Biomedical Research 2017; 28 (15): 6578-6582

ISSN 0970-938X
www.biomedres.info

Effect of anesthetic technique on transluminal interventional therapy following pulmonary thromboembolism surgery.

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Abstract

The aim of this study was to compare adverse cardiac events, treatment effectiveness, and long-term effects between local and general anesthesia, administered during different time periods, in patients with massive and sub-massive pulmonary embolism who received pigtail catheter fragmentation. Two groups of patients received pigtail catheter fragmentation at different times: in Group E, 17 patients received transluminal interventional therapy under local anesthesia between July 2004 and October 2009, while in Group P, 31 patients received the therapy under general anesthesia between March 2010 and December 2015. Adverse cardiac events were compared between the two groups, and vital arterial oxygen concentration (PaO_2) variations, mean pulmonary artery pressure, heart rate, and D-dimer during fragmentation were assessed in Group P. Both groups shared a similar probability of reductions in heart rate, blood pressure, and blood oxygen saturation. However, with regard to disposition effect, Group P was significantly better than Group E. These findings suggest that precise treatment of intraoperative complications under general anesthesia can reduce adverse cardiovascular effects and is necessary in the interventional treatment of pulmonary embolism with a lumen catheter.

Keywords: Pulmonary embolism, Transluminal interventional therapy, Adverse cardiovascular events, Long-term effects.

Accepted on June 3, 2017

Introduction

Pulmonary Embolism (PE) is a common pathophysiological syndrome of pulmonary circulation disorders, caused by endogenous or exogenous pulmonary embolism blocking the main artery of the lung. Missed diagnosis and misdiagnosis frequently occur in clinical practice. Patients can be stratified as "massive", "submassive" and "nonmassive" according to hemodynamic status and imaging or cardiac biomarker assessment of Right Ventricular function (RV). Massive is defined as acute pulmonary embolism with systolic pressure (BP) less than 90 mmHg or pressure drop by at least 40 mmHg for more than 15 min. Submassive is associated with preserved systolic BP but with RV dysfunction on echocardiography and/or with elevated cardiac biomarkers. This disease also has a high recurrence rate and recrudescent mortality. Major morbidity and mortality associated with transluminal interventional therapy for the treatment of this disease are related to cerebrovascular and cardiovascular complications. Local anesthesia has been advocated as a means of reducing perioperative complications in transluminal interventional therapy. Its advantages are primarily related to hemodynamic stability and neurological monitoring. While the use of general anesthesia has been advocated for its cerebral protective effects, it has been associated with greater perioperative blood pressure lability, vasoactive drug use, and surgical intensive care duration, and reduced patient comfort. Since the optimal anesthesia technique for transluminal interventional therapy has yet to be defined, we investigated the effects of local and general anesthesia on cardiac morbidity following transluminal interventional therapy.

Materials and Methods

Subjects

Between July 2004 and January 2015, our hospital applied pulmonary artery intracavitary catheter fragmentation and Inferior Vena Cava Filter Implantation (IVCF) to treat 50 cases of massive and sub-massive acute pulmonary infarction. Among which, 17 cases were patients with pulmonary infarction who received interventional therapy between July 2004 and October 2009. At that time, multi-disciplinary collaborative consultation treatment system (preoperative Multidisciplinary Team (MDT) discussion) was not established, and local anesthesia was administered and monitored during surgery. Another 31 cases comprised patients with pulmonary infarction who received interventional therapy after March 2010; in this time period, preoperative MDT discussions were established and precise treatment of hemodynamic changes during surgery under general anesthesia was administered. Therefore, this allowed us to investigate the postoperative and long-term effects of the establishment of interventional pulmonary infarction treatment related processes on patients with massive and sub-massive pulmonary embolism.

General information

Group E included 12 men and five women with an average age of 61 ± 7 y. Group P comprised 22 men and nine women with an average age of 63 ± 9 y and diagnosed Pulmonary Thromboembolism (PTE) through spiral Computed Tomography (CT) pulmonary angiography. In these two groups, there were 22 cases of massive pulmonary thromboembolism and 28 cases of sub-massive pulmonary thromboembolism.

