

Cases of Spontaneous Pneumothorax in Patients with New Coronavirus Disease SARS-CoV-2 COVID-19

Anna Yuriyivna Gorolyuk

Department of Surgery, Hospital N 7, Kriviy Rih, Ukraine

Email address:

a.gorolyuk@i.ua

To cite this article:

Anna Yuriyivna Gorolyuk. Cases of Spontaneous Pneumothorax in Patients with New Coronavirus Disease SARS-CoV-2 COVID-19.

Journal of Surgery. Vol. 10, No. 5, 2022, pp. 175-179. doi: 10.11648/j.js.20221005.16

Received: April 27, 2022; **Accepted:** September 26, 2022; **Published:** October 14, 2022

Abstract: For the third year after the announcement of the COVID-19 pandemic (March 11, 2020), the main focus of research on the manifestations of this new coronavirus disease is pneumonia and acute respiratory distress syndrome. Meanwhile, COVID-19 promotes the development of surgical lung diseases that require immediate surgical intervention. In particular, with COVID-19, the development of "spontaneous" pneumothorax is possible as a direct consequence of lung tissue damage by the SARS-CoV-2 COVID-19 virus. This report presents case histories of four male and female (one individual) patients with so-called "spontaneous" pneumothorax, which appeared to be a direct complication of the novel coronavirus disease, COVID-19. The author of the article also cites the possible causes of this complication in pneumonia (pneumonitis) caused by the SARS-CoV-2 COVID-19 virus, which, unlike pneumonia caused by influenza viruses and other previously known coronaviruses, directly affects the small arteries of the lungs, which leads to a violation nutrition and, as a result, to local necrosis of lung tissue. The localization of lung lesions plays a certain role in the occurrence of pneumothorax with this new coronavirus disease. Thus, this article will try to prove that the occurrence of pneumothorax with COVID-19 is a rare but completely natural complication of the new coronavirus disease SARS-CoV-2 COVID-19.

Keywords: Coronavirus Disease SARS-CoV-2, COVID-19, Pneumothorax, Drainage of the Pleural Cavity, Pneumonia

1. Introduction

Among the clinical manifestations of coronavirus disease COVID-19, caused by the previously unknown beta-coronavirus SARS-CoV-2, it is rare to report the development of "spontaneous" pneumothorax. Thus, looking at available scientific sources of information (English, German, Ukrainian and Russian-language journals and scientific Internet reports), we found only 37 descriptions of cases of pneumothorax as a direct consequence of coronavirus infection SARS-CoV-2. These cases have been described in scientific journals in Ukraine, USA, Turkey, Canada, Italy, the Russian Federation [1-4]. The development of pneumothorax in this category of patients is due to the peculiarities of lung tissue damage in COVID-19. Peculiarities of the pathogenesis of pneumothorax development are the mechanism of lung damage by SARS-CoV-2 COVID-19 virus and localization of damage. In particular, COVID-19 directly affects the

endothelium of capillaries and small arteries of the lungs due to the direct cytopathic action of the virus, leading to hypercoagulation and thrombosis of the lumen of the arteries, while other coronaviruses and influenza A viruses localize microthrombi in the pulmonary veins [5-9]. Thus, in COVID-19 due to thrombosis of small arteries of the lungs suffers primarily from lung nutrition, which leads to local necrosis and, consequently, to a violation of the integrity of lung tissue and the development of pneumothorax. In addition, changes in lung tissue in COVID-19 are diffuse in nature and compared with other pneumonias are distributed peripherally [8], which against the background of peripheral local necrosis of lung tissue also facilitates the development of pneumothorax.

Here are five cases of pneumothorax in patients with COVID-19. Patients (1 woman and 4 men) were admitted and treated for the period from 03.11.21 to 24.01.22. Age category from 54 to 66 years. The average age is 59 years.

