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The Role of Work and Occupational Factors in the Development of Pulmonary Thromboembolism

Pulmoner Tromboemboli Gelişmesinde İş ve Mesleki Etmenlerin Rolü

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Abstract

Pulmonary thromboembolism (PTE) usually occurs as a complication of deep vein thrombosis (DVT). Venous thromboembolism (VTE) develops through the interaction of individual risk factors and environmental factors. Occupational Diseases are diseases in which a work-specific cause-effect, effect-reaction relationship can be demonstrated. Work-related diseases are diseases caused by many causal factors and other risk factors that exist in the workplace. In fact, occupational and environmental risks cause PTE, but there is very little research on this subject. In PTE patients, occupational history and work conditions should be learned thoroughly in the anamnesis. People with a history of PTE should be enabled to work without being exposed to the risks that may cause or increase PTE during starting and returning to work. In this systematic review, work and occupational causes that may cause PTE and VTE were investigated.

Although there is not enough research, the literature we found shows that air pollution and exhaust emissions, working at high altitudes, long-term inactivity of drivers, pilots, and desk workers, chemicals exposed at work, and Covid 19 infection may be work-related reasons that can increase the risk of PTE and DVT.

Research and case reports on the subject are few and insufficient. For this, new research and case reports are needed. In cases, occupational exposure history should be well learned and its relationship with PTE or VTE should be thoroughly investigated. In order to prevent new PTE cases that may occur, occupational PTE cases should be reported and necessary precautions should be taken.

Keywords: Pulmonary thromboembolism; occupational disease; driver and pilot; air pollution

Öz

Pulmoner tromboemboli **(**PTE) genellikle derin ven trombozunun (DVT) bir komplikasyonu olarak meydana gelir. Venöz tromboemboli (VTE), kişiye bağlı risk faktörleri ile çevresel faktörlerin karşılıklı etkileşimi ile gelişir. Meslek Hastalıkları işe özgü bir neden-sonuç, etki-tepki ilişkisinin ortaya konabildiği hastalıklardır. İşle ilgili hastalıklar ise, işyerinde var olan birçok nedensel etken ve başka risk faktörlerinin birlikte neden olduğu hastalıklardır. Aslında mesleki ve çevresel riskler de PTE oluşmasında sebep olurlar, fakat bu konu ile ilgili araştırmalar oldukça azdır. PTE hastalarında meslek öyküsü ve işin yürütüm şartları anamnezde iyi öğrenilmelidir. PTE öyküsü olan kişilerde, işe başlangıç ve işe geri dönüşlerde PTE ortaya çıkaran, arttıran risklere maruz kalmadan çalışması sağlanmalıdır. Bu sistematik derlemede PTE ve VTE'ye neden olabilecek iş ve mesleki nedenler araştırılmıştır.

Hava kirliliği ve egzoz emisyonlarının, yüksek rakımda çalışmanın, şöför ve pilotların, masa başı çalışanların uzun süre hareketsizliliğinin, iş yerinde maruz kalınan kimyasalların, iş kaynaklı Covid 19 enfeksiyonun PTE, DVT riskini arttırabilen mesleki ya da iş kaynaklı nedenler olabileceği, yeterli araştırmalar olmasa da bulduğumuz kaynaklarda, görülmekteydi.

Konu ile ilgili araştırmalar ve vaka sunuları az ve yetersizdir. Bunun için yeni araştırmalara ve olgu sunumlarına ihtiyaç vardır. Vakalarda mesleki maruziyet öyküsü iyi öğrenilmeli ve maruziyet durumunun PTE ya da VTE ile ilişkisi iyi araştırılmalıdır. Oluşabilecek yeni PTE vakalarının önlenebilmesi için mesleki PTE vakalarının bildirimi yapılmalı ve gerekli önlemler alınmalıdır.

