An approach from the neck to drain expanding pneumomediastinum: a case report

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Background: Several methods for draining pneumomediastinum have been advocated, but no consensus has been established. We propose a novel method for draining air from pneumomediastinum.

Case Description: We used an approach from the neck to drain pneumomediastinum that had started to compress the heart in a 33-year-old man with coronavirus disease 2019 (COVID-19) on mechanical ventilation. Computed tomography showed extension of pneumomediastinum to the lateral and dorsal aspects of the right sternocleidomastoid muscle, presenting as subcutaneous emphysema at the neck. We made a 4-cm incision lateral to the right sternocleidomastoid muscle. After incising the platysma muscle, the dorsal side of the sternocleidomastoid muscle was easily stripped off due to the presence of air, allowing placement of a 14-Fr Nelaton catheter. Subcutaneous emphysema as well as pneumopericardium on X-rays improved and disappeared by 3 days after starting drainage. Positive end-expiratory pressure (PEEP) was titrated in a stepwise manner from 6 to 10 cmH_2O, with no re-appearance of subcutaneous emphysema. The Nelaton catheter at the neck was removed and the skin was sutured using 3-0 Nylon monofilament.

Conclusions: We propose this approach from the neck to release air and prevent deterioration of pneumomediastinum communicating with subcutaneous emphysema at the neck.

Keywords: Case report; drainage; mediastinal emphysema; pneumomediastinum; subcutaneous emphysema

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Introduction

The novel coronavirus has afflicted countless people worldwide in the form of coronavirus disease 2019 (COVID-19). Pneumothorax and emphysema are common complications of COVID-19 (1-3). Pneumomediastinum has also been reported in an increasing number of cases, but remains a relatively rare complication (1-3).

Idiopathic pneumomediastinum can often be managed conservatively, but can also progress to tension pneumomediastinum, which is a life-threatening condition with hypotension that necessitates drainage. Several methods to release the mediastinum have been advocated (4,5), but no consensus has been established.

We advocate a new method to drain pneumomediastinum from a neck incision, which we successfully applied to drain pneumomediastinum in a mechanically ventilated patient with COVID-19. We present the following article in

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accordance with the CARE reporting checklist (available at https://atm.amegroups.com/article/view/10.21037/atm-22-5054/rc).

Case presentation

A 33-year-old man who was obese (body mass index, 28.1 kg/m^2) and had untreated type 2 diabetes mellitus was referred to us due to deteriorating oxygenation associated with COVID-19. He had a 13-year history of smoking five cigarettes a day.

The patient visited the referring physician due to acute malaise and high fever 7 days prior, at which time he had been diagnosed with COVID-19 based on the nasopharyngeal swab polymerase chain reaction test. Computed tomography of the lungs showed multiple ground-glass opacities involving both lungs. He was admitted to the referring hospital and started on oral dexamethasone at 6 mg/day. He did not require supplemental oxygen on admission, but his respiratory condition gradually deteriorated. Oxygen saturation finally reached 90% even on supplemental oxygen at 10 L/min via reservoir mask, so he was referred to our hospital for intensive treatment on hospital day 8.

On admission to our hospital, vital signs were: respiratory rate, 34 breaths/min; oxygen saturation, 91% on supplemental oxygen at 15 L/min via reservoir mask; heart rate, 108 beats/min; blood pressure, 147/77 mmHg; Glasgow coma scale score, 15; and temperature, 36.9 ℃. On physical examination, subcutaneous emphysema was identified lateral to the right sternocleidomastoid muscle, but not in the right axilla or lateral thoracic region.

Arterial blood gas showed hypocapnia and hypoxia (pH, 7.47; PaO_2, 65 mmHg; $PaCO_2$, 33 mmHg; HCO_3^-, 23.9 mmol/L). Blood examinations showed increased levels of inflammatory markers (white blood cell count, 11,600 cells/μL with 93.8% neutrophils; C-reactive protein, 0.65 mg/dL) and of lactase dehydrogenase (770 U/L) with hemoglobin A1c at 6.5%. Chest X-ray showed opacities in the lower zones of both lungs, pneumomediastinum, and pneumopericardium. Computed tomography, in comparison with images obtained in the referring hospital, revealed expansion of ground-glass opacities in the middle and inferior regions of the right lung and inferior regions of the left lung, new pneumomediastinum around the trachea, esophagus, and heart, and emphysema extending to the dorsal aspect of the right sternocleidomastoid muscle (*Figure 1*). The patient was admitted to our intensive care unit and administered intravenous dexamethasone at 6.6 mg/day, remdesivir (200 mg on the first day followed by 100 mg/day), subcutaneous low-molecular-weight heparin at 10,000 units/day, and oral baricitinib at 4 mg/day.

