

# Paralysis of the right diaphragm after laparoscopic appendectomy: A case report

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Jurij Janež<sup>1,2</sup> 

## Abstract

Paralysis of the diaphragm is often associated with direct phrenic nerve injury during operative procedures. It is common after cardiac surgery, but it can also happen after central venous cannulation. Diaphragmatic paralysis is also described after anatomically distant surgery. Two cases have been described after uncomplicated laparoscopic cholecystectomy. We describe an unusual case of a 28-year-old male patient, without previous medical history, who was diagnosed with right diaphragm paralysis after an uncomplicated laparoscopic appendectomy and Meckel diverticulum excision. After diagnostics at the pulmonology clinic, the exact cause of his condition was not established. His condition improved without specific treatment. After discharge from the hospital, he had follow-ups at the pulmonology outpatient clinic. According to our knowledge, this is the first such case described in English literature.

## Keywords

diaphragm, paralysis, surgery, laparoscopy

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## Introduction

Diaphragmatic paralysis is the loss of muscular power due to muscle weakness or damage to its nerve supply. Depending on the severity of the paralysis and whether it is unilateral or bilateral, patients can exhibit various clinical manifestations, ranging from asymptomatic to ventilator-dependent presentations.<sup>1</sup>

Direct injury to the diaphragm is possible and has been described in some cases of laparoscopic cholecystectomy. However, diaphragmatic injury is relatively uncommon, representing <1% of all traumatic injuries after laparoscopic cholecystectomy. Penetrating mechanisms account for 65% of all diaphragmatic injuries, whereas blunt mechanisms account for the remaining 35% of them. During the laparoscopic cholecystectomy, the right hemidiaphragm injury can occur, most commonly because of a slipped fundal grasper that penetrates the diaphragm, as it has been described in some case reports. Inadvertent diaphragmatic injury during transperitoneal laparoscopic surgery in urology has also been described but it is a rare occurrence.

Paralysis of the diaphragm can also occur in some other conditions, not related to surgery, such as diseases of the nervous system, upper cervical spinal cord injury, cervical

spine arthritis, in cancer that has spread and compresses the phrenic nerve. While the cause can be identified in some cases, as many as 40%–50% of paralyzed diaphragms are idiopathic, meaning the cause is unknown.

Unilateral diaphragmatic paralysis is described in the literature in infants and adults after open cardiac surgery due to direct phrenic nerve injury; however, it is also described in patients after anatomically distant surgery. The cause is mainly unknown.<sup>1,2</sup> This paper describes a unique and unusual case of a young, otherwise healthy male patient, who suffered a right diaphragm paralysis 3 weeks after an uncomplicated laparoscopic appendectomy and Meckel diverticulum excision. After extensive diagnostic examinations, no specific cause was established. Due to our knowledge and the review of the existing literature, such a case has not yet been described in the English literature.

<sup>1</sup>Department of Abdominal Surgery, University Medical Centre Ljubljana, Slovenia

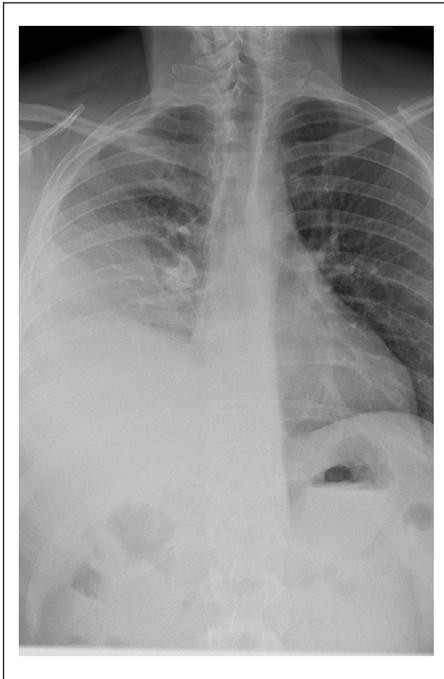
<sup>2</sup>Faculty of Medicine, University of Ljubljana, Slovenia

### Corresponding Author:

Jurij Janež, Department of Abdominal Surgery, University Medical Centre Ljubljana, Zaloška 7, Ljubljana 1525, Slovenia.

