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Original Article

Effects of percutaneous catheter intervention on pulmonary hemodynamic indexes and safety in elderly patients with acute pulmonary embolism

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Abstract: Objective: To investigate the effects of percutaneous catheter intervention (PCI) on pulmonary hemodynamic indexes and safety in elderly patients with acute pulmonary embolism (APE). Methods: The retrospective study was performed on 65 elderly APE patients. According to the risk classification of Guidelines for Diagnosis, Treatment and Prevention of Pulmonary Thromboembolism in China, the patients were divided into the medium-high risk group (n=37) and high risk group (n=28). All patients received PCI based on thrombolysis. The clinical efficacy after treatment, and changes of pulmonary hemodynamic indexes and blood gas indexes before and after treatment were compared between the two groups, and the complications and prognosis of patients were recorded. Results: There was no significant difference in the total effective rate between the two groups after treatment (P>0.05). Compared with before operation, mean pulmonary artery pressure (mPAP), ratio of right/left ventricular end diastolic diameter (RVEDD/LVEDD) and pulmonary vascular resistance (PVR) of the two groups were significantly reduced 12 h after operation, and greater changes were observed in the high risk group (all P<0.05). Compared with before operation, arterial oxygen partial pressure (PaO_2), blood oxygen saturation (SaO_2) and oxygenation index (OI) of the two groups were significantly increased 12 h after operation, and the changes of the high risk group were more obvious (all P<0.05). No significant difference was found in the total incidence of complications between the two groups (P>0.05). The three-month follow-up showed that there was no death in the medium-high risk group and the mortality in the high risk group was 3.08%. Conclusion: PCI has obvious effects in the treatment of elderly APE. It can obviously improve pulmonary blood flow dynamics and oxygenation dysfunction, especially for high-risk patients, and it has fewer postoperative complications with certain security.

Keywords: Acute pulmonary embolism, percutaneous catheter intervention, pulmonary hemodynamics, safety

Introduction

Acute pulmonary embolism (APE) is a common disease of cardiovascular system. It refers to a pathological syndrome in which embolus occludes pulmonary artery and its branches, and pulmonary blood flow is forced to be interrupted, thus a series of pulmonary circulation disorders and respiratory dysfunction emerge [1, 2]. The immediate mortality of APE is about 10%, and the short-term mortality of survivors after rescue is about 20-30%; fatal right ventricular circulation failure induced by acute pulmonary hypertension is the main cause of death [3, 4]. Therefore, it is of great significance for improving hypoxemia and reducing mortality to reduce the number of occluded vascular beds, unblock pulmonary artery and its branches, and quickly recover the normal blood flow of pulmonary artery [5]. Guidelines for Diagnosis, Treatment and Prevention of Pulmonary Thromboembolism in China clearly pointed out that reperfusion of pulmonary vascular should be conducted in time for patients with medium-high-risk and high-risk APE, which is helpful in reducing the right heart load and the immediate mortality [6].

Percutaneous catheter intervention (PCI) is a kind of pulmonary vascular perfusion therapy. It can quickly open the blocked pulmonary artery and restore the normal blood flow of the pulmo-

Table 1. Comparison of general information (n, $\bar{x} \pm sd$)

Indicator	Medium-high risk group (n=37)	High risk group (n=28)	X^2/t	P
Gender			0.371	0.543
Male	20	13		
Female	17	15		
Age (years)	63.3±4.7	62.7±5.2	0.480	0.633
BMI (kg/m^2)	23.40±2.39	23.11±2.64	0.457	0.650
Disease time			0.001	0.969
<3 d	20	15		
3-7 d	17	13		
mPAP (mmHg)	37.58±6.38	37.10±6.50	0.297	0.767
PaO_2 (mmHg)	67.70±2.15	68.02±1.80	0.653	0.516

Note: BMI: body mass index; mPAP: mean pulmonary artery pressure; PaO_2: arterial oxygen partial pressure.