2. Cases from Clinical Practice

2.1. Case 1

Patient G., a 57-year-old woman was admitted to the surgical department on 02.11.21 with complaints of chest pain on the right, exacerbated by breathing, shortness of breath. According to the patient, the chest pain appeared ten days ago (after a domestic injury - ten days ago the patient, according to her, fell on the street). Today the pain intensified, shortness of breath appeared, the patient called an ambulance, which was initially taken to the City Clinical Hospital №2, where she was diagnosed with "multiple fractures of the right ribs, right pneumothorax, subcutaneous emphysema." The patient underwent thoracentesis on the right in the seventh intercostal space along the posterior axillary line, installed a drainage system according to Bülow. A rapid test for SARS-CoV-2 antigen COVID-19 was also performed, the result was positive, after which the patient was transported to the surgical department of Kryvyi Rih City Hospital №7, repurposed to receive patients with suspected new coronavirus infection COVID-19. Epidemiological anamnesis: the patient has not been vaccinated against COVID-19, is in contact with relatives with COVID-19.

Status praesens communis: The general condition of the patient is closer to conditionally satisfactory than moderate. The patient is normosthenic, normotrophic. Physiological skin. Temperature 36.7°C. In the lungs, vesicular respiration with a hard tinge, weakened on the right. Respiratory rate 20/min., Saturation 94% (without oxygen subsidy). Pulse 86/min., Blood pressure 120/80 mm Hg. Abdomen not bloated, involved in the act of breathing, soft and painless throughout. Physical departures are not violated.

Status localis: In the area of the right side wall of the chest - subcutaneous ecchymosis 20×15 cm in size, in the projection of which there is a subcutaneous crepitation. Palpation is painful. In the 7th intercostal space on the right along the posterior axillary line of the line there is a tubular polyvinyl chloride drainage with a Bülow aspiration system. Drainage works, air bubbles go away.

General blood test (November 2, 21): hemoglobin 142 g/l, erythrocytes $4.7 \times 10^{12}/l$, color index 0.96,

Leukocytes $9.3 \times 10^9/l$, eosinophils 1%, rod-shaped 4%, segmental 85%, lymphocytes 9%, monocytes 0%, ESR 22 mm/h, platelets $418 \times 10^9/l$.

Cyto-test for antibodies to HIV: antibodies to HIV were not detected.

General analysis of urine (02.11.21): specific gravity 1019, reaction 10.0, leukocytes 4-5 in the field of view, epithelium 2-3 in the field of view, protein 0.03.

Biochemical analysis of blood (02.11.21): total bilirubin 7.86 $\mu\text{mol/l}$, direct 2.42 $\mu\text{mol/l}$, indirect 6.1 $\mu\text{mol/l}$, total protein 65.0 g/l, fibrinogen 4.2; prothrombin index 91%

Radiography of the lungs from 02.11.21: fractures of 6-8 ribs on the right, subcutaneous emphysema, pneumothorax on the right.

On the basis of complaints, anamnesis data and objective

research, it is established.

DIAGNOSIS: "Coronavirus disease SARS-CoV-2 COVID-19. Closed chest injury, multiple fractures of 6-8 ribs on the right. Right pneumothorax".

The patient received treatment: ceftriaxone, azithromycin, flenox, tivortin, probiz, desket, oxygen insufflation through a mask with an oxygen concentrator. However, the patient's condition worsened the next day on November 3, 21: subcutaneous emphysema spread to the face, increased shortness of breath, pain in the right half of the chest. The review radiograph revealed recurrence of pneumothorax on the right. An operation was performed urgently under local anesthesia: auxiliary drainage of the right pleural cavity according to Bülow. After auxiliary drainage, the patient's condition improved: emphysema disappeared, the lung straightened. Review radiography from 11.11.21: no data for pneumothorax. Both drains were removed on 11.11.21. At the time of discharge 13.11.21 the patient's condition is satisfactory, no complaints, temperature 36.6°C, saturation 97%. Breathing in the lungs is vesicular, carried out in all departments, wheezing is not heard.

2.2. Case 2

Patient I., a 58-year-old man was admitted on 03.11.21 with complaints of shortness of breath, dry cough, fever up to 38°C, general weakness. Ill for the fourth day. Contact with a patient with COVID-19, not vaccinated. History of chronic bronchitis.

