

CASE REPORT

Asymptomatic Pulmonary Embolism After Shoulder Arthroscopy: Case Report and Literature Review

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Background: Pulmonary embolism (PE) is extremely rare after shoulder arthroscopy. However, early identification of the situation deserves attention due to its potential risk of causing death. By now, it is still difficult to detect the PE without symptoms and clear sources during the perioperative period.

Case presentation: We report here two cases of asymptomatic PE, both happening within 24 h after shoulder arthroscopy, without any detected deep venous thrombosis of extremities. It is suspected the cases were due to the abnormal decrease in partial pressures of oxygen and arterial oxygen saturation, and were confirmed by computed tomography pulmonary angiography. We also discuss the reason why the patients showed no related symptoms when PE occurred and perform a review of PE following shoulder arthroscopy.

Conclusions: This report highlights that PE could occur in the early phase after shoulder arthroscopy. An unexplained decrease in partial pressure of oxygen or arterial oxygen saturation should be considered seriously. The symptoms of PE might be masked due to patients' tolerance to hypoxia.

Key words: Partial pressure of oxygen; Pulmonary embolism; Shoulder arthroscopy; Tolerance to hypoxia

Introduction

Pulmonary embolism (PE) is a highly concerning complication of orthopaedic surgeries, especially in knee and hip surgeries. However, it is easily ignored after shoulder arthroscopy because of its low incidence following this treatment¹. Given its potential lethal effect^{2,3}, PE still deserves intensive attention during the perioperative period of shoulder arthroscopy.

A review of the literature reveals that almost all the reported PE cases were symptomatic before diagnosis and the patients presented more or less clinical symptoms such as dyspnea, chest pain, palpitation, and even cardiac arrest mostly between 1 and 6 weeks post-operation³⁻⁷. Only one case of asymptomatic PE following shoulder arthroscopy was reported⁸, in which PE had been identified after the detection of deep venous thrombosis (DVT) in the subclavian vein, 4 weeks after surgery. The study, differing from many other studies, suggested that DVT mostly occurred within 1 to

2 days after surgery⁸. This may indicate a possibility that the reported symptomatic PE at subacute phase or later might have already existed as asymptomatic DVT or PE early in the acute phase. It was not detected, partially due to neglect or the need of more complicated diagnostic methods (such as computed tomography pulmonary angiography or lung perfusion scintigraphy). As a result, PE was noticed only after the situation worsened and symptoms appeared.

Until now, there has been no report of early detection of asymptomatic PE after shoulder arthroscopy. An early identification would be of great help in preventing the deterioration of the situation. In this paper, we report two cases of asymptomatic PE (with no associated DVT in an extremity) developing within 24 h following shoulder arthroscopy and try to analyze the possible reasons why the symptoms were masked. Each of the patients described in this report provided written consent to their information being published.

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Case Presentation

Case 1

A 51-year-old woman (height 161 cm, weight 52 kg) complained of progressive pain in the left shoulder for 6 months without obvious causes. She had a 1-year-history of hypotension, which has been well controlled by oral felodipine. She has long lived in Qinghai-Tibet Plateau at an altitude of 3700 m and denied a history of coagulopathy.

Physical examination and magnetic resonance imaging (MRI) revealed a tear of the left supraspinatus tendon. An arthroscopic acromioplasty and rotator cuff repair using a suture anchor were performed on the third day after hospitalization. The hospital is located in a city at an altitude of 400 m.

The operation was performed under general anesthesia (lasting 55 min), in the beach-chair position, during which a sequential pneumatic compression pump was applied to the lower extremities. After surgery, the shoulder was immobilized using a sling and abduction pillow. No chemical thromboprophylaxis was given perioperatively.