Anahtar sözcükler: Pulmoner tromboemboli; meslek hastalığı; şoför ve pilot; hava kirliliği

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INTRODUCTION

Pulmonary thromboembolism (PTE) is a vital condition that occurs when thrombus settles in the pulmonary arteries, usually through the venous circulation, and blocks circulation. Since sudden death occurs in approximately 25% of PTE patients, risk stratification and disease prevention are of great importance. Known risk factors; these are history of venous thromboembolism (VTE), history of malignancy, major trauma, surgery, recent hospitalization, oral contraceptive treatment, long travel history, immobility, obesity and accompanying heart diseases. Hereditary risks that cause VTE; factor V Leiden and prothrombin gene mutations, protein C, S and antithrombin III deficiencies. Covid-19 infection increases the risk of thrombosis as a result of severe inflammation, hypoxemia and associated endothelial damage and coagulopathy (1,2).

Venous thromboembolism develops through the interaction of individual risk factors and environmental factors (1). In fact, occupational and environmental risks cause PTE, but there is very little research on this subject.

Occupational Diseases are diseases in which a work-specific cause-effect, effect-reaction relationship can be demonstrated. Work-related diseases are diseases in which many causal factors and other risk factors that exist in the workplace play a role. Work-related diseases do not occur directly in the workplace, but are affected by factors in the workplace (3).

Depending on the cause of PTE, there is a possibility that it may be an occupational disease or a work-related disease. In order to define this, in PTE patients, the occupational history and the conditions of work should be learned well in the anamnesis. In addition, people with a history of PTE should be encouraged to work without being exposed to the risks that cause PTE, as the possibility of recurrence is higher. Pulmonary thromboembolism should be prevented from occurring in healthy people by reducing and eliminating the risks that cause PTE.

This is a systematic review study. Since it was a review article, an ethics committee was not required. PubMed, Researchgate, Google Scholar and DergiPark databases were searched for English and Turkish publications.

Relevant laws in our country were examined. While researching for publications, work and occupational reasons that could cause PTE and VTE were written down.

It is important to be aware of the risks that cause PTE to ensure that employees are protected from factors that may cause PTE. For this reason, we wanted to draw attention to the risks incurred due to the execution conditions of the work that may cause PTE.

Work-Related and Occupational Factors

1. Working at High Altitude and High Hematocrit

A hypercoagulable state may occur when a person remains in a high altitude environment. Staying in a high-altitude environment is a little-known risk factor for PTE. Unusual environmental conditions such as extreme cold, hypoxia, immobility, polycythemia, and dehydration contribute to the hypercoagulable state. There may be inactivity and dehydration, which can trigger thrombus formation. Pulmonary tromboembolism has been reported in employees serving at a minimum altitude of 10,000 feet and a maximum altitude of 20,500 feet (4,5).

Staying at high altitudes for a long time may lead to activation of the coagulation system by increasing hematocrit and blood viscosity (6). High hematocrit increases platelet margin and stickiness, blood viscosity and venous stasis. A single elevated hematocrit (or hemoglobin) has been found to be associated with VTE (7,8).

Military personnel working at high altitude are at risk for PTE (9). In a study, 50 soldiers with suspected PTE working at high altitude were examined, and when the frequency of PTE risk factors was examined, it was seen that the only risk factor in 50% of the patients was high altitude (10).

Although high altitude climbing is essential in some lines of work, it is also done as a holiday, sport or hobby (11).

2. Air Pollution and Exhaust Emissions

There is a significant relationship between exposure to air pollution and VTE (12). Exhaust emissions from traffic are particles released into the air during vehicle use due to the combustion of fuels, additives and the wear of engine parts in the system. Exhaust gas emissions are increasing due to the widespread use of diesel fueled vehicles in the transportation sector (13).

Exposure to particulate air pollution has been associated with an increased risk of arterial cardiovascular disease, but data on the association with VTE are rare. Since road traffic is a major source of exposure to particle pollution, people living close to major traffic routes are at higher risk for air pollution effects. In a study conducted in Italy, living near main traffic roads was found to be associated with an increased risk of VTE (14).