Status praesens communis: The general condition of the patient is severe. Normosthenic, normotrophic. Skin and visible mucous membranes are clean, pale, moderate acrocyanosis. Temperature 37.8°C. In the lungs, vesicular respiration is weakened in the posterior-lower extremities on both sides, where moist rales of various calibers are heard. Respiratory rate 26/min., Saturation 50%. Heart tones are muffled, rapid, the rhythm is correct. Heart rate 116/min. Abdomen not bloated, symmetrical, soft, painless, no peritoneal symptoms. Physiological departures are not broken.

General blood test (03.11.21): erythrocytes $3.9 \times 10^{12}/l$, hemoglobin 118 g/l, color index 0.9, leukocytes $9.3 \times 10^9/l$, eosinophils 1%, rod 8%, segmental 73%, lymphocytes 16%, monocytes 2%, erythrocyte sedimentation rate 62 mm year, sugar 3.04 mmol/l.

General analysis of urine (03.11.21): color yellow, transparent, specific gravity 1020, reaction 8.0, protein 0.05, epithelium 5-7, leukocytes 10-15, erythrocytes 2-5.

Biochemical analysis of blood (03.11.21) prothrombin index 95%, fibrinogen B negative, ethanol test negative, total bilirubin 12.1 $\mu\text{mol/l}$, direct 3.53 $\mu\text{mol/l}$, indirect 6.8 $\mu\text{mol/l}$, total protein 59.1 g/l, creatinine 61.2, urea 8.82, ALT 13.6, ASAT 69.1, thymol test 6.4.

Review radiograph (01.11.21): left-sided pneumonia.

PCR for the presence of RNA SARS CoV-2 COVID-19 positive 02.11.21.

The patient received treatment: azithromycin, atherocardium, dexamethasone, ceftriaxone, lazolex, tivortin,

xarelta, methylprednisolone, infusolid, noglpaza, probiz, moflox, flenox, oxygen insufflation. Despite treatment, the patient's condition progressively deteriorated, progressive respiratory failure. 17.11.21 performed control radiograph of the chest, conclusion: left hydropneumothorax, subcutaneous emphysema. Urgently under local anesthesia surgery was performed: thoracentesis on the left, drainage of the left pleural cavity according to Bülow. In the postoperative period, the patient's condition improved, saturation 95-97% (periodically with oxygen donation), respiratory rate 22/min., Vesicular respiration, weakened on the left, where you hear wet rales of various calibers. However, the left lung did not fully heal, the drainage in the left pleural cavity continued to function with the release of air and a small amount of purulent contents. After receiving a negative PCR result on 15.12.21 on SARS CoV-2 COVID-19 RNA, the patient was transferred to the thoracic department of the City Clinical Hospital №2 on 16.12.21.

As it became known later, in the thoracic department the patient's condition was progressively deteriorating, respiratory and multiorgan failure was progressing. Despite the ongoing treatment in the intensive care unit, the patient died on the twenty-eighth day after transfer.

2.3. Case 3

Patient B., a 54-year-old man was admitted on 04.11.21 with complaints of general weakness, shortness of breath at rest, which is significantly exacerbated by exercise, fever up to 39.5°C. The patient for the second week, not vaccinated against COVID-19, was treated on an outpatient basis, the condition worsened in the last 2 days after inhalation with a nebulizer, when he felt pain in the right half of the chest. 04.11.21 was hospitalized in the surgical department of one of the city hospitals, where he was diagnosed with Coronavirus disease (PCR on RNA SARA-CoV-2 COVID-19, positive result 03.11.21), Outpatient bilateral pneumonia, spontaneous pneumothorax on the right, Coronary heart disease, Hypertensive disease of the 2nd century. The patient underwent thoracentesis on the right, drainage of the right pleural cavity according to Bülow, after which the patient was immediately transferred to the surgical department of the city hospital №7. On admission, the patient's condition is moderate. Hypertensive, hypertrophic. Excess body weight 2 degrees. In the lungs, vesicular breathing with a hard tinge, weakened in the lower parts, more on the right, wheezing is not convincingly heard. Respiratory rate 22/min., Saturation 88% (without oxygen subsidy). Heart tones are muffled, rhythmic. Pulse 98/min., Blood pressure 160/90 mm Hg. Temperature 37, 4°C. Bülow drainage, installed on the right in 2 intercostal spaces along the mid-clavicular line, is functioning. Palpation of the right half of the chest in the area of the wound around the drainage is moderately painful, there is local subcutaneous emphysema. The bandage is dry.

