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A case's root cause analysis of osteofascial compartment syndrome induced by radial artery puncture and its defensive strategy

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ABSTRACT

Objective: The objective of this study was to reduce or avoid the occurrence of the cases of osteofascial compartment syndrome induced by a radial artery puncture for arterial blood gas analysis.
Methods: We analyzed an adverse event using cheese model analysis, "fish bone" analysis, root cause analysis, and other methods.
Results: There are three root causes leading to an adverse event: operation technique, assessment of the disease, and informing patient families. However, there are many reasons to promote the occurrence and development of the event.
Conclusions: We should analyze and manage the adverse events in patients from the point of view of a system. Developing the measures of a system defense can enhance patient safety and create a good safety culture.

1. Introduction

Arterial blood gas analysis is the most commonly used inspection means in the clinical assistant treatment of respiratory and circulatory system diseases. Through the analysis of arterial blood components, doctors can determine the condition of patients, treatment, and medication usage. An arterial puncture should be completed strictly in accordance with the standard operation. We should choose the puncture side without causing infection, arteriovenous embolism, and other problems. Meanwhile, we should choose the obvious position of pulsation as the puncture point. The radial artery, femoral artery, brachial artery, and dorsalis pedis artery are good choices. Complications, such as bleeding, hematoma, thrombosis, vasospasm, and infection, may occur when an artery is punctured. Research shows that[1] the puncture needle into the vein is the most important reason for failure to acquire arterial blood gas, but hemorrhage and hematoma are the most common complications of an arterial puncture.

One case that was diagnosed as osteofascial compartment syndrome occurred in the emergency department in the First Hospital of Shanxi Medical University in August 2014. The patient was punctured in the radial artery for arterial blood gas analysis. Now, we will analyze the process and correlative factors of this adverse event to look for the root cause of this complication.

2. Methods

2.1. Case description

2.1.1. Key information

The patient was a 73-year-old male. He felt that he was being suffocated and was having difficulty breathing, so he went to a local hospital in the evening of August 8, 2014. He was actually having an asthma attack. The doctors gave him antihypertensive drugs and remissed him with asthma. However, he did not feel any better, so he came to our emergency department accompanied by his family members and the 120 emergency workers for further treatment at 11:45 in August 9, 2014. The patient had bronchial asthma for more than 10 years, and the disease would attack him in the winter of each year. In addition, he had a cerebral infarction more than 1 year ago. The patient had taken aspirin enteric-coated tablets for more than 1 year, once a day, and one piece at a time. The patient did not admit suffering from hypertension or any other disease (e.g., diabetes mellitus). Physical Examination: The patient was conscious.

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Blood pressure: 150–160/100–110 mmHg; heart rate: 130–150 beats/min; and blood oxygen saturation: 90%–92%. Bilateral lung breath sounds were crude and wheezing was observed. Relevant examination: electrocardiogram showed that V2 and V3 showed an abnormal QS waveform. His blood biochemical examination showed that the creatine kinase isoenzyme (CK-MB) level was 19.4 U/L, and the troponin level was 1.39 μg/L, which is above the normal range. Other blood examination-related parameters had no obvious changes except for the red blood cell count and hematocrit. The doctor diagnosed him with acute myocardial infarction, bronchial asthma, and cerebral infarction.