nary artery, bringing little trauma to the body and little risk of intraoperative hemorrhage, which is recommended by Guidelines for Diagnosis, Treatment and Prevention of Pulmonary Thromboembolism in China [7, 8]. However, there is no unified report on the application effect of PCI in elderly APE patients. In the past, clinical symptoms combined with echocardiography examination results (such as pulmonary hypertension) were usually used to evaluate the therapeutic effect of APE. However, there possibly exists the evaluation delay for the patients with poor thrombolytic therapeutic effect, which sets them in long-time pulmonary hypertension and causes delay in the treatment [9]. Some studies have shown that the changes of circulatory system in APE patients are closely related to the severity of APE condition and the area of pulmonary embolism [10-12]. Therefore, the detection of pulmonary hemodynamic changes can better reflect the improvement of pulmonary embolism, which is helpful to evaluate the progress and prognosis of patients. This study mainly examined the effects of PCI on pulmonary hemodynamics and analyzed its safety in the elderly patients with APE.

Materials and methods

General information

A total of 65 elderly APE patients admitted to our hospital from December 2017 to December 2019 were selected in this retrospective study. According to the risk classification of Guidelines for Diagnosis, Treatment and Prev ention of Pulmonary Thromboembolism in China, the patients were divided into the medium-high risk group (n=37; without shock or hypotension) and high risk group (n=28; those who had any of the following conditions: cardiac arrest, obstructive shock or persistent hypotension). The general data of the two groups are shown in **Table 1**. This study was approved by the medical ethics committee of our hospital.

Inclusion criteria: Patients aged 60-80 years; patients who met the APE diagnostic criteria of Guidelines for Diagnosis, Treatment and Prevention of Pulmonary Thromboembolism in China, and were confirmed to have double pulmonary artery embolism by imaging examination [6]; patients with mean pulmonary artery pressure (mPAP) <50 mmHg; patients with arterial oxygen partial pressure (PaO_2) <70 mmHg.

Exclusion criteria: Patients with severe heart, liver, lung, kidney and other organ dysfunction; patients with contraindications for PCI, such as infective endocarditis, etc.; patients who fell into a coma due to other diseases, such as cerebral hemorrhage, brain tumor, etc.; patients with cardiac pacemakers; patients with malignant tumors; patients who were allergic to contrast agents during intervention.

Methods

All patients received PCI based on thrombolysis. Details of thrombolysis treatment were as follow. Intravenous thrombolysis with urokinase (10000U; Heilongjiang Dilong Pharmaceutical Co., Ltd., China) and subcutaneous injection of low molecular weight heparin calcium injection (1.0 mL:5000AXaIU; Shenzhen Saibaoer Biological Pharmaceutical Co., Ltd., China) were given once every 12 hours. After 5 days of continuous medication, warfarin sodium tablets (2.5 mg; Shanghai Fuda Pharmaceutical Co., Ltd., China) were orally administered for anticoagulation for 3 consecutive months, and the international standard ratio (INR) was recommended to be 2.5-3.0 times of the normal value. Details of PCI were as follows. The femoral vein on the healthy side was punctured, and

the 5F vascular sheath was placed. Then subcutaneous injection of heparin (100 IU/kg) was given, and the 4F pig tail catheter was successively inserted into the main, left and right pulmonary arteries for angiography, so as to determine the embolization site and size. The 8F pig tail catheter was inserted into the blocked pulmonary artery, and the 0.035 cm guidewire was sent to the distal end of the blood vessel through the thrombus. The thrombus was repeatedly aspirated along the guidewire, and it was repeatedly pushed and squeezed by balloon to break up the pulmonary artery thrombus. After the thrombus was sucked, 54 mg of recombinant human tissue plasminogen kinase derivatives (18 mg:10 mL; China Resources Angde Biotech Pharma Co., Ltd., China) and 20 mL 0.9% of sodium chloride injection (10 mL:90 mg; Shanghai Xudong Haipu Pharmaceutical Co., Ltd., China) were injected via a catheter. Pulmonary angiography was performed half an hour later to determine the embolic vascular recanalization and pulmonary artery perfusion. And then pulmonary artery pressure was measured and blood gas analysis was conducted.

