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CASE REPORT

Delayed massive hemothorax due to a diaphragmatic laceration caused by lower rib fractures

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Abstract
A delayed hemothorax requiring surgical treatment is considered a rare minor thoracic injury. We experienced four cases of delayed massive hemothorax due to a diaphragmatic laceration caused by lower rib fractures. A computed tomography scan on admission revealed multiple rib fractures in all patients, and at least one fractured lower rib was severely displaced, which injured the diaphragm. The duration between the injury and the diagnosis were 14 h–30 days. Emergency surgical treatment was performed, and intraoperative findings revealed a diaphragmatic laceration with oozing due to injury caused by the edge of a fractured rib. After the operation, all patients were successfully discharged.

Keywords Delayed hemothorax · Diaphragmatic laceration · Rib fractures

Introduction

A traumatic massive hemothorax is potentially life-threatening. The cause of a massive hemothorax includes tearing of the intercostal or internal thoracic vessels, rupture of intrathoracic great vessels, or injury to the lung parenchyma. A drainage tube is initially placed in the thorax, and surgical treatment for hemostasis is subsequently performed at the acute stage in most cases. Therefore, a delayed hemothorax requiring surgical treatment is considered rare.

We experienced four cases of a delayed massive hemothorax due to diaphragmatic laceration caused by lower rib fractures between December 2016 and June 2018. Herein, we report on these cases and review the relevant literature.

Case report

Table 1 shows the patients' characteristics and perioperative results. Cause of trauma was fall in any patient. Except for a patient who revealed massive hemothorax 14 h after the trauma, the other three patients were followed in outpatient clinic after the initial consultations because initial computed tomography (CT) did not reveal any pleural effusion. Afterwards, they consulted to our hospital because of respiratory symptoms including chest pain and dyspnea. No patients had received anti-coagulant therapy and wore rib belt after the initial consultations.

A CT scan on admission revealed multiple rib fractures without other severe traumatic injuries in other parts of their bodies in all patients, and one patient (case 2) showed extravasation of contrast agent between the edge of a fractured rib and the diaphragmatic dome (Fig. 1). At least one fractured lower rib was severely displaced in all patients, which injured the diaphragm. Two of the patients received chest tube drainage, and revealed more than 1000 g bloody discharge. A lower rib was defined as lower than the sixth rib based on previous studies [1–5]. Based on Chang's report, delayed hemothorax was defined as one without significant pleural effusion on the initial radiograph or CT [5]. Additionally, massive hemothorax was defined as more than 1000 ml drainage and hematoma.

Emergency surgical treatments were performed after the diagnosis, and intraoperative findings revealed a diaphragmatic laceration with oozing due to injury caused by the edge of fractured rib in all patients (Fig. 2). Subsequently, evacuation of hematoma, suture of injured region in diaphragm, and reconstruction of fractured ribs were performed. Mean total blood loss involving chest tube drainage and intraoperative hematoma was 1353 ± 242 (1000–1666) g. However, no

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Table 1 The patients' characteristics and perioperative results are shown in this table

Case	Sex	Age	Extent of multiple rib fractures	Extravasation of contrast agent on CT	Duration between injury and diagnosis	Initial discharge on drainage	Approach	Postoperative hospital stay
1	F	44	rt. 9th–12nd	–	22 d	Not performed	VATS	3 d
2	F	55	lt. 9th–11st	+	30 d	Not performed	Open	4 d
3	F	85	lt. 9th–11st	Not examined	15 d	1000 ml	Open	6 d
4	M	57	rt. 5th–12nd	–	14 h	1000 ml	Open	28 d