2.1.2. Key therapeutic measures and blood specimen collection

After the patient came to the emergency department, a doctor immediately performed a physical examination. At the same time, nurses gave him oxygen, performed dynamic electrocardiograph monitoring, and helped the doctor complete the related examination. After some related results returned, the doctor treated him by controlling his blood pressure and applied antiasthmatic drugs, anticoagulation therapy, and other symptomatic treatment. The patient had to be hospitalized for observation. During the 3-day observation period, his arteries were punctured three times for blood gas analysis because of his illness. Sampling time and sites were in the right brachial artery at 12:00 on August 9, in the right radial artery at 23:00 on August 10, and in the right femoral artery at 09:00 on August 11. Arterial blood samples were collected successfully. Before the femoral arterial blood sample was collected, one nurse collected venous blood from the lower one-third dorsal side of his right forearm, which was not successful. At 04:00 on August 12, the patient complained of pain in his right forearm. Immediately, a nurse notified the doctor on duty. Physical examination showed that there was a red oncotic area about 5–10 cm on his forearm. The skin temperature of the injured area was lower than the normal temperature. His radial artery pulsed normally. The doctor considered that it may be puncture-site hematoma, and that using 20% magnesium sulfate wet dressing was applied on his forearm, which was thought might relieve the pain and swelling. At 05:50, the patient complained that he felt more pain, and the oncotic area enlarged to about 7–12 cm. His radial artery pulsed weakly. The doctor checked his blood vessels of the right forearm using the color Doppler ultrasound. However, some inspection facilities were found unavailable in our hospital, especially at nighttime, so the doctor comforted the patient by injecting Bucinnazine. Dosage of the drug is 100 mg. At 08:10, the doctor checked his blood vessels of the right forearm using the color Doppler ultrasound. The results showed that there was a diffuse hematoma in the right side of the forearm and an open wound on the vessel. His doctor advised to hemostasis by pressing the puncture site. Because his pain and the oncotic area continued to increase, a large consultation of doctors was organized at 11:00 on that day. He was diagnosed with osteofascial compartment syndrome, and then his forearm was operated on. (One circular laceration about 1 mm was found during the operation on his radial artery near the wrist dorsa.) During the postoperative period, he was taken to the intensive care unit.

2.1.3. Reasons

We considered that the direct reason for the patient's osteofascial compartment syndrome was due to the damage of the patient's dorsal radial artery from an arterial puncture by the nurse. In addition, there are other reasons to precipitate the occurrence and development of the accident. To clarify its essential reason and related factors for the occurrence of this special case, we hoped to find answers to alert nurses to operate according to standards and improve the management process using a scientific analysis method.

2.2. Research method

We had studied the process of osteofascial compartment syndrome using a root cause analysis (RCA). A RCA is a retrospective analysis tool of an adverse event and a structured method to solve the problem. We can understand the process and causes of adverse nursing events with the help of an RCA. At the same time, we can find the root problem and solve it gradually. It is helpful to review and improve the management process.[2] RCA is a process to find out the potential or causal reason of an executive deviation.[3] This method focuses on aspects of the whole system and process improvement not just on an individual behavior review.[4] By analyzing the details of the process of the adverse events, we can understand the root causes of the incident through an executable program of the RCA. Then, we can take preventive measures to reduce the incidence of similar adverse events.[5]

2.3. Research process

One patient was diagnosed with osteofascial compartment syndrome due to a radial arterial puncture, which led to a surgical operation and a prolonged hospital stay. It brought severe injury to the patient, consistent with the standard of an RCA event. According to the RCA execution program,[6] the first step is to define the problem (Table 1).

The second step in RCA execution program is to find possible causes. We can analyze the possible causes and the related factors leading to the adverse events by “fish bone” tools (Fig. 1).

According to the RCA execution program, the third step is finding the primary cause by the following diagram (Fig. 2).

The fourth step is to make the improving measures and the control form (Table 2).

3. Results

The event was analyzed seriously. When collecting arterial blood the second time, the depth of the depth of the puncture needle was too deep to damage the blood vessel on the other side in the right radial artery. At the same time, because the nurse could not assess his condition seriously, and his family did not pressure the punctured site in the right methods and time, the injured blood vessel was bleeding for a long time. After that, the nurse did not assess the puncture point, and collecting venous blood in the ipsilateral forearm using a tourniquet was unsuccessful. This behavior aggravated the damage to the blood vessel and hemorrhage. When the patient complained that his right forearm hurt, his family rubbed the punctured area and aggravated the bleeding. After informing his doctor, his problem was not resolved in a timely manner, resulting in osteofascial compartment syndrome in his right forearm. The fundamental reasons for this adverse event are that the operative technique was not standard, and the assessment was not accurate. However, there are many factors to promote the occurrence and development of this event. Therefore, a strategy of a system defense needs to be developed.

4. Discussion

4.1. Occurrence of nursing errors are caused by a series of errors

James Reason, professor of psychology at University of Manchester emphasizes systematic concept of adverse events as a “Swiss cheese model”.[6] Each level of a defense system for defects or vulnerabilities is not able to intercept each other, resulting in the occurrence of “the final cumulative effect” and medical disputes.[7] This case illustrates this view. Reason[6] believed that, if a multi-