Incorporating underlying diseases

There were 10 cases of colorectal cancer surgery, nine cases of femoral neck fracture surgery, 11 cases of cervical cancer surgery, eight cases of lung cancer surgery, two cases of breast cancer, and 10 cases of deep vein thrombosis and long-term paralysis. Embolism location in Group E and Group P patients comprised the following: 14 cases in the double pulmonary artery, 15 cases in the right pulmonary artery, and 21 cases in the left pulmonary artery.

Preoperative discussion

Prior to 2010, there was no multi-disciplinary collaborative consultation treatment system available for patients (Group E); however, this became established after 2010. PTE occurs widely across clinical departments, its diagnosis and treatment requires multi-disciplinary collaboration including vascular surgery, respiratory, cardiology, anesthesiology, radiology, and the intensive care unit teams. First, the staging, area, and range of preoperative patients with pulmonary embolism should be confirmed. Then, if bilateral pulmonary infarction is confirmed, the appropriate therapeutic strategy should be discussed. In addition, according to changes in pathophysiology, appropriate treatment measures should be proposed for potential intraoperative fatal complications arising during surgery.

Induction of anesthesia

Before surgery, patients in Group E were administered local anesthesia; patients were closely watched and asked if they have chest tightness, chest pain, or breathing difficulties during the operation. Anesthesiologists prepared atropine and epinephrine injections before surgery that were administered according to non-invasive blood pressure and heart rate changes during surgery.

After 2010, patients in Group P received internal jugular vein puncture and the dynamic pressure of the radial artery was measured. Following this, a double-lumen catheter was inserted and the radial artery pressure sensor was connected. During surgery, changes in airway resistance, heart rate, blood pressure dynamics, central venous pressure, Electrocardiogram (ECG), and intraoperative blood gases were monitored. Anesthesia induction was begun with administration of propofol at a target concentration of 4.0 μg/ml (March Mode); the plasma concentration achieved equilibrium in 2 minutes. Following this, an input target-controlled concentration of 4.0 ng/ml of remifentanil (Minto mode) was administered to the patient *via* a micro pump; the patient lost consciousness and then received an injection of rocuronium 0.6 mg/kg intravenously. Endotracheal intubation was initiated 10 min after target-controlled infusion induction. After intubation, mechanical ventilation was applied to maintain an end-tidal carbon dioxide of 30-35 mmHg, and airway resistance was continuously monitored throughout surgery.

Therapeutic methods

For patients in both groups, a 5 F pigtail catheter was inserted *via* the femoral vein into the pulmonary artery; angiography was used to determine the site, number, and size of the emboli. Coordination with a loach guide wire was performed through the rotation of the pigtail catheter, chunks of thrombosis were minced, and the loach guide wire was then withdrawn. Thrombus aspiration under negative pressure was repeatedly performed until the thrombus was eliminated. Urokinase was then injected in impulse-type *via* the 5 F pigtail catheter; the urokinase dose of each side was 250,000 U and the drug dose of the bilateral pulmonary artery thrombolytic was 500,000 U. The patient was maintained for 30 min and the angiography was then repeated (to provide angiography before and after surgery). Inferior vena cava filters were imbedded and 0.4 ml of low molecular weight heparin sodium was injected after surgery, twice a day. Oral warfarin 3 mg once daily was prescribed, and the pulmonary thrombosis and International Normalized Ratio (INR) were monitored. Heparin sodium injections were stopped when the INR increased to twice its original level; oral warfarin was continuously prescribed in order to ensure that the INR was maintained at 2-2.5 times its original level. Long-term oral warfarin was prescribed for 6 months. Changes in hemodynamic and respiratory parameters, and relevant disposition of patients in Group P under general anesthesia, were observed.

Changes in heart rate

Before surgery, patients often show ECG changes such as atrial fibrillation and ventricular arrhythmia; during the process of pigtail catheter thrombus mincing, patients often show bradycardia. At this moment, we administered a single dose of atropine (0.5-1.0 mg); if it was ineffective, isoprenaline (1 mg/2 ml/dose) was injected using a micro pump. The maintenance dose ranged from 0.05 to 0.1 μg/kg per min, while the maintenance time was approximately 5-10 min. When the heart rate increased to 1.2 times its level before surgery, the pump was stopped.