Email: [jurij.janez@kclj.si](mailto:jurij.janez@kclj.si)





**Figure 1.** Chest X-ray showing elevated right diaphragm and right-sided pleural effusion.

## Case report

A 28-year-old male patient, otherwise healthy, without previous medical history, has been admitted to the emergency surgical outpatient clinic due to abdominal pain. Abdominal ultrasound (US) showed signs of acute appendicitis. He was admitted to the abdominal surgery ward and after a short preoperative preparation, a laparoscopy was performed. At laparoscopy, inflamed appendix vermiformis was found and incidentally, a Meckel diverticulum of the terminal ileum was also found. Laparoscopic appendectomy and Meckel diverticulum excision were performed. The postoperative course was uneventful and 6 days after the surgery, the patient was discharged from the hospital. Three weeks after the surgery, the patient started to feel progressive dyspnoea, coughing and right-sided chest pain. Initially, he was referred to the internist emergency outpatient clinic due to suspected pulmonary thromboembolism. Upon inspection he was stable, his blood pressure was 140/90 mmHg, his heart rate was 87 beats/min, he was eupnoeic and acyanotic, his body temperature was normal and his oxygen saturation was 97%. Breathing sounds were reduced on the right lower side. The electrocardiogram was normal and mild sinus tachycardia was noticed (107 heartbeats/min). In laboratory findings, we observed elevated levels of C-reactive protein (CRP, 126 mg/L), leukocytes ( $11.6 \times 10^9/L$ ) and D-dimer (5045  $\mu\text{g/L}$ ), blood gas analysis was normal. A chest X-ray was performed, which revealed an elevation of the right diaphragm and right-sided pleural effusion (Figure 1). Further, computed tomography angiography (CTA) of the pulmonary

vessels was performed, which did not show signs of pulmonary thromboembolism. Elevated right diaphragm and right-sided pleural effusion were observed, as already noticed on previous chest X-rays. Abdominal US was also performed due to a recent abdominal operation to exclude a possible abdominal cause of his condition; however, it was without obvious intraabdominal pathology. The cause of his condition was not cleared, so he was referred to a pulmonary clinic for further investigations. At the pulmonology clinic, a sample of pleural fluid was acquired and sent to microbiology and cytology investigations. There were no bacteria found in the exudate, only eosinophils. The stool sample was investigated for possible parasites; however, no parasites were found in the stool sample. CTA of the pulmonary vessels was repeated and showed no signs of pulmonary thromboembolism or any other pathology. Chest US was performed, which showed an elevated right diaphragm that was poorly movable during respiration. The diagnosis of right hemidiaphragm paralysis was set. The patient was sent for the electromyography (EMG) of the phrenic nerves during the outpatient follow-up. The phrenic nerve EMG was performed 6 months after the surgery. The EMG showed normal conduction values in the right phrenic nerve, without electrophysiological signs of the right phrenic nerve injury. Despite numerous diagnostic tests, the specific cause of the patient's condition was not established. The patient did not need any specific treatment, except respiratory physiotherapy. His condition spontaneously improved after a few days. He did not feel any chest pain or breathing problems, so he was discharged from the hospital.

After discharge from the hospital, he had follow-ups at the pulmonology outpatient clinic. After 1 month, he was under the first planned examination at the pulmonology outpatient clinic. He was asymptomatic regarding his previous dyspnoea, chest pain and cough. Chest X-ray was repeated, which showed still elevated right diaphragm, but less than previously. The right-sided pleural effusion is completely resolved. He was advised to continue with respiratory physiotherapy and he was ordered to attend another inspection in a few months. At the last follow-up, he was completely asymptomatic.

## Discussion

Paralysis of the diaphragm is described in patients after cardiac surgery and is usually associated with direct phrenic nerve injury. Occasionally, diaphragm paralysis can also occur after central venous cannulation.<sup>1-3</sup> Rarely, diaphragm paralysis can occur in patients after anatomically distant surgery, where there is minimal possibility for direct phrenic nerve injury. Parker and Wathen described a case of symptomatic hemidiaphragm paralysis after an uncomplicated laparoscopic cholecystectomy.<sup>4</sup> They reported a case of a 55-year-old man, who suffered from progressive dyspnoea, which started 2 months after the surgery and lasted for

another 3 months before he was referred for further investigations. He was diagnosed with unilateral right hemidiaphragm paralysis. The condition was attributed to neuralgic amyotrophy isolated to the phrenic nerve. This is a self-limiting condition and its aetiology remains unclear.<sup>4</sup> Castillo et al. also reported a case of right diaphragm paralysis in a patient after laparoscopic cholecystectomy due to acute gangrenous cholecystitis. The specific cause was not known, but it was likely also associated with neuralgic amyotrophy because there was no sign of direct diaphragmatic injury.<sup>5</sup>

Neuralgic amyotrophy is a rare disorder of the peripheral nervous system and besides other peripheral nerves, phrenic nerves can also be affected. The exact cause is unknown, but genetic, autoimmune and external factors can be involved. It can occur at any age but is most frequently seen in those between the third and seventh decades of life and is more frequent in men.<sup>6</sup>