A decrease in arterial oxygen saturation was detected at 12 h post-operation. The saturation ranged from 85% to 87% without additional oxygen supply and increased only to 88% after oxygen administration at a rate of 4 L/min. However, the patient presented no discomfort except slight pain in the left shoulder. There was no swelling or pain in the upper or lower extremities, and the lung auscultation was normal. The arterial blood gas measurement, performed 30 min after suspension of oxygen therapy, showed significant decrease of partial pressure of oxygen (60 mm Hg). The blood test showed an increased D-dimer level of 3.76 mg/L (normal range 0–0.59 mg/L) and normal levels of RBC and hemoglobin. The arterial oxygen saturation did not improve after 3 h of persistent oxygen administration and the retested partial pressure of oxygen

dropped to 54 mmHg. Computed tomography pulmonary angiography (CTPA) showed emboli in the left pulmonary artery and its branches (Fig. 1A and B). No DVT was observed through Doppler ultrasounds in both upper and lower extremities. The patient presented no symptoms during this process. In the subsequent 3 months, the patient received treatment of rivaroxaban at a dosage of 20 mg per day. Passive motion of the shoulder was performed twice daily.

Case 2

A 75-year-old woman (height 156 cm, weight 64 kg) presented to our hospital with pain and limited mobility of her right shoulder for 6 months. She had a history of atrial fibrillation for 2 years and chronic obstructive pulmonary disease (COPD) for 6 years. Physical examination showed positive Hawkins sign of the right shoulder and limited range of passive and active motion, including flexion, external rotation, and internal rotation. MRI showed a partial tear of supraspinatus tendon.

After treatment in the respiratory department, the patient's partial pressure of oxygen increased from 52 mmHg (pre-hospitalization) to 65 mm Hg, and the arterial oxygen saturation reached 93.1%. Preoperative assessment was then performed by physicians and an anesthetist to exclude surgical contraindications.

Acromioplasty, debridement of subacromial bursa, and arthroscopic lysis were performed under general anesthesia in the beach-chair position. The operation lasted for 45 min and a sequential pneumatic compression pump was applied. Reexamination was performed 24 h post-operation. The retested partial pressure of oxygen was 50 mm Hg, which rose slightly to 53 mm Hg after oxygen therapy. The arterial oxygen saturation was 84.8% and the level of D-dimer was 8.38 mg/L. The patient presented no symptoms related to

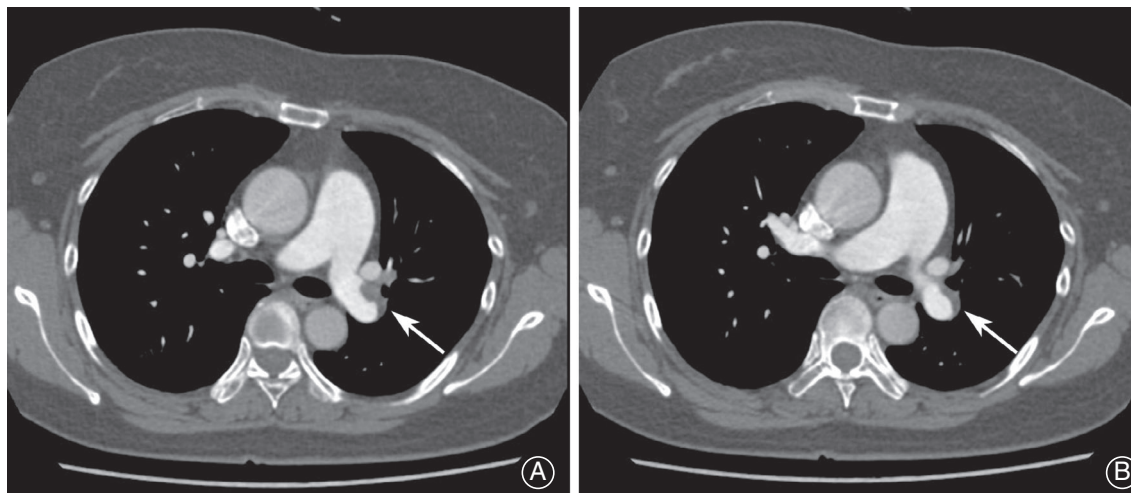


Fig. 1 Asymptomatic pulmonary embolism happened within 12 h after arthroscopic acromioplasty and rotator cuff repair. Computed tomography pulmonary angiography showed enlarged pulmonary trunk and eccentrically located filling defect in the left pulmonary artery (arrow in A and B) (70 mL iodixanol was used as a contrast agent and injected at 4 mL/s intravenously, delay time: 15 s, slice thickness: 0.625 mm).