Supplemental oxygen at 60 L/min via high-flow nasal cannula was initially instituted to avoid deterioration of pneumomediastinum. However, oxygen saturation was below 90% with 90% oxygen and the patient was therefore intubated. After intubation, we maintained positive end-expiratory pressure (PEEP) at 6 cmH_2O in consideration of pneumomediastinum and subcutaneous emphysema. The initial PaO_2/FiO_2 ratio was 210. However, at 22 h after intubation, subcutaneous emphysema was found to be spreading toward the jaw and anterior chest. Chest X-ray showed deterioration of pneumopericardium (*Figure 2*). Circulatory status at that time was: heart rate, 76 beats/min; and blood pressure, 124/70 mmHg. Cardiac ultrasonography showed that the diameter of the inferior vena cava was 24 mm without respiratory changes and the wall of the right atrium and ventricle were collapsed and compressed toward the atrial and ventricular septa, respectively. The decision was made to drain the pneumopericardium out of concerns of cardiac tamponade.

We considered that drainage of air from the pneumopericardium would be easily achieved if we attempted an approach from the subcutaneous emphysema on the right side of the neck, which communicated with the pneumomediastinum and eventually pneumopericardium. We made a 4-cm incision at the lateral border of the right

Highlight box

Key findings

- We successfully drained air from subcutaneous emphysema at the neck and prevented expansion of pneumomediastinum in a patient with COVID-19.

What is known and what is new?

- Several methods to drain air from pneumomediastinum have been advocated, but no consensus has been established.
- We propose another method to drain air from pneumomediastinum. We make an incision lateral to the right sternocleidomastoid muscle. After incising the platysma muscle, the dorsal side of the sternocleidomastoid muscle is easily stripped off due to the presence of air, allowing placement of a Nelaton catheter.

What is the implication, and what should change now?

- We propose this approach from the neck to release air and prevent deterioration of pneumomediastinum communicating with subcutaneous emphysema at the neck.