F Female, *M* male, *d* days, *hr* hours, *VATS* video-assisted thoracic surgery

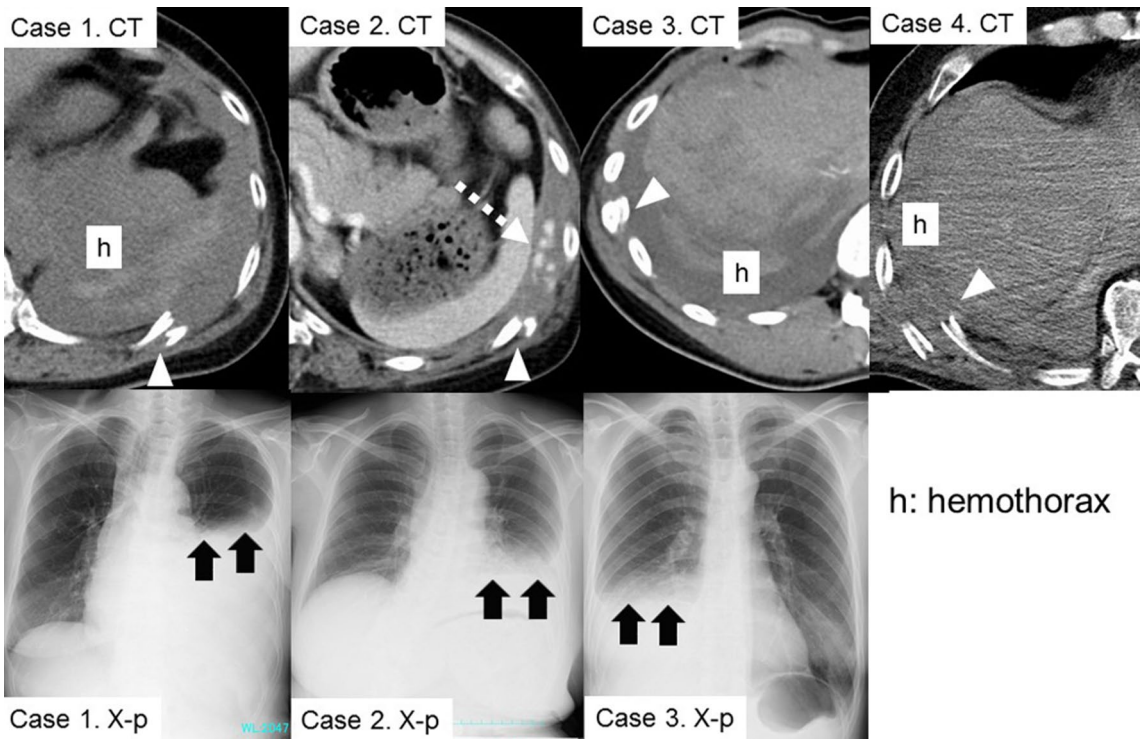

Fig. 1 CT and X-p findings on admission revealed massive hemothorax in three cases (case 1–3). CT findings 14 h after the injury in a case (case 4) also revealed hemothorax. An arrowhead in any case revealed a severely displaced fractured rib. In addition, a dotted arrow in case 2 showed extravasation of contrast agent. Arrows in X-p findings indicated accumulation of fluid in the thorax. Case 4 did not have X-p finding at the time when massive hemothorax occurred because the patient was emergently transferred to our operation room without X-p examination

patients received transfusion. One patient in shock remained hospitalized for 28 days preoperatively, while the remaining three patients were discharged successfully within 6 days.

Discussion

A delayed hemothorax is a rare situation, and Emond et al. reported that 12.3% of patients with a minor thoracic injury revealed a delayed hemothorax within 14 days from the trauma [1]. The duration from injury to diagnosis of a delayed hemothorax has not been clearly defined; the period varied from 3 to 4 h to more than 1 month in a previous report [2]. Most cases are diagnosed within 4 days and subsequently treated.

Most cases with diaphragmatic injuries requiring surgical treatment have intrathoracic herniation of abdominal organs. Therefore, the preoperative radiographic findings, particularly a coronal section CT scan, can easily confirm the diagnosis. In contrast, it is difficult to confirm a diagnosis of a superficial diaphragmatic laceration on preoperative radiographic findings, as in our case. Although our case revealed extravasation between the edge of a fractured rib and the diaphragmatic dome, it was unclear whether the bleeding originated from injury to the intercostal vessels or a diaphragmatic laceration. A few English studies

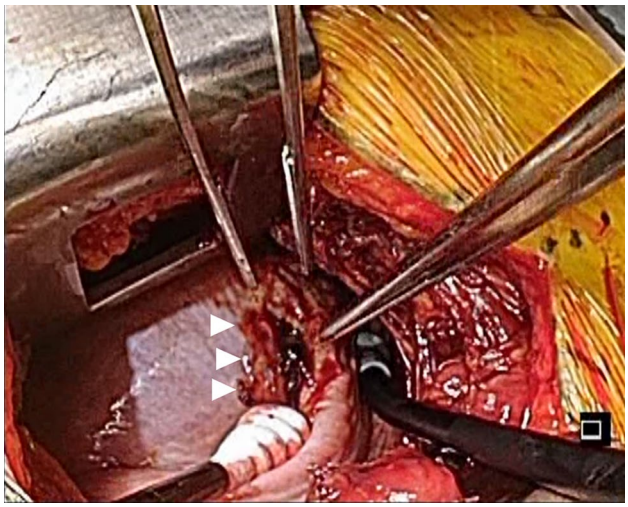

Fig. 2 Intraoperative findings in case 2 revealed a diaphragmatic laceration (arrowheads) due to injury caused by the edge of a fractured rib. The lacerations oozed

have described a delayed massive hemothorax due to a diaphragmatic laceration caused by rib fractures [4, 5]. In these reports, all cases suffered from lower rib fractures, and at least one of the rib fractures demonstrated severe displacement. Our cases also had lower rib fractures and severe displacement. We speculate that the trigger of diaphragmatic injury is excessive diaphragm movements related to a cough or a hiccup as well as Chang and colleagues [5]. After the trigger happened, intrathoracic bleeding lasted and finally caused massive hemothorax although the duration between injury and diagnosis depended on the degree of the bleeding. Therefore, we should keep the possibility of a delayed massive hemothorax in mind for patients with severely displaced lower rib fractures.

Unfortunately, it might be difficult to determine accurately the occurrence rate of delayed hemothorax due to a diaphragmatic laceration caused by rib fractures because not all patients with a fractured rib and a sharp edge were enrolled in a previous study [5]. Therefore, Chang et al. insisted that we should inform any patients with lower rib fractures of the need for closer observation on admission, although the fractured ribs in all patients do not need to be reconstructed surgically.

The approach including thoracotomy or thoracoscopy should depend on the cardiopulmonary status of the patient as described previously, although one patient with unstable cardiopulmonary status underwent a thoracoscopic approach because of the surgeon's preference in this study. The thoracoscopic approach has the advantage of less invasiveness; however, a speedy procedure is required to achieve hemostasis in some cases. Therefore, it might be safer to select the thoracotomy approach in a patient with unstable cardiopulmonary status.

Conclusion

We experienced four cases of a delayed massive hemothorax due to diaphragmatic laceration caused by lower rib fractures, had successful results by surgical treatment in all cases. Although a delayed massive hemothorax due to diaphragmatic laceration is a rare disease, we should keep it in mind when we encounter the patients with severely displaced lower rib fractures.

Compliance with ethical standards

Conflict of interest Hitoshi Igai has no conflict of interest. Mitsuhiro Kamiyoshihara has no conflict of interest. Ryohei Yoshikawa has no conflict of interest. Fumi Ohsawa has no conflict of interest. Tomohiro Yazawa has no conflict of interest.

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