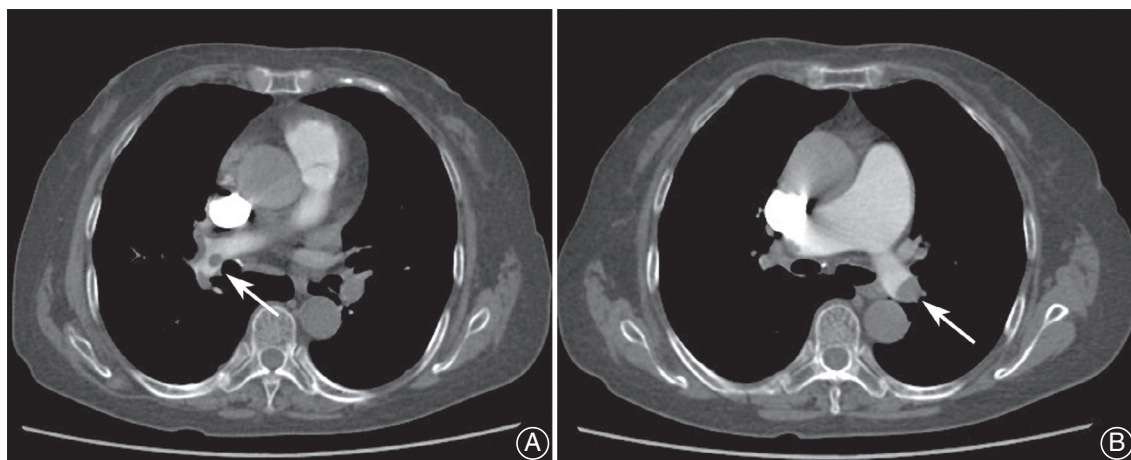


Fig. 2 Asymptomatic pulmonary embolism was confirmed at 24 h after arthroscopic lysis and acromioplasty. Computed tomography pulmonary angiography showed the round embolus in the right pulmonary artery forming acute angles with the vessel wall (arrow in A). The pulmonary trunk was enlarged and intraluminal filling defect was observed in the left pulmonary artery (arrow in B) (70 mL iodixanol was used as a contrast agent and injected at 4 mL/s intravenously, delay time: 15 s, slice thickness: 0.625 mm).

problems in the respiratory or cardiovascular systems. Lung auscultation presented weakened respiratory sounds on the right side. CTPA suggested an embolus in the bilateral pulmonary arteries and their branches (Fig. 2A and B). Doppler ultrasounds showed no detectable DVT in upper and lower extremities.

In consideration of her underlying diseases, the patient was transferred to ICU immediately. After 10 h, the patient presented shortness of breath, which was alleviated gradually after anticoagulant treatment first with a therapeutic dose of low molecular heparin calcium and subsequently transitioning to oral rivaroxaban.

Discussion

PE After Shoulder Arthroscopy

PE is a rare event following shoulder arthroscopy^{1,10}. What we know about this condition is mainly drawn from reports on VTE (including DVT and PE) after shoulder surgery such as arthroplasty, arthroscopy, and trauma. Systematic analysis of PE is lacking. Possible reasons for such a lack of research may be the inconvenience of performing pulmonary angiography and the potential risk of iodine allergy. All the existing studies on PE are reports of cases occurring across time and regions. To gain a more comprehensive understanding of this condition, we pooled altogether 27 cases reported so far in order to understand the typical clinical characteristics of PE following shoulder arthroscopy and to establish referential criteria in its diagnosis and prevention.

Incidence

The incidence of PE after shoulder arthroscopy has been reported to be 0.01%–0.13%^{1,7,10–15}. A study by Jameson *et al.*¹¹, which presented the largest sample size to date,

reported less than 0.01% incidence from 65,302 shoulder arthroscopy cases, while two prospective studies suggested relatively higher incidences of 0.11%⁹ and 0.57%⁸, respectively. Due to such a low occurrence, these studies were often based on large sample sizes. One thing is that only symptomatic PE was considered in these studies. Considering the existence of asymptomatic PE, the incidence could be higher than reported. Take our own experience for example. Between 2018 and 2020, we performed 928 shoulder arthroscopies in our department, among which three cases were complicated with PE, accounting for 0.32% of the cases with post-surgery complications.