Exposure to particulate matter (PM) 2.5, PM 10, and O3 is associated with increased levels of inflammatory and coagulation factors and may lead to an increased risk of DVT triggered by the blood coagulation system. A study has shown a positive relationship between ambient air pollutants, including PM 2.5, PM10 and O3, and lower extremity deep vein thrombosis (LEDVT) in patients after surgical

operations (15). It was observed in another study that DVT risks increased with the increase in long-term PM 2.5 exposure concentration (16).
Examined the relationship between PM 2.5 exposure and hospital admissions for DVT and PE in an elderly population (65 years and older) in the Eastern USA. A positive relationship was found between PM 2.5 exposure and DVT (17).
It is known that the risk of exposure to diesel exhaust increases for drivers, toll booth attendants and construction workers (18). Traffic police and people carrying luggage at airports are exposed to intense vehicle exhaust and jet fuel (19).
Miners, bridge and tunnel workers, and garage workers are occupations exposed to diesel exhaust particles (20).

3. Long Distance Truck Driving

Long-term inactivity and long-distance travel are factors that cause PTE (21). Long-haul truck drivers face many medical problems due to their lifestyle and work environment. The case of a 45-year-old truck driver who was found dead in his truck at a service station on the side of the A1 motorway in Umbria, Italy, was reported.
While the case was on an international trip, he reported to his relatives in a phone call that he suddenly noticed shortness of breath, numbness and weakness in his legs. He was traveling on the highway with minimal food and water consumption as well as minimal rest. Two days later, he was found dead. After 48 hours, the autopsy revealed that the cause of death was PTE and a DVT region was detected in the leg veins (22).
Long-distance truck drivers are exposed to work stress due to reasons such as irregular shift work, unsuitable working environment, long working hours and limited rest time (23). Stress leads to an increase in D-dimer and sympathetic activity, which may contribute to PTE in patients (4). The relationship between cortisol and VTE is not fully understood.
VTE occurs more frequently in people with Cushing syndrome (CS) than in the general population. It is known that high cortisol levels are associated with the risk of cardiovascular disease (CVD) (24). Psychological distress caused by workload may reveal chronic hypercoagulability (25).
In a study in which urinary epinephrine, norepinephrine and cortisol were measured as stress factors in long-haul truck drivers, it was observed that urinary epinephrine levels were directly related to anxiety scores. Epinephrine and norepinephrine excretion was found to be higher when weather and traffic conditions were stressful (26).

4. Pilots

The health of pilots is of great importance to ensure the safe travel of millions of people around the world. Pilots may experience various health problems due to the work they do. A collaborative effort between airlines, governments and regulators is required to ensure pilots' health and flight safety. Prioritizing pilots' health can increase profitability in the aviation industry by reducing costs associated with absenteeism, turnover and accidents.
Inactivity during long-haul flights is a well-known risk factor for VTE. Although this topic attracts great interest among passengers, published literature about pilots remains limited. However, the effectiveness of prophylaxis depends critically on awareness of the potentially life-threatening situation (27,28).
In a survey-based study of pilots, approximately half of the participants (57.1%) had just heard of a VTE-related health problem and 63.9% of the participants were unaware of flight-related VTE. Pilots between the ages of 20 and 40 were less aware of VTE compared to pilots aged 41 and over, and pilots who flew more than 90 hours per month were found to be at greater risk.
The overall safety of civil aviation should be increased by increasing pilots' awareness of flight-related VTE (29).

5. Desk Workers

Prolonged work and computer-related sedentary inactivity have been associated with VTE. In this regard, professional strategies need to be developed to reduce the risk.
The term seated immobility thromboembolism (SIT) syndrome has been proposed to encompass all situations in which prolonged seated immobility contributes as a risk factor for VTE, including prolonged airplane, car, or train travel, work, and recreation. In a study, prolonged work and computer-related sitting were found to be associated with VTE. Occupational strategies need to be developed to reduce the risk associated with VTE (30,31).
Employees such as public personnel, holding and plaza personnel, bank employees, administrators, office workers, which we refer to as white-collar workers, some security personnel, educators, psychologists, and accountants, meet the definition of desk workers (32).

6. Employees Exposed to Covid 19

Coronavirus disease 2019 (Covid19) is characterized by an increased risk of thromboembolic events in patients affected by more severe manifestations of the disease.

It has been observed that thromboembolic complications such as sepsis-induced coagulopathy, disseminated intravascular coagulation, venous and arterial thromboembolism, and microthrombosis affect different organs such as lung, heart, kidney, and brain (33).