Changes in blood pressure

During thrombolysis, blood pressure drops rapidly, often in line with changes in heart rate. In response to the reduction in blood pressure, 5-10 μg/kg/min dobutamine or 0.2-0.3 μg/kg/min milrinone was injected using a micro pump. If this was ineffective after 5 min, 6-8 μg/kg/min norepinephrine was continuously injected through a micro pump, and the dose was reduced and adjusted as appropriate when the blood pressure increased to 20% of its preoperative basic blood level.

Changes in blood oxygen saturation

Under general anesthesia and intubation during surgery, the SPO_2 drops below 90%; therefore, we used positive End Expiratory Pressure (PEEP) to adjust to 5-10 mmH_2O, in addition, as the pulmonary embolism effectively dissolve, the blood oxygen saturation increases to equal to or more than 97%.

Changes in airway resistance

During thrombolysis, airway resistance increases by more than 20%. PEEP was used to adjust to 8-15 mmH_2O. In addition, as the pulmonary embolism effectively dissolved, the airway resistance could be reduced.

Statistical analysis

The Statistical Package for Social Sciences v 17.0 (SPSS, Chicago, IL, USA) was used to analyse the data. Normal distribution measurements were shown by calculations of mean ± standard deviation. A t-test was used to compare data between groups. Nonparametric tests were applied to analyse non-normal distribution data. Chi-square test or Fisher's exact test were performed for the counting data comparison. Statistical significance was accepted when $P<0.05$.

Results

There were no significant differences in preoperative incidence of hypotension, diabetes mellitus, angina, dysrhythmias, age, previous myocardial infarction, or distribution of neoplasma/hip or knee replacement/other between the two groups (Table 1).

Differences in operative factors between the two groups were also evaluated. Of those patients undergoing general anesthesia, 57.4% had prior symptoms of amaurosis, Transient Ischemic Attack (TIA), or stroke, while 62.1% of those undergoing local anesthesia had the same symptomology. Intraoperative hypotension, defined as a systolic blood pressure<90 mmHg, occurred in 16 general anesthesia and 10 local anesthesia patients. Mean operative time was longer in local anesthesia patients (47.7 ± 8.1 versus 67.4 ± 7.9 min, $P<0.01$). The perioperative stroke rate was 2.1%: one stroke case (3.2%) and three cases of TIA (9.6%) occurred following general anesthesia, while no cases of stroke (0%) and three cases of TIA (11.1%) occurred after local anesthesia.

A total of 68 hemodynamic events occurred in 43 patients (67.8%). In Group E, nine patients' heart rate dropped to 50 beats/min and lasted more than 5 min; four patients were administered a single dose of atropine 0.5 mg. In Group P, 17 patients' heart rate dropped to 50 beats/min and lasted more than 5 min; six patients were administered a single dose of atropine 0.5 mg-1.0 mg, while two patients received isoprenaline *via* a micro pump to maintain their heart rate. In Group E, reductions in blood pressure greater or equal to 20% of the basic blood pressure occurred in 11 patients, while in Group P, 13 patients experienced the same; however, after receiving vasopressor drug treatment, their blood pressure was less than or equal to 20% of their basic blood pressure.

In Group E (administered with local anesthesia and carefully watched), 10 patients' SPO_2 decreased to 90%; these patients did not receive any specific treatment. In Group P (received general anesthesia and carefully watched), six patients' SPO_2 decreased to 90% or less, and after receiving PEEP treatment, the SPO_2 returned to 97% or more.

In total, two patients died and there were two cases of respiratory failure in patients receiving local anesthesia; however, the differences between the two anesthesia groups were not statistically significant. Hemodynamic parameters are shown in Table 2. Ventricular dysthythmias occurred more often in patients receiving general anesthesia ($P<0.03$).

Thrombus aspiration is performed for small particles, and line or bar-shaped blood clots. In Group P, the results of the patients' spiral CT pulmonary angiography were as follows: 25 cases showed significant thrombus ablation, four cases showed partial ablation, and two cases showed a small amount of ablation. After successful pulmonary arterial thrombolysis, the patients' SaO_2 significantly increased and PaO_2 markedly increased; pulmonary arterial mean pressure and heart rate decreased significantly. D-dimmer decreased significantly after discharge. Changes in PaO_2, mPAP, heart rate, and D-dimer between before and after surgery are presented in Table 3. During the 6-month follow-up, 27 patients in Group P and nine patients in Group E all resumed normal physical labor without death, recurrent pulmonary infarction, inferior vena cava thrombosis, or other complications. Five patients in Group P and seven patients in Group E developed post-thrombotic syndrome of a lower extremity and needed compression stockings. Two patients in Group P and six patients in Group E presented with inferior vena cava obstruction syndrome 2 months after surgery.