Clinical Manifestation and Diagnosis

By reviewing past studies, we identified a total number of 27 cases of PE following shoulder arthroscopy that were reported in detail^{2–8,16–26}. All the cases, except one, were symptomatic before diagnosis. The symptoms of 18 patients were documented in detail, among which the most common symptom was dyspnea, which was recorded in 11 cases^{4,6,7,17–19,23,24,26}. Chest pain often appeared simultaneously with dyspnea and was presented in eight cases^{4,6,18,20,21,26} (Table 1). Some patients developed arrhythmias as the only symptom, requiring differentiation from cardiogenic diseases. Electrocardiography rarely provided specific findings for diagnosing PE. Cardiac arrest was the most serious condition in these cases^{3,5}, predicting a high risk of death and a poor prognosis. The only asymptomatic case was reported by Takahashi *et al.*⁸, in which PE was detected 4 weeks after surgery. This case indicates the possible existence of asymptomatic PE after shoulder arthroscopy. However, no asymptomatic cases have been reported since then.

TABLE 1 Summary of the clinical characteristics of the patient with PE after shoulder arthroscopy

		Number of cases (cases/recorded cases)	
Sex	Male	15/26	
	Female	11/26	
Age (years)	18 - 29	6/26	
	30 - 49	7/26	
	50 - 76	13/26	
BMI (kg/m ²)	<30	9/16	
	≥30	7/16	
Duration of surgery (min)	>60	14/18	
	>80	12/18	
Surgery position	Beach chair	12/24	
	Lateral decubitus	12/24	
Onset time post-surgery (days)	≤1 d	2/26	
	1 d - 7 d	7/26	
	≥7 d	17/26	
Symptoms	Dyspnea	11/18	
	Chest pain	8/18	
	Dyspnea and chest pain	5/18	
	Arrhythmias	2/18	
	Anxiety	3/18	
	Blood sputum	1/18	
	Cardiac arrest	2/18	
Pain or swelling of limbs	Ipsilateral arm	5/8	
	Contralateral arm	1/8	
	Ipsilateral leg	2/8	
DVT	Contralateral leg	0/8	
	Ipsilateral arm	8/20	
	Contralateral arm	1/20	
	Leg	Ipsilateral	2/20
		Uncertain	1/20
Negative	8/20		
Elevation of D-dimer		6/6	
Comorbidities	Diabetes	7/26	
	Hypertension	8/26	
	Taking estrogen	2/26	
	Thyroid disease	2/26	
Duration of treatment (month)	6	10/11	
	9	1/11	

Based on these cases, PE was identified after a median time of 7 days (range, 1 day - 6 weeks) postoperatively. Most patients (65.4%) developed symptoms at 1 week or more after shoulder arthroscopy (Table 1). Only in one case was PE detected within 24 h after surgery²¹.

Some patients had developed pain or swelling of limbs before PE was confirmed^{6,7,18,19,21,23,24}. The scapular pain may be mistaken as regular reaction after surgery or functional training, and would delay the diagnosis of PE. A new onset of pain in limbs or swelling of extremities (reported in eight cases), especially in the non-acute phase after surgery, might imply the occurrence of DVT, which may lead to or coexist with PE. Of the 27 PE cases pooled here, information about DVT was recorded in 20 cases with the aim to trace the possible source of embolus in the pulmonary artery

(Table 1). In these cases, DVT was detected by venous duplex ultrasound or enhanced CT of the upper and lower extremities. DVT in the extremities was reported in 12 patients (60%)^{3,4,7,8,17,19,20,23,25,26}. Eight of them had DVT in the ipsilateral arm, indicating that the surgical operation was a critical factor for the development of DVT. Only three patients developed DVT in the lower extremities^{7,26}. Different from what was presented in these cases, a prospective cohort study found that DVT mostly occurred in the lower extremities even after shoulder surgery⁸. The reason would be that DVT in the lower extremities tends to be asymptomatic, while that in the upper extremities is more easily noticed as it is more likely to progress to PE⁴.