General blood test (04.11.21): erythrocytes $5.4 \times 10^{12}/l$, hemoglobin 170 g/l, color index 0.94, leukocytes $20.6 \times 10^9/l$,

eosinophils 0%, rod-shaped 9%, segmental 85%, lymphocytes 3%, monocytes 3%, ESR 12, platelets $200 \times 10^9/l$.

General analysis of urine (04.11.21): yellow, cloudy, specific gravity 1023, reaction 10.0, protein not detected, epithelium 2-3 in the field of view, leukocytes 3-5, erythrocytes 0.

Biochemical analysis of blood (04.11.21): prothrombin index 95%, fibrinogen 2.8, total bilirubin 6.9 $\mu\text{mol}/l$, direct 2.3 $\mu\text{mol}/l$, indirect 4.6 $\mu\text{mol}/l$, total protein 85.0, urea nitrogen 3.59, urea 7.69.

Review radiograph of the chest (04.11.21): pneumothorax on the right, bilateral polysegmental pneumonia.

The patient was treated with: flenox, dexamethasone, ceftriaxone, ingamist, tivortin, probiz, nelpase, ambroxol, calcium, furoemide, merobac, gentamicin, metronidazole, oxygen insufflation, dressings were performed. However, the patient progressed subcutaneous emphysema with spread to the entire torso, upper extremities, neck, face, 09.11.21 performed a control chest radiograph: right-sided pneumothorax. On November 9, 21, under local anesthesia, thoracentesis was performed on the right, auxiliary drainage according to Bülow of the right pleural cavity in the sixth intercostal space along the middle axillary line. After the auxiliary drainage, the patient's condition improved. Shortness of breath does not bother, saturation 98-99% without subsidies. The emphysema disappeared. 15.11.21 on the control radiograph it is established: the right lung is completely straightened. 16.11.21 drainage from the right pleural cavity was removed. 17.11.21 patient in satisfactory condition was discharged under the supervision of a family doctor.

2.4. Case 4

Patient O., 66 years old, was admitted to the surgical department on 30.11.21 with complaints of general weakness, shortness of breath, dry cough, pain in the left half of the chest. He has not been vaccinated against COVID-19. According to the patient, today, November 30, 21, around 2 am, he suddenly felt a sharp pain in the left half of his chest, shortness of breath appeared. In the morning he called an ambulance, which was taken to the city hospital at the place of residence, where he was tested by a rapid test for SARS-CoV-2 antigen COVID-19, the result is positive. The review radiograph revealed left-sided pneumothorax. The patient received emergency care: thoracentesis, drainage of the left pleural cavity according to Bülow. Then the patient was transported to the surgical department of the City Hospital №7. Upon admission, the patient's condition is severe. Normosthenic, normotrophic. The skin is pale, acrocyanosis. In the lungs, breathing on the right is vesicular with a hard tinge, the left is not audible. When percussion of the chest on the left -box sound throughout. Respiratory rate 26/min. Saturation 80% without oxygen donation. Heart tones are muffled, rhythmic, frequent. Pulse 100/min. Blood pressure 110/70 mm Hg. On the left in the second intercostal space along the mid-clavicular line there is a drainage with a connected aspiration system according to Bülow, the drainage of air comes only with a strong cough of the patient.

General blood test (30.11.21): erythrocytes $5.2 \times 10^{12}/l$, hemoglobin 158 g/l, color index 0.91, leukocytes $14.2 \times 10^9/l$, eosinophils 5%, rod 6%, segmental 84%, lymphocytes 8%, monocytes 1%, erythrocyte sedimentation rate 5 mm/h., platelets $286 \times 10^9/l$, sugar 6.0 mmol/l.

