist crackles and coarse rales, and weak breathing after 5 days of intervention. The excellent rate = (cases of excellent + moderate)/total cases × 100%.

Statistical analysis

Statistical analysis was performed using SPSS24.0 statistical software (Shanghai Yuchuang Network Technology Co., Ltd.). Data visualization was performed using Graphpad8 software (SOFTHEAD Inc.). Measurement data were expressed as mean ± standard deviation and were compared between two groups by the t-test. Count data were expressed as rate and were compared between two groups by the chi-square test. Risk factors were analyzed by logistic regression. A statistical difference was recognized when $P<0.050$.

Results

The two groups were not different in basic information

The research group and the control group were not statistically different in age, BMI, medical history, sex, smoking, drinking, type of cancer, degree of differentiation, type of surgery, time duration of surgery, intraoperative blood loss, and analgesic drugs ($P>0.050$). More details are shown in **Table 1**.

The research group had higher nursing satisfaction rate than the control group

The nursing satisfaction rate was notably higher in the research group than in the control group (88.89% vs. 69.81%, $P = 0.015$). More details are shown in **Table 2**.

The research group had lower postoperative VAS score than the control group

The preoperative VAS scores in the research group and the control group were not significantly different ($P>0.050$), while the postoperative VAS score in the research group was significantly lower than that of the control group ($P<0.050$) (**Figure 1**).

Factors affecting the postoperative pulmonary infection included smoking, type of cancer, degree of differentiation, type of surgery, and the intraoperative blood loss

Among the 107 patients, 48 patients had postoperative pulmonary infections and were assigned to the infected group. The other 59 patients who were free of postoperative pulmonary infection were assigned to the non-infected group. The infected group and the non-infected group were not statistically different in age, BMI, medical history, sex, drinking, time duration of surgery, and analgesic drugs ($P>0.050$). Smoking, type of cancer, degree of differentiation, type of surgery, intraoperative blood loss were single factors affecting postoperative pulmonary infection in cancer patients ($P<0.050$). More details are shown in **Table 3**.

Table 1. Comparison of basic information [n (%)]

	Research group (n = 54)	Control group (n = 53)	χ^2 or t	P
Age (year)	72.6±2.0	72.2±1.8	1.087	0.280
BMI (kg/cm^2)	24.28±2.90	24.17±2.86	0.198	0.844
Medical history			0.057	0.972
Diabetes	24 (44.44)	24 (45.28)		
Hypertension	22 (40.74)	22 (41.51)		
No	8 (14.81)	7 (13.21)		
Sex			0.077	0.781
Male	32 (59.26)	30 (56.60)		
Female	22 (40.74)	23 (43.40)		
Smoking			0.094	0.759
Yes	30 (55.56)	31 (58.49)		
No	24 (44.44)	22 (41.51)		
Drinking			0.249	0.618
Yes	25 (46.30)	22 (41.51)		
No	29 (53.70)	31 (58.49)		
Type of cancer			0.610	0.894
Gastric cancer	10 (18.52)	11 (20.75)		
Esophageal cancer	30 (55.56)	26 (49.06)		
Colorectal cancer	8 (14.81)	8 (15.09)		
Pancreatic cancer	6 (11.11)	8 (15.09)		
Degree of differentiation			0.573	0.449
Poor differentiation	10 (18.52)	13 (24.53)		
High and moderate differentiation	44 (81.48)	40 (75.47)		
Type of surgery			0.239	0.625
Thoracotomy	27 (50.00)	29 (54.72)		
Laparotomy	27 (50.00)	24 (45.28)		
Operation time (min)	160.25±22.18	163.44±19.18	0.795	0.428
Intraoperative blood loss (ml)	426.62±25.92	430.42±26.57	0.749	0.456
Analgesic drugs			0.224	0.636
Yes	34 (62.96)	31 (58.49)		
No	20 (37.04)	22 (41.51)		

Table 2. Comparison of nursing satisfaction [n (%)]