For the diagnosis of PE after shoulder arthroscopy, elevation of D-dimer has been recorded in some previous cases^{3-5,21,23,25}. Similarly, it also served as a warning of PE in the two cases presented by us in this paper. In addition to D-dimer, CTPA is considered the standard of PE diagnosis and was performed in all the 27 cases. We recommend the arterial blood gas analysis as routine monitoring after shoulder arthroscopy, especially for patients with a high risk of VTE. Timely CT angiography (if conditions permit) and extremity venous duplex ultrasound are the preferred methods upon suspicion of VTE. Echocardiography (both transthoracic and transesophageal), as a feasible and low-risk test, could be an alternative method especially in critically ill patients or patients undergoing cardio-pulmonary resuscitation (CPR).

Treatment and Prognosis

Hospital treatment was suggested for all the 27 patients. Anticoagulant therapy, such as subcutaneous injection of heparin, low-molecular-weight-heparin (LMWH), or enoxaparin, was the main treatment in the initial management. Oral anticoagulants (rivaroxaban or warfarin) were commonly applied in the primary treatment and secondary prevention. Thrombolytic therapy followed by anticoagulation was performed in two cases^{17,19}, one of which presented a hemodynamic compromise¹⁷. Catheter-directed thrombolysis for PE, as an alternative therapy especially for patients with an intermediate to high risk of bleeding, was not reported in these cases. The most frequent duration of treatment in these cases was 6 months, which was consistent with the "shorter course of anticoagulation" recommended by American Society of Hematology (ASH)²⁷. No recurrent PE was reported within the cases.

According to the 27 cases reported so far, postoperative PE had little influence on the functional rehabilitation of the shoulder, except that one patient developed an adhesive capsulitis due to an acute hemarthrosis, which required manipulation under anesthesia, including arthrolysis and bursectomy⁷. No research has mentioned whether postoperative rehabilitation should be paused once DVT or PE is confirmed. There is no sufficient evidence to show that rehabilitation exercise of the shoulder increases the risk of PE caused by detachment of thrombus. However, strenuous

activities and squeezing of the arm should be contraindicated.

Risk Factors

As mentioned earlier, there has been hardly any research on PE after shoulder arthroscopy as well as its risk factors, and the understanding of it has been inferred from studies on VTE after various surgical procedures of shoulders. The patients pooled in this study were aged from 18 to 76 years, and the number of patients under 50 was the same as the number of those above 50 (Table 1). Jameson *et al.*, who included 65,302 patients in their study, found that the risk of VTE after shoulder arthroscopy was significantly increased in patients over 70¹¹. Whereas, the case-control study by Schick *et al.* involving 15,033 patients did not verify the association between age and VTE risk¹². Apart from age, male sex was found to be a risk factor of VTE after rotator cuff repair in a retrospective study involving 31,615 patients having received arthroscopic surgery and 8210 patients having received an open procedure¹. The study also reported that body mass index (BMI) of over 30 kg/m² was the greatest contributor to the risk of VTE after rotator cuff repair. However, other studies found no significant association between BMI and VTE after shoulder surgery^{8,9,12}. Of the PE patients reviewed in this paper, the average BMI was 29.9 kg/m² ($n = 16$).

Duration of surgery is generally considered a risk factor for VTE after shoulder surgery. Sager *et al.*¹ found that an operative time over 80 min was associated with a 2.17-fold increased risk of VTE following shoulder arthroscopy. Similarly, Imberti *et al.*⁹ suggested that a surgical duration greater than 60 min was an independent risk factor for VTE after shoulder surgery. Among the 27 PE cases investigated in this paper, the exact duration of the shoulder arthroscopy was reported in 18 cases. The average time of operation was 132.8 min, with the longest being 360 min³. Most of the patients underwent a lengthy operation (≥ 60 min in 16 cases and >80 min in 12 cases) (Table 1). Based on the above, we tend to believe that prolonged operation is a risk factor for PE, as it means a longer duration of surgical position, more severe swelling of limbs, and more chances of vascular irritation.