General analysis of urine (30.11.21): yellow, transparent, specific gravity 1022, reaction 5.0, protein 0.012, epithelium 4-7 in the field of view, leukocytes 2-4 in the field of view, erythrocytes 0.

Biochemical analysis of blood (30.11.21): prothrombin index 106%, fibrinogen 3.5, total bilirubin $13.8 \mu\text{mol/l}$, direct $4.6 \mu\text{mol/l}$, indirect $9.2 \mu\text{mol/l}$, total protein 89.0 g/l, urea nitrogen 1.0, urea 2.14, amylase 27.0.

Chest radiography (30.11.21): left-sided pneumothorax.

Urgently, the patient underwent surgery under local anesthesia: thoracentesis, auxiliary Bulau drainage of the left pleural cavity in the seventh intercostal space along the posterior axillary line. The dynamics are positive, the lung was fully straightened on the second day. Drains were removed on the sixth (upper) and eighth (lower drainage) days. The patient was discharged on 13.12.21 in satisfactory condition under the supervision of a family doctor, consultation with a thoracic surgeon was recommended.

2.5. Case 5

Patient B., a 60-year-old man was admitted to the surgical department on 23.12.21 with complaints of general weakness, dry cough, shortness of breath at rest, which is significantly exacerbated by light exercise, fever up to 39°C . Ill for the last 8-9 days, engaged in self-medication. He has not been vaccinated against COVID-19. 23.11.21 performed PCR on RNA SARS-CoV-2 COVID-19, the result is positive. The condition worsened, on 01.12.21 he was hospitalized in the therapeutic department of one of the hospitals in Kryvyi Rih with a diagnosis of Coronavirus COVID-19, Bilateral pneumonia. 09.12.21 the course of the disease was complicated by spontaneous right pneumothorax, the patient was immediately drained of the right pleural cavity according to Bülow. 16.12.21 drainage in the pleural cavity ceased to function: repeated drainage of the right pleural cavity, but the drainage does not work. On December 23, 21, the patient was transferred to the surgical department of the Kryvyi Rih City Hospital № 7. On admission 23.12.21 general condition is severe. Patient with normosthenic physique, malnutrition. The skin and visible mucous membranes are pale. In the lungs, breathing with a hard tinge, weakened in the lower left, where you hear a variety of wet rales. On the right of breathing is sharply weakened, in the lower parts is not heard. At percussion in the upper parts on the right there is a "box" sound. Respiratory rate 22/min.. Saturation 90-92% without oxygen subsidy.. Heart tones are muffled, rhythmic. Pulse 98/min.. Blood pressure 160/90 mm Hg. Temperature 37.3°C . Drainage according to Bülow, installed on the right mid-clavicular line in the second intercostal space, does not work. Palpation of the right half of the chest in the wound around the drainage is moderately painful, there is local subcutaneous emphysema. The bandage is dry.

General blood test (23.12.21): erythrocytes $4.4 \times 10^{12}/l$, hemoglobin 132 g/l, color index 0.91, leukocytes $11.2 \times 10^9/l$, eosinophils 1%, rod-shaped 14%, segmented-nuclear 63%, lymphocytes 21%, monocytes 1%, erythrocyte sedimentation rate 72 mm/h, platelets $242.0 \times 10^9/l$, sugar 4.51 mmol/l.

General urine analysis (23.12.21): yellow, cloudy, specific gravity 1023, reaction 4.0, protein 0.09, epithelium 1-2 in the field of view, leukocytes 30-40 in the field of view, erythrocytes 5-7 in the field of view, urate 2+, mucus 3+

Biochemical analysis of blood (23.12.21): prothrombin index 89%, fibrinogen 5.1, ethanol test negative, fibrinogen B negative, total bilirubin $10.89 \mu\text{mol/l}$, direct $2.42 \mu\text{mol/l}$, indirect $8.47 \mu\text{mol/l}$, total protein 57.7 g/l, creatinine 69, urea 6.63, amylase 39.9.

PCR on SARS-CoV-2 COVID-19 RNA from 23.11.21, 13.12.21 and from 17.12.21 is positive.