Outcome measures

Main outcome measures: (1) The clinical efficacy after treatment was judged according to Guidelines for Diagnosis, Treatment and Prevention of Pulmonary Thromboembolism in China [6]. Markedly effective: clinical symptoms such as dyspnea, cyanosis and chest pain completely disappeared 24 h after operation, the recanalization rate of pulmonary artery was above 90%, and blood gas indexes were completely back to normal level. Effective: the above clinical symptoms were improved, the recanalization rate of pulmonary artery was 80-90%, and blood gas was improved by above 20%. Ineffective: the above clinical symptoms and blood gas were not obviously improved or even aggravated, the recanalization rate of pulmonary artery was less than 80% or embolic vessels were more serious than before operation, or patients died. Total effective rate = number of (markedly effective + effective) cases/total number of cases ×100%. (2) FloTrac/Vigileo system (American Edwards Lifesciences Company, USA) was adopted to detect and compare the pulmonary hemodynamic parameters before and 12 h after operation, including mPAP, the ratio of right ventricular end diastolic diameter to left ventricular end diastolic diameter (RVEDD/LVEDD) and pulmonary vascular resistance (PVR) [13]. (3) Blood Gas Analyzer (Shanghai Huanxi medical devices Co., Ltd., China) was used for blood gas analysis before and 12 h after operation, and PaO_2, blood oxygen saturation (SaO_2) and oxygenation index (OI) were recorded. OI = PaO_2/fraction of inspiration O_2 (FiO_2).

Secondary outcome measures: (1) The occurrence of complications within 1 month after operation was recorded, such as pericardial tamponade, gingival hemorrhage, aggravated dyspnea, recurrent pulmonary infarction, etc. (2) The death of the patients was counted during the 3-month follow-up.

Statistical analysis

SPSS 20.0 was used for data analysis. The count data and measurement date were expressed as n (%) and $\bar{x} \pm sd$, respectively. Comparisons of measurement data between groups were conducted by independent sample t test, and comparisons of count data were carried by chi-square test. The comparison before and after operation was performed by paired t test. $P<0.05$ indicates that the difference is statistically significant.

Results

Comparison of general information

There was no significant difference in the general information between the two groups (all $P>0.05$). See **Table 1**.

Comparison of clinical efficacy

Twenty-four hours after operation, the clinical efficacy was judged according to Guidelines for Diagnosis, Treatment and Prevention of Pulmonary Thromboembolism in China. There was no significant difference in the total effective rate between the two groups after treatment ($P>0.05$). See **Table 2**.

Comparison of pulmonary hemodynamics

Compared with before operation, mPAP, RVEDD/LVEDD and PVR of the two groups were significantly declined 12 h after operation, and the changes in the high risk group were more obvious (all $P<0.05$). See **Table 3**.

Table 2. Comparison of clinical efficacy after treatment (n, %)

Group	Markedly effective	Effective	Ineffective	Total effective rate
Medium-high risk group (n=37)	20 (54.05)	15 (40.54)	2 (5.41)	35 (94.59)
High risk group (n=28)	11 (39.29)	13 (46.43)	4 (14.29)	24 (85.71)
χ^2	1.393	0.225	1.500	1.500
P	0.238	0.635	0.221	0.221

Table 3. Comparison of pulmonary hemodynamics before and after treatment ($\bar{x}$ ± sd)

Time	mPAP (mmHg)	RVEDD/LVEDD	PVR
Medium-high risk group (n=37)			
Before operation	37.58±6.38	0.95±0.11	25.40±2.20
12 h after operation	33.05±4.59*,#	0.90±0.11*,#	24.29±2.38*,#
High risk group (n=37)			
Before operation	37.10±6.50	0.96±0.10	25.98±3.60
12 h after operation	29.40±7.69*	0.84±0.09*	23.01±2.63*

Note: Compared with the same group before operation, *P<0.05; compared with the high risk group 12 hours after operation, #P<0.05. mPAP: mean pulmonary artery pressure; RVEDD/LVEDD: left ventricular end diastolic diameter; PVR: pulmonary vascular resistance.