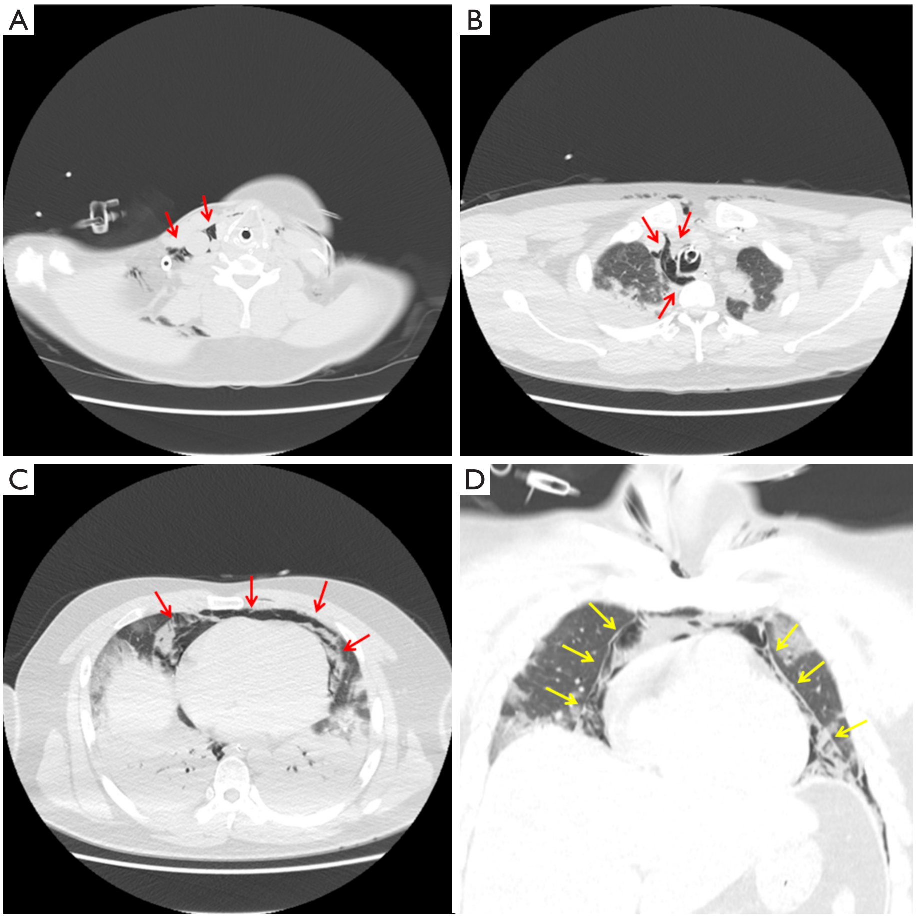

Figure 1 Computed tomography on admission shows subcutaneous emphysema (arrows) around the muscles at the neck (A), pneumomediastinum (arrows) (B), and pneumopericardium (arrows) on a sagittal view (C) and on a coronal view (D).

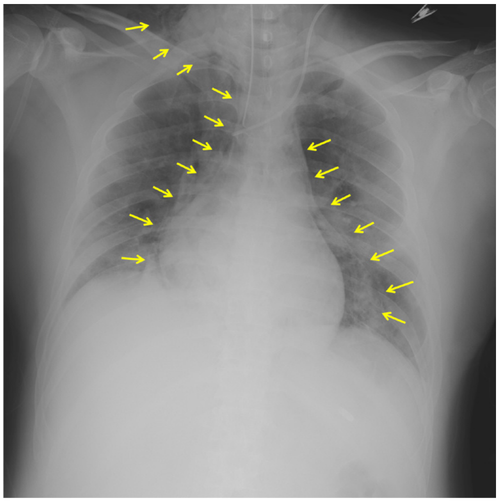

Figure 2 Chest X-ray shows subcutaneous emphysema (arrows) at the neck, pneumomediastinum, and pneumopericardium.

sternocleidomastoid muscle (*Figure 3A*). No sounds of deaeration were audible during drainage. After incising the platysma, we identified the sternocleidomastoid muscle. We were able to easily strip off the dorsal side of the sternocleidomastoid muscle down to 5 cm in depth due to the presence of air (*Figure 3B*), where we placed a 14-Fr Nelaton catheter (*Figure 3C,3D*). We left the Nelaton catheter unlocked and open, because the pressure inside mediastinum should be higher than atmospheric air pressure and we anticipated that air from pneumomediastinum would be drained simultaneously. No immediate changes in circulatory or respiratory status were seen after placement of the catheter. Subsequently, subcutaneous emphysema and pneumopericardium on X-rays improved and disappeared by 3 days after starting drainage (*Figure 4*). Repeat cardiac ultrasonography showed improvements in the collapse and compression of the right atrium and ventricle. We

