Pneumothorax after minimally invasive plate osteosynthesis for midshaft clavicle fracture
A case report
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Abstract
Rationale: Isolated fracture of clavicle is usually treated with nonoperative conservative treatment. However, surgical treatment, customized for individual patient’s need, is increasingly done. With regard to the surgery of the clavicle fracture, pneumothorax is a possible, but rare complication.

Patient concerns: We report the case of a 32-year-old healthy female patient who underwent minimally invasive plate osteosynthesis (MIPO) due to a clavicle fracture. To avoid direct exposure of fracture site, the pre-contoured plate was inserted through the lateral incisional port to reach the medial incisional port. There was no problem during the surgery, but the patient complained of dyspnea in the post-anesthesia care unit.

Diagnoses: A chest radiograph was taken immediately, and a definitive finding of pneumothorax was revealed.

Interventions: A tube was inserted at the right chest.

Outcomes: The patient’s dyspnea was resolved. On the 6th day after the surgery, the chest radiograph revealed that pneumothorax was nearly resolved, enabling to remove the chest tube. On the 9th day after the surgery, the patient was discharged without complication.

Lessons: After clavicle surgery requiring strong dissection like MIPO, the possibility of pneumothorax is suspected and the patient should be carefully observed.

Abbreviations: BP = blood pressure, HR = heart rate, IV = intravenous, MIPO = minimally invasive plate osteosynthesis, ORIF = open reduction and internal fixation, PACU = post-anesthesia care unit, PIP = peak inspiratory pressure, SpO2 = peripheral oxygen saturation.

Keywords: clavicle fracture, complication, minimally invasive plate osteosynthesis, pneumothorax

1. Introduction
Isolated fracture of the clavicle is frequently encountered in daily practice, and is traditionally regarded as a prime candidate for nonoperative, conservative treatment. Recently, however, a much higher incidence of non-union has been observed with conservative treatment, particularly in a subgroup of patients who sustained a fracture with displacement.[1] Therefore, surgical treatment customized for an individual patient’s needs is increasing. Pneumothorax is a possible but rare complication of clavicle fracture, and has been reported in patients with direct trauma and comminuted fracture.[2] Generally, symptomatic pneumothorax rarely occurs after shoulder surgery. Herein, we report a case of postoperative pneumothorax in a patient undergoing open reduction and internal fixation for clavicle fracture, and provide a review of the literature.

2. Case presentation
The written informed consent for patient information and images to be published was provided by the patient. A 32-year-old female patient (height 160 cm, weight 51 kg) was admitted via emergency room with right clavicle shaft fracture. The patient had an evaluation period of 4 days after admission without cardiopulmonary complications. The patient was applied shoulder sling and the pain was well controlled with tramadol and ice pack. After 4 days, scheduled open reduction and internal fixation (ORIF) of a right clavicle shaft fracture was performed. The patient had no relevant history of medical or surgical illness, and preoperative evaluation revealed no specific abnormalities of lung images on the ipsilateral shoulder computed tomography (CT) and chest x-ray (Figs. 1 and 2). Vital signs measured before induction of anesthesia were as follows: heart rate (HR) of 60/min, blood pressure (BP) of 110/63 mmHg, and peripheral oxygen saturation...
(SpO$_2$) of 100% in room air. Anesthesia was induced intravenously with 10 mg of etomidate, and 40 mg of rocuronium was administered intravenously after confirmation of unconsciousness. Endotracheal intubation was performed smoothly, and the position of the endotracheal tube was confirmed as appropriate with bilateral auscultation of breath sounds. Anesthesia was maintained with 6.0 vol% desflurane in an oxygen-nitrous oxide mixture at 4 L/min (FiO$_2$ 0.5). The surgery was performed in a sitting position, and stable vital signs were also maintained during surgery. The minimally invasive plate osteosynthesis (MIPO) surgical method was adopted. Before the incision, the plate was placed on the fracture site and checked with a C-arm fluoroscope to determine the approximate plate size. To avoid direct exposure of the fracture site, a pre-contoured plate was inserted through the lateral incisional port to reach the medial incisional port. There was a strong dissection process to enter the plate along the clavicle because it is difficult to flatten the lumen of the clavicle as it was before fracture. After precise alignment between the plate and the clavicle was identified in the anteroposterior view using C-arm fluoroscope, and the depth was measured with depth gauze to fix the screw of the corresponding size. Then, 2.8-mm drill bits were inserted through a drill sleeve into the proximal and distal holes. After removing the drill bits, 3.5-mm lock screws were inserted continuously into the lateral holes while checking the depth with a C-arm fluoroscope. Cortical screws were inserted into the inner 3rd hole of the plate in the same manner as fixing the lateral clavicle. At the end of surgery, 100 mg of sugammadex was administered intravenously to reverse muscle relaxation, and extubation was performed after confirmation of spontaneous respiration with a peak inspiratory pressure (PIP) of 20 cmH$_2$O, SpO$_2$ of 100%, and full awakening with obedience to verbal commands. After extubation, SpO$_2$ of 100% and BP of 110/80 mmHg were maintained with spontaneous respiration with oxygen supply via a face mask. The patient was then transferred to the post-anesthesia care unit (PACU) for observation. However, in the PACU, the patient complained of dyspnea and presented with reduced SpO$_2$ of 93% to 94%, reduced BP of 86/49 mmHg, and elevated HR of 118/min. A chest radiograph taken in the PACU revealed a definitive finding of pneumothorax over the right lung field (Fig. 3). A chest tube thoracostomy was performed immediately in the PACU, and the patient was then transferred to the general ward after confirmation of the recovery of SpO$_2$ to 100% and the disappearance of dyspnea. On the 6th day after the thoracostomy, chest radiography revealed that pneumothorax was almost completely resolved (Fig. 4), enabling the removal of the chest tube. On the 9th day after the surgery, the patient was discharged without complications.