Table 4. Comparison of blood gas analysis before and after operation ($\bar{x}$ ± sd)

Time	PaO_2 (mmHg)	SaO_2 (%)	OI
Medium-high risk group (n=37)			
Before operation	67.70±2.15	93.28±2.22	273.02±8.29
12 h after operation	70.48±3.30*,#	95.07±1.74*,#	321.05±10.04*,#
High risk group (n=37)			
Before operation	68.02±1.80	93.64±2.03	274.84±6.50
12 h after operation	75.20±3.83*	96.96±1.44*	374.40±17.47*

Note: Compared with the same group before operation, *P<0.05; compared with the high risk group 12 hours after operation, #P<0.05. PaO_2: arterial oxygen partial pressure; SaO_2: blood oxygen saturation; OI: oxygenation index.

Comparison of blood gas analysis

Compared with before operation, PaO_2, SaO_2 and OI of the two groups were significantly increased 12 h after operation, and the changes of the high risk group were more obvious (all P<0.05). See **Table 4**.

Comparison of safety

Within one month after operation, the medium-high risk group had 2 cases with gingival hemorrhage and 2 cases with aggravated dyspnea, with a total incidence of complications of 10.81%; while the high risk group had 2 cases with gingival hemorrhage, 1 case with aggravated dyspnea, 1 case with recurrent pulmonary infarction and 1 case with pericardial tamponade, with a total incidence of complications of 17.86%. Statistical analysis showed that there was no significant difference in the total incidence of complications between the two groups (P>0.05). See **Figure 1**.

Comparison of prognosis

All the 65 patients successfully underwent PCI and were followed up for 3 months after discharge. There was no death in the medium-high risk group and 2 deaths in the high risk group, with an overall mortality of 3.08%.

Discussion

PCI is a kind of endovascular technique. For pulmonary embolism, it is a treatment method to open up the blocked pulmonary artery vessels by means of intervention, so as to reduce pulmonary vascular resistance, increase pulmonary blood perfusion and reduce cardiac

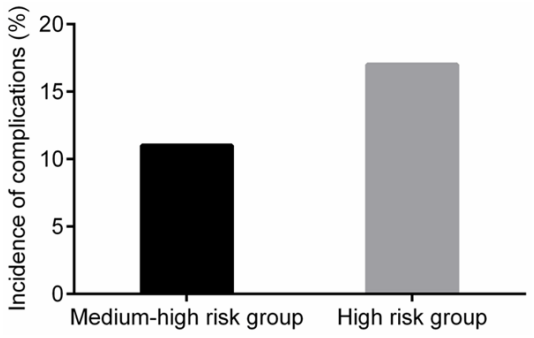

Figure 1. Incidence of complications of the two groups.

load [14, 15]. For APE patients with acute massive pulmonary embolism (MPE), contraindications to thrombolytic therapy or failure in thrombolytic therapy, and hemodynamic instability, PCI is recommended in Guidelines for Diagnosis, Treatment and Prevention of Pulmonary Thromboembolism in China [6].