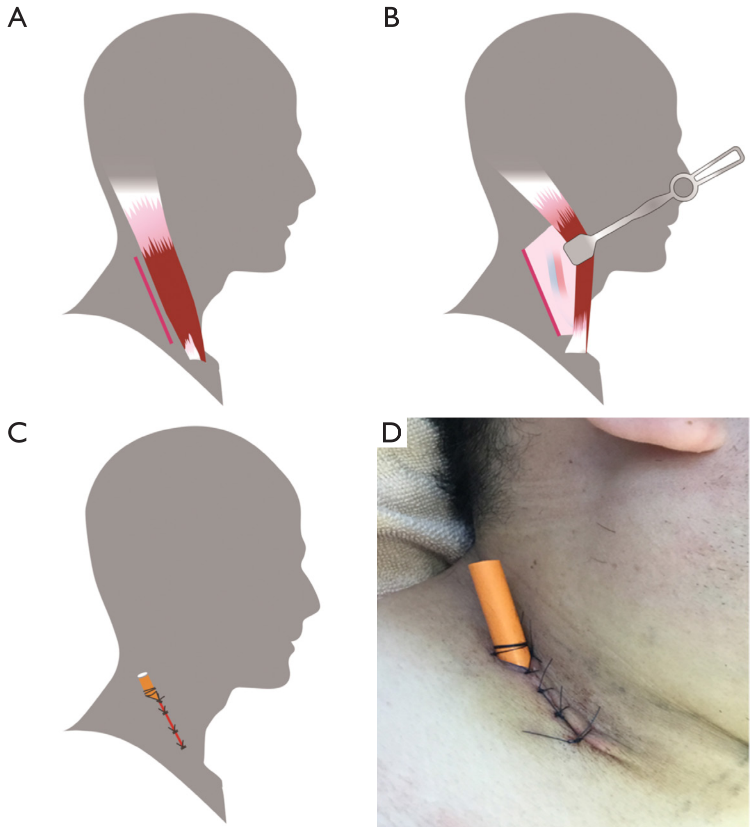

Figure 3 Surgical process of our method. (A) We made an incision at the lateral border of the right sternocleidomastoid muscle. (B) The dorsal side of the sternocleidomastoid muscle was stripped off while avoiding the carotid artery and internal jugular vein. (C) A 14-Fr Nelaton catheter was placed at the dorsal aspect of the sternocleidomastoid muscle. (D) The surgical site at the neck with placement of a 14-Fr Nelaton catheter.

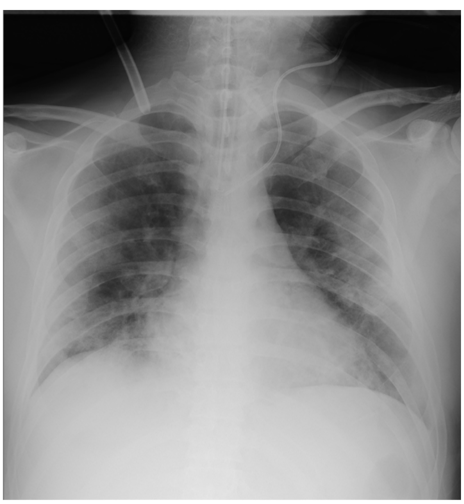

Figure 4 Chest X-ray shows resolution of subcutaneous emphysema at the neck, pneumomediastinum, and pneumopericardium after drainage of pneumomediastinum.

performed stepwise titration of PEEP from 6 to 10 cmH_2O as the oxygenation status of the patient improved, with no re-appearance of subcutaneous emphysema. The Nelaton catheter at the neck was then removed and the skin was sutured with 3-0 Nylon monofilament. The patient was weaned off and liberated from mechanical ventilation on day 5 after starting drainage (7 days after intubation and 14 days from symptom onset). Since the patient showed weakness of the lower extremities, he continued rehabilitation and was discharged 28 days after symptom onset.

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Helsinki Declaration (as revised in 2013). Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the

Table 1 Complications and level of difficulty in wound closure by type of procedure to drain pneumomediastinum

Methods	Complications	Wound closure
Chamberlain procedure	Bleeding	Difficult
	Infection	
	Pneumothorax	
	Recurrent/vagus nerve paralysis	
	Thoracic duct injury	
Pericardial window technique	Bleeding	Difficult
	Infection	
	Iatrogenic cardiac injury	
	Pericardial decompression syndrome	
Our method	Bleeding	Easy
	Infection	
	Iatrogenic internal jugular vein/common carotid artery injury	

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Discussion

The incidence of pneumomediastinum in adults is reportedly 0.001–0.01% (6), with a recurrence rate of 1.2% (7). With the prevailing conditions of the COVID-19 pandemic, pneumomediastinum has become known as a complication, with a reported incidence of 2.3% (1). The incidence of pneumomediastinum or subcutaneous emphysema in patients with acute respiratory distress syndrome (ARDS) due to COVID-19 is even higher, at 13.6% (3). The incidence of barotrauma among patients with moderate to severe ARDS due to COVID-19 has been reported as 7.2% (2). COVID-19 patients are thus at increased risk of pneumomediastinum. In general, however, conservative management of pneumomediastinum is considered possible, irrespective of the association with COVID-19.

To prevent further extension or deterioration of pneumomediastinum, PEEP and plateau pressure should be as low as possible in mechanically ventilated patients with pneumomediastinum. In contrast, maintaining high PEEP is recommended in mechanically ventilated patients with COVID-19 (8). The treatment of COVID-19 with pneumomediastinum thus poses a dilemma. In our patient, we handled this dilemma by keeping PEEP low while maintaining a high fraction of inspiratory oxygen.