	Research group (n = 54)	Control group (n = 53)	χ^2	P
Satisfaction	32 (59.26)	19 (35.85)		
Expectations for improvements	16 (29.63)	18 (33.96)		
Dissatisfaction	6 (11.11)	16 (30.19)		
Satisfaction rate (%)	88.89	69.81	5.960	0.015

Independent risk factors of postoperative pulmonary infection included smoking, degree of differentiation, type of surgery, and the intraoperative blood loss

Factors with differences between the infected group and the non-infected group indicated by the univariate analysis were assigned (the assignment is shown in **Table 4**). Then the logistic regression analysis was performed with the Forward: LR method of the SPSS software. According to the results, the type of cancer was not an independent risk factor affecting the postoperative pulmonary infection of patients (P>0.050). Multivariate analysis also suggested that smoking, degree of differentiation, type

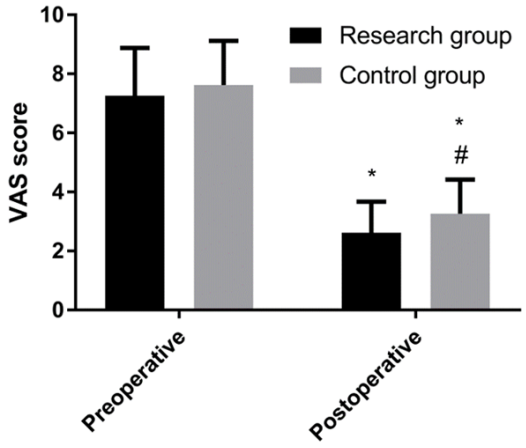

Figure 1. VAS scores in the two groups. *indicates P<0.050 when compared with the preoperative VAS score in the same group; #indicates P<0.050 when compared with the preoperative VAS score in the research group.

of surgery, and intraoperative blood loss were independent risk factors for postoperative complications in elderly cancer patients (P< 0.050). More details are shown in **Table 5**.

Infected patients had higher amount of sputum excretion and SpO_2 after intervention than before intervention

Patients with infection received interventions of sputum excretion. The results showed that in the infected group, the amount of sputum excretion and SpO_2 after intervention were significantly higher than those before intervention (P<0.050), and the excellent rate after intervention was also significantly higher than that before intervention (P<0.050). More details are shown in **Table 6** and **Figure 2**.

Discussion

At present, cancer is the "number one killer" of human life, especially in elderly patients [13]. The decline in physical function and immune function expose elderly patients to a higher risk of postoperative adverse reactions [14]. Adverse reactions not only impede postoperative recovery, but also threaten the life of patients [15]. Therefore, methods to reduce the incidence of postoperative pulmonary infection in elderly cancer patients and the effective interventions for patients with pulmonary infection are of great significance for future clinical cancer treatment. In this study, we employed targeted intervention for pulmonary infections in elderly patients with cancer and achieved good outcomes.

In this study, the nursing satisfaction and VAS scores in the research group receiving the targeted intervention were significantly superior to those in the control group receiving the conventional intervention, suggesting that targeted intervention can effectively enhance the nursing effect and reduce the pain of patients. We speculate that this difference is a result of the more meticulous nursing in the targeted intervention. Merlotti et al. [16] suggested that an appropriate preoperative diet can effectively improve the patient's surgical outcome and postoperative conditions. Guidance on the diet for patients in the research group could strengthen the body functions, better qualify patients for invasive surgical operations, and reduce the body's inflammatory response and oxidative stress response. The thermal care and the heated infusion helped improve the affinity of the body, and promoted the recovery of patients. The research results of Nelson et al. [17] are consistent with our findings and can support our opinions. We assume that sputum excretion is the key factor affecting pulmonary infection. Elderly patients generally feel feeble when coughing and cannot completely cough out the sputum, which will easily obstruct the airway and induce pulmonary infection [18]. Assistance for sputum excretion can ensure the smooth airway breathing, improve the respiratory function, and prevent the pulmonary infection. The study by Cookson et al. [19] also confirmed the important role of sputum excretion in the treatment of chronic and acute pulmonary infections, which is consistent with our view. Close attention and detailed rehabilitation guidance are beneficial to promoting the relationship between doctors and patients, enhancing patient compliance, building trust on the medical staff, boosting confidence in rehabilitation, as well as to developing higher satisfaction for the nursing after discharge.