On December 23, 21, the patient underwent drainage of the right pleural cavity according to Bülow in the sixth intercostal space along the posterior axillary line. Chest radiography (27.12.21): bilateral pneumonia, hydropneumothorax on the right, the dynamics of 16.12.21 positive. Control radiography of the chest (03.01.22): bilateral pneumonia, hydropneumothorax on the right remains, the dynamics of 27.12.21 negative. Given the negative X-ray dynamics on 03.01.22, the patient on 03.01.22 underwent another repeated (fourth) drainage of the right pleural cavity according to Bülow in the eighth intercostal space along the posterior axillary line. Microbiological study of secretions from the pleural cavity from 10.01.22: *A. baumannii* 1×10^5 , resistant to all beta-lactams, aminoglycosides, fluoroquinolones. The patient also received medical treatment 6 ibuprofen, nolvase, tivortine, calcium, probiz, xarelto, medrol, olidetrin, flenox, ATC-long, linesa, ingamist, dexamethasone, ceftriaxone, analgeson, diphenhydrol, diphenhydramine, diphenhydramine support with concentrated humidified oxygen. After the last re-drainage of the right pleural cavity, the patient's condition improved, the right lung was partially straightened, breathing was easier, saturation 97-98% (periodically with oxygen donation). At auscultation the breath on the right is listened, however considerably weakened on all extent, amphora, on the left vesicular breath, rales are not present. Pulse 80/min., Blood pressure 120/80 mm Hg Bulau drainage is functioning, air with a small amount of serous-purulent exudate is released. Given the negative PCR result on SARS-CoV-2 RNA obtained on 23.01.22, the patient was transferred to the highly specialized department of thoracic surgery of the Kryvyi Rih City Clinical Hospital № 2 for further treatment. Currently, the patient continues treatment at the center of thoracic surgery. The condition is stable, moderate, drainage in the right pleural cavity continues to function, during computed tomography on 31.01.22 revealed a fistula of the right lung with a constant discharge of air, the lung remains partially collapsed.

3. Conclusions

Analyzing these cases, we can draw the following conclusions:

- 1) In all the described cases, spontaneous pneumothorax developed against the background of the new coronavirus disease SARS-Cov-2 COVID-19. A somewhat controversial issue is the first case, where pneumothorax was preceded by a chest injury. However, shortness of breath in the patient occurred only 10 days after injury on the background of a confirmed test for SARS-CoV-2 antigen COVID-19. Thus, we can assume that the injury may have created certain preconditions for the development of pneumothorax, but pneumothorax, which arose after a significant period of time on the background of lung tissue damage by COVID-19 virus may well be a direct complication of new coronavirus disease.
- 2) All these patients were not vaccinated against COVID-19.
- 3) In all the described patients there was an inefficiency of primary drainage of the pleural cavity, which may indicate a recurrence of pneumothorax.
- 4) Recurrence of pneumothorax is quite possible, given the peculiarities of lung tissue damage in the new coronavirus disease COVID-19.
- 5) There are two links of lung damage in COVID-19, which contribute to the development of pneumothorax. First of all, COVID-19 directly affects the endothelium of capillaries and small pulmonary arteries due to the direct cytopathic action of the virus, which leads to hypercoagulation and thrombosis of the lumen of the arteries, while other coronaviruses and influenza A viruses localize thrombosis in the pulmonary veins. That is, in COVID-19 due to thrombosis of small arteries of the lungs suffers primarily from lung nutrition, which leads to local necrosis and, consequently, to the destruction of lung tissue and the development of pneumothorax [5-15]. Secondly, changes in lung tissue in COVID-19 are diffuse in nature and compared to other pneumonias are distributed peripherally [8], which against the background of peripheral local necrosis of lung tissue also facilitates the development of pneumothorax.