3. Discussion

Pneumothorax is an entrapment of air in the pleural space, which separates the affected lung and the chest wall. It compresses the ipsilateral lung and causes symptoms and signs that range from

![Figure 1. Preoperative lung images on the ipsilateral shoulder computed tomography with no findings of pneumothorax.](image1)

![Figure 2. Chest radiography performed preoperatively revealed right clavicle shaft fracture with isolated segmental displacement and no findings compatible with pneumothorax.](image2)

![Figure 3. Chest radiography performed in the post-anesthesia care unit revealed a definitive finding of pneumothorax over the right lung field.](image3)
asymptomatic or mild dyspnea to circulatory collapse, depending on the amount of entrapped air. Symptoms or signs of pneumothorax are not properly observed during general anesthesia. Therefore, suspicion along with close observation in patients or surgery with a high risk for developing pneumothorax is essential to prevent the unnoticed development of pneumothorax and unexplained adverse events during general anesthesia for surgery.

A large study revealed that pneumothorax accounts for 1.2\% of complications after ORIF for clavicle fractures, but it remains unclear whether pneumothorax is due to injury or surgery.\(^2\) In our patient, preoperative chest radiography and lung image on shoulder CT revealed no major findings. Chest CT is useful for accurate diagnosis, considering the amount of pneumothorax in the postoperative chest radiograph, but it was unlikely that such extensive air leaking could have resulted from rupturing of tiny bullae or blebs that had not been found preoperatively. The other possible mechanism explaining the development of pneumothorax is intraoperative injury to the pleural structures.

Pneumothorax found after induction of anesthesia is scarcely reported. Furthermore, it is mostly related to shoulder arthroscopy, rupturing of undiagnosed blebs or bullae,\(^4\) or injury with a negative pressure shaving device,\(^5\) or has an unclear etiology.\(^6\) By contrast, a review of the literature revealed only a single case of postoperative pneumothorax related to ORIF for a comminuted clavicle fracture of clavicle, as reported by Skedros et al.\(^7\) Their patient had a medial 1/3 fracture nonunion and an acute lateral 1/3 fracture of the clavicle. They primarily attributed this to an injury to the pleura over the lung apex during the dissection of the nonunion portion of the medial 1/3 of the clavicle (i.e., the portion that exhibited nonunion where the bone fragments were angulated toward the lung apex). However, in our case, the patient had a fracture in the middle of the clavicle, and the fractured bone was located outside the thoracic cavity. Therefore, it was assumed that the cause of pneumothorax differed from that of the previous case.

The MIPO technique which avoids direct exposure of the fracture site requires the insertion of a pre-contoured plate through the lateral incisional port to reach the medial incisional port. This minimally invasive technique has the advantage of cutting the fracture site to protect the surrounding soft tissue, minimizing nerve damage and vessel injury.\(^8\) Recent studies have provided clinical and imaging evidence that the MIPO technique is effective for bony union and self-healing of fracture sites.\(^9,10\) During this process, however, a strong dissection is required for the advancement of the plate. Because the apex of the lung lies behind and above the medial 1/3 of the clavicle anatomically, injury to the adjacent pleural structures can occur. In the present case, an incision was made in the lateral part of the clavicle. During the operation, there was a strong dissection process to enter the plate along the clavicle due to the difficulty of clavicle reduction, which may have caused damage to the adjacent pleural structures. The use of a pre-contoured plate may help to restore the clavicle to its original shape after surgery, but it is difficult to advance along the clavicle if reduction is not achieved during surgery.

Pneumothorax caused by surgery may be exacerbated by several factors. First, an oxygen–nitrous oxide mixture is used to maintain anesthesia, but vascular transport of inhaled nitrous oxide can cause a rapid increase in the size of a preexisting pneumothorax. A small pneumothorax caused by surgery could increase considerably in size with the use of nitrous oxide during anesthesia, and is thus likely to eventually result in dyspnea. Second, a surge in PIP could aggravate small air leaking through a pleural injury occurring during recovery from anesthesia. Furthermore, the intrathoracic negative pressure generated by a patient’s awakening could exacerbate the pneumothorax.

In conclusion, pneumothorax is uncommon in surgery for clavicle fracture but can cause hemodynamic instability when it develops. Therefore, pneumothorax should be considered after surgery requiring strong dissection such as MIPO, even in patients without a noteworthy past history. Furthermore, sufficient diagnosis and treatment could prevent potentially fatal adverse events.

**Author contributions**

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