In this study, FloTrac/Vigileo system was used to detect the mPAP, RVEDD/LVEDD, PVR and other hemodynamic parameters of patients before and after operation. FloTrac/Vigileo system is composed of FloTrac sensor and Vigileo monitor. It is a minimally invasive continuous cardiac output monitoring system, with less trauma to the body and less impact on pulmonary artery pressure during operation [16]. The results of this study showed that compared with before operation, mPAP, RVEDD/LVEDD and PVR of the two groups were significantly reduced 12 h after operation, and the changes in the high risk group were more obvious. Meanwhile, this study comprehensively evaluated the clinical efficacy of patients after treatment by combining the improvement of clinical symptoms, pulmonary artery recanalization rate and blood gas indexes. The results showed that there was no significant difference in the total effective rate between the two groups after treatment, suggesting that PCI significantly improved the pulmonary hemodynamics of elderly APE patients. There was no significant difference in the treatment effect between the two groups, but more obvious improvement of pulmonary artery blood flow was seen in the high risk group. In addition, mPAP and PVR decreased significantly in this study, indicating that pulmonary embolism was significantly improved. Jaber et al. analyzed the efficacy, risk and prognosis of PCI in the treatment of APE, and found that compared with thrombolytic therapy alone, the mortality of APE patients after PCI was significantly reduced, and the hemodynamic improvement was more obvious [17]. Okada et al. also reported that interventional therapy could significantly improve the right cardiac function of APE patients; therefore, they pointed out that PCI on the basis of routine thrombolysis was helpful for improving the prognosis of APE patients and therapeutic effect [18].

Pulmonary embolism can directly affect the heart and lung circulation, resulting in significant changes in a variety of cardiopulmonary reflex and appearance of hyperventilation state in the body. Moreover, it easily causes respiratory alkalemia and hypocapnia. However, dysfunction of alveolar ventilation can further aggravate the occurrence of hypoxemia and hypocapnia [19, 20]. Therefore, the analysis of blood gas indexes such as PaO_2 and SaO_2 is helpful to make an accurate judgment of APE condition, which plays an important role in guiding clinical treatment [21]. In this study, compared with before operation, PaO_2, SaO_2 and OI were significantly increased in the two groups 12 h after operation, and the changes in the high risk group were more obvious. It suggested that PCI on the basis of routine thrombolysis could effectively improve the oxygenation dysfunction of elderly APE patients, and the improvement effect of oxygenation in the high risk group was better than that in the medium-high risk group. Tu et al. also believed that interventional therapy was an effective means to improve the pulmonary recanalization rate of APE patients, and the improvement of pulmonary ventilation function was more obvious after interventional therapy [22].

In terms of safety, among the 65 APE patients selected in this study, the most common complications were gingival hemorrhage and aggravated dyspnea, without immediate death. Follow-up for 3 months after discharge showed that there was no death in the medium-high risk group and 2 deaths in the high risk group, with a total mortality of 3.08%. Among them, one died 42 days after discharge due to recurrent pulmonary infarction, and the other died 55 days after discharge due to pericardial tamponade. Becattini et al. reported that the mor-

tality of APE patients receiving endovascular treatment was 20-30% within one year after discharge [3]. Marti et al. reported that the incidence of fatal intracranial hemorrhage in APE patients could be up to 25% if thrombolytic therapy was given alone [23]. The mortality of the 65 patients in this study was 3.08%, which was significantly lower than that reported above; it suggested that PCI based on routine thrombolysis could significantly reduce the mortality of APE patients and improve the prognosis, showing the high safety. Also, Devcic et al. pointed out that interventional therapy could greatly reduce the immediate mortality of APE patients [24].

This study compared the therapeutic effects of PCI in patients with medium-high-risk and high-risk APE. However, due to the small sample size and short follow-up time, no difference was found in the total effective rate and mortality after treatment between the two groups. In the future, extended follow-up time and increased sample size should be included to obtain more convincing results.

To sum up, PCI has obvious effects in the treatment of elderly APE. It can obviously improve pulmonary blood flow dynamics and oxygenation dysfunction, especially for high-risk patients, and it has fewer postoperative complications with certain security.

Disclosure of conflict of interest

None.

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