Multivariate analysis also suggested that smoking, degree of differentiation, type of surgery, and intraoperative blood loss were independent risk factors for postoperative infection in elderly cancer patients. Previous studies have explored the effects of smoking on respiratory functions and pulmonary functions [20, 21], so

Table 3. Univariate analysis [n (%)]

	Infected group (n = 48)	Not-infected group (n = 59)	χ^2 or t	P
Age (year)	72.1±1.8	72.5±1.7	0.241	1.179
BMI (kg/cm^2)	24.18±2.89	24.26±3.05	0.890	0.138
Medical history			0.050	0.975
Diabetes	21 (43.75)	27 (45.76)		
Hypertension	20 (41.67)	24 (40.68)		
No	7 (14.58)	8 (13.56)		
Sex			0.218	0.640
Male	29 (60.42)	33 (55.93)		
Female	19 (39.58)	26 (44.07)		
Smoking			4.896	0.027
Yes	33 (68.75)	28 (47.46)		
No	15 (31.25)	31 (52.54)		
Drinking			0.129	0.720
Yes	22 (45.83)	25 (42.37)		
No	26 (54.17)	34 (57.63)		
Type of cancer			17.960	<0.001
Gastric cancer	5 (10.42)	16 (27.12)		
Esophageal cancer	36 (75.00)	20 (33.90)		
Colorectal cancer	4 (8.33)	12 (20.34)		
Pancreatic cancer	3 (6.25)	11 (18.64)		
Degree of differentiation			7.229	0.007
Poor differentiation	16 (33.33)	7 (11.86)		
High and moderate differentiation	32 (66.67)	52 (88.14)		
Type of surgery			17.920	<0.001
Thoracotomy	36 (75.00)	20 (33.90)		
Laparotomy	12 (25.00)	39 (66.10)		
Operation time (min)	162.21±20.74	165.74±18.50	0.930	0.355
Intraoperative blood loss (mL)	455.16±30.57	384.63±22.69	13.690	<0.001
Analgesic drugs			0.112	0.738
Yes	30 (62.50)	35 (59.32)		
No	18 (37.50)	24 (40.68)		

Table 4. Assignment

Factors	Assignment
Smoking	No = 0; yes = 1
Type of cancer	Gastric cancer = 0; esophageal cancer = 1; colorectal cancer = 2, pancreatic cancer = 3
Degree of differentiation	High and moderate differentiation = 0; poor differentiation = 1
Type of surgery	Laparotomy = 0; thoracotomy = 1
Intraoperative blood loss (mL)	If data conforms to continuous variables, raw data were used for analysis

we did not bother to detail this in this study. Patients with a long history of smoking have markedly worse respiratory function than non-smoking patients, so smoking is also a major cause of pulmonary infection. The degree of differentiation determines the development of tumors in patients [22]. Patients with severe tumors have more body parts to be resected, longer operation time, and longer exposure of the internal environment to the air, vulnerable to bacterial infection from the external environment and oxidative stress damage in the internal body. Thoracotomy leads to more significant effects on the entire respiratory system and

Table 5. Multivariate analysis

Factors	B	S.E.	OR	Wald	P	95% CI
Smoking	2.304	0.668	4.842	12.542	0.013	3.542~7.862
Type of cancer	1.008	0.543	2.623	3.524	0.097	0.575~8.265
Degree of differentiation	2.124	0.534	3.567	15.954	<0.001	4.621~7.6324
Type of surgery	1.254	0.318	8.348	16.524	0.009	1.084~5.164
Intraoperative blood loss	1.245	0.476	6.484	6.862	0.018	2.184~9.624

Table 6. Comparison of sputum excretion performance between before and after the intervention in the infected group [n (%)]