Despite efforts to prevent deterioration of pneumomediastinum, some patients may develop hypotension or shock due to the extension of pneumomediastinum. If air is trapped and intra-mediastinal pressure increases, compression of the heart and vessels will lead to decreased venous return and cardiovascular compromise (obstructive shock), representing tension pneumomediastinum. Air needs to be emergently drained in cases of tension pneumomediastinum. Complications of drainage frequently include bleeding and infection. Attention to such complications is crucial in patients with COVID-19 and pneumomediastinum, since anticoagulants and corticosteroids are generally used as treatments for COVID-19 (8).

Two major surgical procedures are used to release the mediastinum and pericardium: the Chamberlain procedure (5); and the "pericardial window technique" (4). The Chamberlain procedure is a method to biopsy the anterior mediastinum via anterior mediastinotomy. The procedure consists of a left second intercostal incision with removal of cartilage and ligation of internal mammary vessels. At least one report has described the use of the Chamberlain procedure to drain air in a case of tension pneumomediastinum associated with COVID-19 (9). The pericardial window technique releases the pericardial cavity using an incision over the xiphoid process, removing this bone and resecting soft tissue toward the heart and epicardium. This diagnostic and therapeutic procedure for pericardial effusion is generally performed for trauma patients. At least a case report has noted use of the pericardial window technique to drain air in cases of tension pneumomediastinum associated with COVID-19 (10).

Subcutaneous emphysema can extend to the upper body and lead to tension pneumomediastinum, even if tube thoracostomy is performed. If a patient with subcutaneous emphysema and pneumomediastinum is mechanically ventilated, airway pressure should first be reduced. However, in refractory subcutaneous emphysema, blow holes need to be considered (11). This simple and easy method to drain air from subcutaneous emphysema requires only bilateral 3-cm infraclavicular incisions.

If obstructive shock had developed in our patient, we might have chosen the pericardial window technique to immediately release the mediastinum. However, the condition of the patient was not emergent, so we considered a simpler method. Drainage of pneumomediastinum was also considered necessary because we could not predict when we would be able to wean the patient off the ventilator or whether the circulatory status would change due to compression of the heart in the absence of interventions. We decided to drain air from the neck, where subcutaneous emphysema was easily palpable. Like the blow hole method, we considered that drainage of air at the neck might prevent deterioration of or mitigate the pneumomediastinum, since subcutaneous emphysema at the neck communicated with the pneumomediastinum and was easily palpable. During this procedure, attention should be paid to avoid damaging the carotid artery and internal jugular vein while bluntly stripping off the dorsal side of the sternocleidomastoid muscle. In our patient, before the procedure, we anticipated that air should have separated the sternocleidomastoid muscle from the surrounding organs, which would allow an easier procedure compared to the situation with no air. In fact, tissue around the muscle was sparse due to the presence of air and we were able to easily strip off the muscle compared to the normal situation between muscles without air. After performing this procedure, pneumopericardium shrank and finally disappeared. We believe that we could achieve drainage of air from the pneumomediastinum with less-invasive procedures, including only a skin incision and intermuscular abrasion. However, knowledge of the anatomy of the neck and previous surgical experience in the neck by the operators are prerequisite.

Complications specific to the Chamberlain procedure include pneumothorax, paralysis of the recurrent and vagus nerve, and thoracic duct injury (*Table 1*). Those of the pericardial window technique include cardiac injury and pericardial decompression syndrome, which is a type of myocardial ischemia that follows acute, low-cardiac-output heart failure after uncomplicated pericardial drainage. In contrast, our method may be technically considered a modified version of blow holes, because only the incision site differs and the mediastinum per se is not approached. However, in addition to bleeding and surgical site infection, the internal jugular vein and common carotid artery can be damaged. This situation can be avoided by carefully stripping off the fascia of the sternocleidomastoid. Closure of the wounds related to blow holes and our method is easy. However, our method needs further validation of the level of difficulty of the procedure and the potential complications.

Conclusions

We successfully drained air from subcutaneous emphysema at the neck and prevented expansion of pneumomediastinum in a patient with COVID-19. We propose this approach from the neck to release air and prevent deterioration of pneumomediastinum communicating with subcutaneous emphysema at the neck.

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Footnote

Reporting Checklist: The authors have completed the CARE reporting checklist. Available at https://atm.amegroups.com/article/view/10.21037/atm-22-5054/rc

Conflicts of Interest: Both authors have completed the ICMJE uniform disclosure form (available at https://atm.amegroups.com/article/view/10.21037/atm-22-5054/coif). Both authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Helsinki Declaration (as revised in 2013). Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the editorial office of this journal.

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