References

- [1] Pneumothorax in COVID-19 disease- incidence and clinical characteristics Massa Zantah, Eduardo Dominguez Castillo, Ryan Townsend, Fusun Dikengil Gerard G. Criner volume 21, Article number: 236 (2020).
- [2] Sagar Rohailla MD MSc, Najma Ahmed MD, Kevin Gough MD Practice | CLINICAL IMAGES Cite as: CMAJ 2020 May 11; 192: E510. doi: 10.1503/cmaj.200609; early-released April 21, 2020.
- [3] Spontaneous pneumothorax as a complication of lung injury due to COVID-19 A. V. MIKHEEV, E. V. AFTAIEVA, S. S. KAZAKOVA, Z. V. ZINOVIEVA, I. N. GAVRIKOVA Razyan State Medical University Named after Academician I. P. Pavlov, Razyan, Russia <https://doi.org/10.21292/2075-1230-2021-99-3-18-22>.
- [4] Spontaneous pneumothorax as unusual presenting symptom of COVID-19 pneumonia: surgical management and pathological findings Roberto Bellini, Maria Chiara Salandini, Serena Cuttin, Stefania Mauro, Paolo Scarpazza and Christian Cotsoglou Bellini et al. Journal of Cardiothoracic Surgery (2020) 15: 310 <https://doi.org/10.1186/s13019-020-01343-4>
- [5] Zhu N, Zhang D, Wang W, et al. A novel coronavirus from patients with pneumonia in China. New Eng J Med. 2020; 382 (8): 727–33.R.
- [6] Selvaraj V, Dapaah-Afriyie K. Lung cavitation due to COVID-19 pneumonia. BMJ Case Rep. 2020; 13: e237245. doi: 10.1136/bcr-2020-237245.
- [7] Martinelli AW, Ingle T, Newman J, et al. COVID-19 and pneumothorax: a multicentre retrospective case series. European Respiratory Journal. 2020; 56: 2002697. DOI: 10.1183/13993003.02697-2020.
- [8] Russian Journal of Archive of Patology = Arkhiv patologii 2020, vol. 82, no 4, pp. 32-40 <https://doi.org/10.17116/ptol20208204132>
- [9] Huang C, Wang Y, Li X, Ren L, Zhao J, Hu Y, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet. 2020; 395: 497-506. [https://doi.org/10.1016/s0140-6736\(20\)30183-5](https://doi.org/10.1016/s0140-6736(20)30183-5)
- [10] Elhakim TS, Abdul HS, Pelaez Romero C, Rpdriquerz-Fuentes Y. Spontaneous pneumomediastinum, pneumothorax and subkutaneous emphysema in COVID-19 pneumonia: arare case and literature review. BMJ Case Rep. 2020 Dec 12; 13 (12): e 239489. doi: 10.1136/bcr-2020-239480. PMID: 33310838 Free PMC article. Reviewers.
- [11] Abushahin A, Degliomini J, Aronov WS, Newman T. A Case of Spontaneous Pneumothorax 21 Days After Diagnosis of Coronavirus Disease 2019 (COVID-19) Pneumonia. Am J Case Rep. 2020 Aug. 15; 21: e925787. doi: 10.12659/AJSR.925787 PMID: 32798215 Free PMC article.
- [12] Ahmed I, Shahab H, Ahmed MA, Sohaib M. COVID-19 Presenting with Spontaneous Pneumothorax. J Coll Physicians Surg Pak. 2021 Jan; 30 (1): s29-s31. Doi: 10.29271/jcpsp.2021.01.s29. PMID: 33650421.
- [13] Sahagun J, Chopra A, David AG, Dao D, Chittivelu S. Secondary Spontaneous Pneumothorax in a COVID-19 Recovered Patient. Coreus. 2021 Jul 16; 13 (7): e16415. doi: 10.7759/coreus.16415. Ecollection 2021 Jul. PMID: 34401214 Free PMC article.
- [14] Cabrera Gautan DA, Perez Andrade Y, Espiritu Valenzo Y. Pneumothorax due to COVID-19: Analysis of case reports. Respir Med Case Rep. 2021; 34: 101490. doi: 10.1016/j.rmcr.2021.101490.Epub 2021 Jul 26. PMID: 34336592 Free PMC article.
- [15] Hu B., Guo H., Zhou P., Shi Z. L. Characteristics of SARS-CoV-2 and COVID-19. Nat. Rev. Microbiol. 2020 doi: 10.1038/s41579-020-00459-7. - DOI - PMC – PubMed.