Surgical positions could also be an influential factor. It is still debatable whether the lateral decubitus, compared with the beach-chair position, is more likely to cause VTE. No research so far has looked into the relationship between surgical positions and the risk of postoperative PE. Lateral decubitus position, usually accompanied by arm traction, is generally regarded as a risk factor of upper extremity deep vein thrombosis (UEDVT), which may develop into PE. Whereas, beach-chair position is considered to be related to an increased risk of lower extremity deep vein thrombosis (LEDVT)¹², and this has been proved by Takahashi *et al.*⁸ who reported that most of the patients with DVT after arthroscopic shoulder surgery under beach-chair position had it in the lower extremities (calf veins), with an incidence

of 5.14%. The 27 PE cases reviewed in this paper were almost evenly split between beach-chair position and lateral decubitus (Table 1).

One more risk factor for PE, which could be hard to notice, is the high altitude of the region where the surgery is performed. As reported by Cancienne *et al.*²⁸, the incidence of PE after shoulder arthroscopy performed at an altitude above 4000 feet was 4 times that after the same surgical procedure at an altitude below 100 feet. This difference might be associated with venous hypoxia caused by the decreased partial pressure of oxygen at high altitude.

Although shoulder arthroscopy is a low-risk procedure, the comorbidities could increase the risk of complications (including PE) during and after the operation¹¹. Of various comorbidities, diabetes is a highly concerning factor significantly associated with post-surgery VTE¹¹. In the PE patients we review here, 12 were reported to have comorbidities; seven of them had diabetes, including the only two death cases^{3,6}. Aside from diabetes, we found that two PE patients had taken both levothyroxine and estrogen^{4,18}. Estrogen is a known risk factor for VTE. It is not clear whether levothyroxine, when used together with, enhances the role of estrogen in the formation of PE.

Because of the low incidence of PE, it is difficult to collect a large number of cases to confirm the dominance of any known risk factors. We tend to agree that the formation of postoperative PE depends on the coexistence and interaction of multiple risk factors²³. This could be verified by a case reported by Cortés *et al.*¹⁸. The patient underwent an arthroscopic rotator cuff repair that was completed in only 37 min but still developed PE 10 days after operation. The suspected risk factors in this patient included obesity, diabetes, and administration of levothyroxine and estrogen.

Prevention

There are still no clear guidelines or even consensus regarding the prevention of VTE after shoulder arthroscopy. Mechanical prophylaxis, as a low-risk strategy, is widely recommended and accepted. Early ambulation after surgery is strongly encouraged in all patients. The lower extremity sequential compression device is routinely used during operation regardless of the surgery position. Nevertheless, Takahashi *et al.*⁸ reported a high incidence (5.7%) of DVT after shoulder arthroscopy in spite of the use of mechanical prophylaxis (pneumatic compression devices or elastic stocking). Of the 27 cases considered in this paper, at least 19 cases were recorded to have used pneumatic compression devices^{2,5-8,24,26}. Given the fact that mechanical prophylaxis does not necessarily contribute to a lower incidence of VTE, many researchers still think routine chemoprophylaxis for perioperative VTE in shoulder arthroscopy patients is unnecessary, in view of its low incidence and the potential adverse drug reactions of anticoagulants. The majority of researchers recommend an implementation of chemoprophylaxis in patients at a high risk of VTE, particularly when multiple risk factors coexist^{2,15,17,29}. Chemoprophylaxis should be

based on the substantial estimation of individual risk of bleeding. Prophylactic doses of LMWH or heparin are preferred over antiplatelet agents such as aspirin²⁷.

Why No Symptoms?

We present here two cases of asymptomatic PE in the early stage after shoulder arthroscopy, which has not been reported elsewhere. One common feature in the two cases is that the patients presented no symptoms when PE occurred, even when the partial pressure of oxygen fell to 54% and the arterial oxygen saturation dropped to 85%, which were low enough to cause hypoxia symptoms. Why were the symptoms masked? By analyzing the similarity between the two cases, we speculate that hypoxia tolerance might be one of the reasons. The first patient has long lived in the plateau region at an altitude of 3700 m, where the hypobaric environment has improved her tolerance to hypoxia. According to the reported data, the average partial pressure of oxygen in healthy people living in such areas is lower than 61 mmHg³⁰. This may be the reason why the patient, when hospitalized in the plain region, did not present any discomfort even when the partial pressure of oxygen declined to 54%. It is suggested in Jourdan *et al.*'s study that high altitude over 4000 feet (1219 m) is an independent risk factor for postoperative venous thromboembolism (VTE), including DVT and PE following arthroscopic rotator cuff repair²⁸. Our current analysis further suggests that the symptoms of PE in patients living for a long time at a high altitude might be masked when the patient is in a low altitude area upon the occurrence of PE.