Table 1. *Comparison of characteristics.*

	Anesthesia technique		P value
	General (n=31)	Local (n=27)	
Mean age (y ± SEM)	67 ± 1.8	65 ± 2.3	0.9
Sex			
Male	22	19	0.81

Female	9	8	0.81
Hypotension	8	6	0.99
Diabetes	8	7	0.88
Smoking	17	14	0.97
Previous myocardial infarction	5	4	0.82
Angina	3	2	0.87
dysrhythmia	12	9	0.87
Neoplasma/Hip or knee replacement/ others	16/7/8	15/5/7	0.65
This difference is statistically significant			

Table 2. *Perioperative complications.*

	Anesthesia technique		P value
	General (n=31)	Local (n=27)	
Cardiac			
HR<50/min	18*	7	0.02
Hypotension	13	11	0.86
Spo_2<90%	5*	12	0.03
Respiratory failure	0	2	0.41
Total patients	24	19	0.75
Neurologic			
Stoke	1	0	0.94
TIA	3	3	0.79
Note: *P<0.05.			

Table 3. *Group P patients: changes of PaO_2, mPAP, heart rate, D-dimer before and after surgery.*

Time	PaO_2	mPAP	HR	Airway resistance	D-dimer
Before surgery	81.3 ± 7.1	37.2 ± 7.6	122 ± 9	22.5 ± 2.1	1.55 ± 0.77
After surgery	98.3 ± 8.7**	25.3 ± 7.9**	94.3 ± 7**	16.7 ± 1.6*	0.41 ± 0.12**
T value	5.43	10.12	12.7	8.1	7.39
P value	<0.01	<0.01	<0.01	<0.05	<0.01
Note: *P<0.05; **P<0.01.					

Discussion

The safety and efficacy of endovascular interventional therapy for PTE has been demonstrated in several recent prospective studies [1-3]. Low complication rates are attributable to diligent preoperative risk assessment; controlling associated medical conditions requires careful surgical technique and precise monitoring in perioperative care. The role of anesthetic technique, as a potentially controllable means of reducing perioperative complications, is now being emphasized [4].

PTE cases occur widely in clinical departments [5,6]. Diagnosis and treatment also requires a multidisciplinary collaboration involving vascular surgery, respiratory, cardiology, anesthesiology, intensive care unit and radiology teams. Hemodynamic changes occur in relation to the location and size of emboli, coronary heart disease, and the release of neuroendocrine factors [7]. It could be indicated by right ventricular dysfunction [8]. Transesophageal echocardiography monitor the right ventricular function should be necessary [8,9]. Improper handling of heart rate, ambulatory blood pressure, oxygen saturation, and airway resistance (Table 2) can cause adverse cardiovascular effects. Vasoactive drug treatment can significantly alleviate the patient's right ventricular failure [10]. These data and vasoactive drugs usage are more convenient for observation under general anesthesia than under local anesthesia.

From the changes of PaO_2, mPAP, heart rate, D-dimer before and after surgery, (Table 3) Interventional thrombolysis therapy may be the primary strategy for massive and sub-massive pulmonary infarction [11]. It has the advantages of high accuracy and apparent effect, and can significantly improve the survival rate of patients. Removal of the pulmonary embolism degree is closely related to in the quiet and careful operation environment of general anesthesia.

With updated guidelines for interventional pulmonary infarction treatment, we have made significant progress in a multidisciplinary consultation system and significantly improved patient prognosis. In summary, the incidence of death, myocardial infarction, and stroke were independent of anesthetic technique used. For patients with massive and submassive pulmonary embolism, general anesthesia can allow the operator to increase focus on the operation itself and on the removal of the pulmonary embolism.

Acknowledgements

This study was supported by Zhejiang Province Public Welfare Technology Application Project (2015C3401).

Declaration of Interest

All authors declare that they have no conflicts of interest concerning this article.

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