	Before the intervention	After the intervention	χ^2	P
Excellent	12 (25.00)	22 (45.83)		
Moderate	12 (25.00)	18 (37.50)		
Poor	24 (50.00)	8 (16.67)		
Excellent rate (%)	50.00	83.33	12.100	<0.001

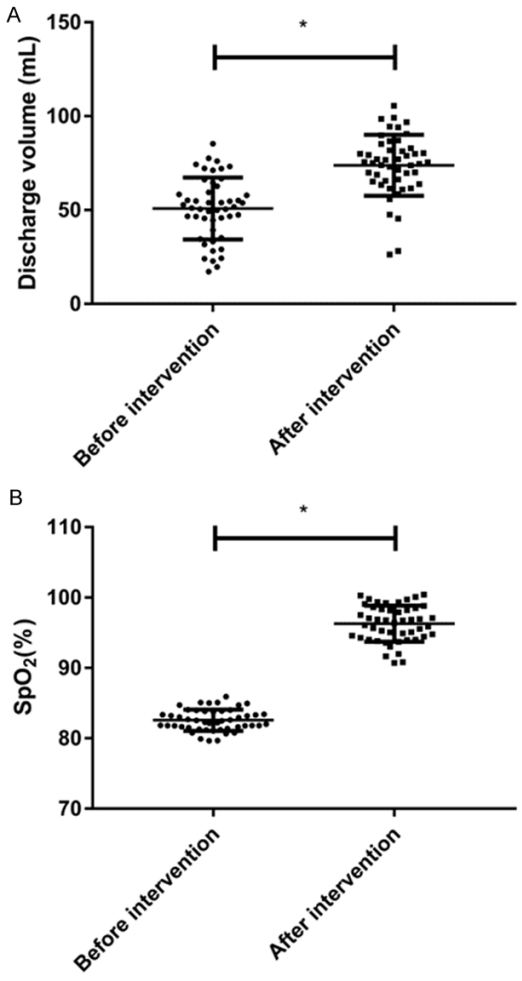

Figure 2. Comparison of the amount of sputum excretion and SpO_2 between before and after the intervention. A. P<0.050 when the amount of sputum excretion was compared between before and after the intervention in the infected group. B. *P<0.050 when SpO_2 was compared between before and after the intervention in the infected group.

higher risks of pathogen invasion as compared with laparotomy, which explains why pulmonary infection mainly occurs in patients receiving thoracotomy. The intraoperative blood loss affects the patient's postoperative recovery [23] and indirectly induces adverse reactions during postoperative rehabilitation, which is consistent with the results of a previous study [24]. The vibrating sputum excretion machine delivers good outcomes for patients with pulmonary infection. Compared with artificial sputum excretion, vibrating sputum excretion machine is accurate in identifying the infection part, with a stable and strong force. Besides, vibrating sputum excretion machines can minimize the risk of bacterial infection in patients with a severe problem of sputum excretion, harboring great significance for preventing postoperative pulmonary infection in elderly cancer patients.

This study aimed to investigate the risk factors affecting postoperative pulmonary infection in elderly cancer patients and the use of related countermeasures. However, this study is subjected to certain limitations due to poor experimental conditions. For example, this study only included patients with gastric cancer, esophageal cancer, colorectal cancer, and pancreatic cancer, so we cannot analyze the pulmonary infection in patients with other malignant tu-

mors. Besides, the short research period restricted us from analyzing the effects of targeted measures on the long-term prognosis of patients. Besides, risk factors for pulmonary infection may be more than these discussed in this study. We will conduct a more in-depth and comprehensive analysis of the above limitations to obtain more representative research results.

Conclusion

In summary, risk factors for postoperative pulmonary infection in elderly cancer patients include smoking, degree of differentiation, type of surgery, and intraoperative blood loss. Corresponding interventions can essentially enhance the nursing satisfaction and improve the sputum excretion of infected patients.

Disclosure of conflict of interest

None.

Address correspondence to: Yadong Yang, Emergency of Shengli Oilfield Central Hospital, Dongying, Shandong Province, China. E-mail: yangmizha5259-22585@163.com

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