Covid 19 occupational infection rates in many professions, especially healthcare workers, have exceeded the infection rates in the general population. For example, other non-healthcare professions have been defined as grocery store workers, agricultural workers, and construction workers (34).

Workers who have more human contact are more exposed to SARS-CoV-2. Workers in healthcare and preventive services (e.g., healthcare workers, police officers), as well as taxi and bus drivers, are at increased risk (35).

For this reason, when Covid 19 is considered occupational, the PTE complication that occurs should also be considered occupational.

7. Cadmium

Cadmium (Cd), an environmental and industrial pollutant, is a heavy metal found in battery wastes, cigarette smoke, blue paint pigments, and copper foundries as Nickel Cadmium (Ni-Cd). In an experiment in mice, acute intraperitoneal injection of Cd showed a significant acceleration ($P<0.001$) in platelet aggregation, leading to pial cerebral thrombosis, compared to the control group. It has been observed that Cd exposure causes acute thromboembolic events in mice (36).

8. Cyanoacrylate

Cionacrylate can be used for bonding porous and non-porous surfaces such as plastic (PVC, ABS, polystyrene, polystyrene), wood, ceramic, tile, porcelain, leather, rubber, cork and cardboard. Workers in these industries may be exposed to cyanoacrylate. Due to their hemostatic and anastomotic properties, the use of cyanoacrylate derivatives as tissue adhesives is preferred for closing incision wounds, especially in neurosurgery, plastic surgery, vascular surgery, ophthalmic surgery and dentistry surgery. In our country, a case of pulmonary embolism that developed after cyanoacrylate treatment in a cirrhosis patient who presented with acute gastric variceal bleeding has been reported (37).

Prevention:

Here we wanted to mention about its prevention against PTE and VTE in some work-related situations. Risk factors related to high altitude should be reduced with training and experience. In order to adapt to climate conditions and altitude (acclimatization), light-paced aerobic running or medium-paced walking (basic endurance) programs should be carried out. Adequate and balanced nutritional and fluid intake should be ensured for those working at high altitudes (9).

We mentioned that diesel exhaust particulates may be associated with VTE. Precautions should be taken in accordance with the relevant regulations in exposed occupational groups. As an example, Miners are covered by the Mine Safety and Health Administration abroad. A miner's personal exposure to DPM should not exceed 160 Micrograms per cubic meter (μg/m3) of total carbon measured as an 8-hour time-weighted average. Respiratory protection should be used to support applicable engineering and administrative controls to reduce a miner's exposure to or below the permissible exposure limit. A mask with a suitable filter is recommended for respiratory protection (20).

Maintaining mobility is important in preventing VTE. Considering the possible pathogenesis of travel-associated VTE, maintaining mobility is recommended for all travelers traveling longer than 3 hours. It is known that long-distance travel, both by air and by road, increases the risk of VTE. Risk assessment should be made on an individual basis, but for passengers who have a high risk of thrombosis such as major surgery within the last month, active malignancy, who are at high risk for travel-related thrombosis, and who travel for >3 hours, compression stockings that fit well below the knee are recommended.

In appropriate conditions, anticoagulants are recommended. General contraindications to the use of any thromboprophylaxis should be considered (38).

Based on this recommendation, long-distance drivers should first take necessary breaks and maintain mobility. For people with a high risk of thrombosis, compression stockings that fit well below the knee may be recommended. Mobility in the cabin is important for pilots, and breaks and maintenance of mobility are important for those working sitting at a desk. For people at high risk of VTE, compression stockings that fit well below the knee may be recommended.

Although there is insufficient evidence for any chemical substances, exposure should be within legal limits in accordance with regulations and employee exposure should be prevented with appropriate personal protective equipment.

CONCLUSION

Research and case reports regarding occupational causes of PTE are few and insufficient. For this, new research and case reports are needed. It should be kept

in mind that PTE may be occupational or work-related, and work history should be asked in the anamnesis. Occupational exposure history should be well learned and the relationship between exposure status and PTE or VTE should be thoroughly investigated.

If PTE is considered occupational or work-related, those with a similar exposure history may be protected against PTE. Necessary precautions can be taken to prevent PTE from developing. Legal rights can be provided in terms of occupational diseases. Legal rights can be provided in terms of occupational diseases.

Author Contribution

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