The second patient has a 6-year history of COPD without systematic treatment. Before admission, the disease was in a static period and the partial pressure of oxygen was 52 mmHg. This indicated a prolonged state of hypoxia in the patient, which would induce her hypoxia tolerance. The patient received preoperative drug therapy until the partial pressure of oxygen increased to 65 mmHg. After surgery, PE occurred and the partial pressure of oxygen declined to 50 mmHg. This level was very close to that before surgery, so the patient did not show any symptoms in the early phase. This case suggests the possibility that COPD, similar to high altitude, not only acts as a risk factor for PE, but could mask the valuable symptoms at the early stage of PE.

PE Could Occur Within 24 h After Shoulder Arthroscopy

Another common feature of the two cases is that PE occurred within 24 h after operation, which was remarkably earlier than in most of the previously recorded cases. Among the 27 reported cases of PE following shoulder arthroscopy^{2-8,16-26}, only five were diagnosed within 3 days post-operation^{2,3,6,16,21}, and most of them (65.4%) were diagnosed 1 week after operation. In these reports, it was only after the patients had developed symptoms that PE was suspected and diagnosed by objective tests. However, the second case described here showed that symptoms could appear some time later after PE formed.

Therefore, it may be possible that the reported symptomatic PE in the subacute phase or later might have already existed as asymptomatic DVT or PE in an earlier phase, but the patient was not concerned earlier because of the lack of sentinel symptoms. The delayed onset of symptoms, as demonstrated in case 2, indicates the continued aggravation of the disease. Early detection and timely treatment are definitely valuable. By now, the predilection time of PE following shoulder arthroscopy is still unclear. Further prospective studies with large samples are needed for a better understanding of this complication.

Isolated PE After Shoulder Arthroscopy

The emboli in pulmonary arteries are mainly from DVT of the upper or lower extremities. DVT of the upper extremities has a lower incidence than that of the lower extremities, but it is more easily complicated by PE²⁸. The asymptomatic PE reported by Takahashi⁸ was suspected just because of the detection of DVT in the subclavian vein. Therefore, negative DVT of extremities would make asymptomatic PE easier to neglect. Similar to these two cases we have presented, eight patients developed only PE^{5,6,21}. In our two cases, DVT was also not observed in any of the extremities. But there is no insufficient evidence to show that the PE complication is unrelated to DVT. It is possible that the thrombus might have already shed off by then because the elbow and wrist were not immobilized. For the second patient, the 2-year atrial fibrillation was a high-risk factor of thrombogenesis. The right atrial thrombus could be an alternative origin of PE, but no further test was performed for verification.

Conclusion

Considering the existence of PE without symptoms or clear sources of emboli, the incidence of PE following shoulder arthroscopy could be higher than reported¹. Unlike DVT of extremities, PE is not a routine examination item unless there are suspectable symptoms. Additionally, most patients are discharged within 2 days after this minimally invasive surgery and early clinical manifestation may escape from medical observation. Given its potential lethal risk^{2,3}, early identification of PE deserves more attention from clinical surgeons during the perioperative period of shoulder arthroscopy. In both the asymptomatic cases presented here, PE was suspected due to the decreased partial pressure of oxygen and arterial oxygen saturation in the early phase after surgery. Based on this, we recommend arterial blood gas analysis as a routine test after shoulder arthroscopy, especially for patients with a high risk of VTE. Particular attention should be paid to an unexplained decrease and no improvement of partial pressure of oxygen or arterial oxygen saturation after oxygen therapy, especially when it was accompanied by increased D-dimer. In agreement with Kim³, we believe that clinical assessment alone is unreliable for diagnosis of PE. The symptoms of PE may be masked due to patients' tolerance to hypoxia.

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