Nevertheless, neuralgic amyotrophy with phrenic nerve paralysis is a self-limiting condition of unknown aetiology. No treatment is known to hasten recovery, but the identification of the condition is worthwhile if only to spare the patient unnecessary investigations. The recovery of the diaphragm strength is variable and can take up to 5 years.<sup>3</sup>

Different factors encountered during laparoscopic surgery could explain the impairment in phrenic nerve conduction. Sharma et al. reported that a reduction in diaphragmatic activity was observed after laparoscopic cholecystectomy. Reflex inhibition of phrenic nerve output was the most likely cause of reduced diaphragmatic activity.<sup>7</sup> The same situation could happen to our patient after laparoscopic appendectomy. The afferents for the reflex could come from the abdominal sympathetic ganglia. As reported by Prabhakar et al., the activation of the visceral afferents of the mesenteric region reflexly changes diaphragmatic breathing to intercostal breathing.<sup>8</sup> An inhibition of phrenic nerve activity has been reported in response to electrical stimulation of splanchnic afferents in anesthetized rabbits and cats. Not only stimulation of splanchnic afferents but also activation of pelvic visceral afferents, that is, distention of the urinary bladder, inhibit phrenic nerve activity.<sup>8,9</sup> In addition, during laparoscopic abdominal surgery, the alterations of abdominal compliance induced by gas insufflation induce stretching of the diaphragm and consequently the phrenic nerve. It has been suggested that pneumoperitoneum, causing stretching of the phrenic nerve, could induce neurapraxia.<sup>10</sup>

Our patient had a laparoscopic appendectomy and Meckel diverticulum excision. The operative procedure was uncomplicated and it was in an anatomically distant location, far from the diaphragm, with no direct injury to the right diaphragm and possible phrenic nerve injury. After extensive diagnostic investigations (abdominal US, CTA of the pulmonary vessels, EMG of the phrenic nerves and analysis of the pleural fluid), no specific cause was found in our patient for diaphragmatic paralysis. It could be attributed to the neuralgic amyotrophy with isolated right phrenic nerve paralysis; however, as already mentioned, the EMG showed normal

conduction values of the right phrenic nerve, without electrophysiological signs of the right phrenic nerve injury. The EMG study was conducted 6 months after surgery during follow-up, and after that time interval, the right phrenic nerve could fully recover; and for that reason, the EMG study did not show any abnormality. Even if the EMG study of the phrenic nerve had been conducted earlier, the results could be erroneous and would not allow for documentation of the impairment in the phrenic nerve conduction. This is possible because artefacts are common in this test, due to the activity of adjacent muscles. In our patient, preoperative chest X-ray was not performed, hence we do not know about pre-existing possible right hemidiaphragm elevation. Hemidiaphragm paralysis may be a clinically silent entity. Sadovnikoff and Maxwell reported respiratory failure secondary to pre-existing hemidiaphragm paralysis following laparoscopic cholecystectomy.<sup>11</sup> Our patient had also pleural effusion on the postoperative chest X-ray. As reported by Boussuges et al., pleural effusion can also affect diaphragm motion and function. The fluid in the pleural space can decrease the diaphragmatic movement.<sup>12</sup>

According to our knowledge and available data, the internist did not evaluate the patient for orthopnea, as this is a classic presentation of diaphragmatic paralysis. Orthopnea is likely to be profoundly evident in cases of bilateral paralysis, whereas it may be more subtle in instances of unilateral paralysis.

The likely aetiology of the patient's presentation could be brachial plexus, which suggests a neuromyopathic origin of the paralysis, further supported by the elevated CRP. To assess such an elevated CRP, it is essential for the patient to have undergone evaluation for vasculitis and other autoimmune pathologies. CT scan of the cervical spine would also be beneficial, as cervical pathologies are among the more prevalent causes of diaphragmatic paralysis. Finally, in this specific case, an EMG of the diaphragm—in addition to the phrenic nerve—and an MRI of the brachial plexus would have been beneficial. The patient likely experienced Parsonage–Turner syndrome, which is recognized as self-limiting, and recovery may have been improved with a course of corticosteroids.

Diaphragmatic injury is a recognized complication of laparoscopic surgery. The incidence ranged from 6.0% to 15.2% in the 1990s and decreased from 0.1% to 2.0% with improvements in laparoscopic techniques. However, diaphragmatic injury following laparoscopic cholecystectomy is an extremely rare complication, and it can become life-threatening, as in the case of respiratory distress syndrome induced by a giant diaphragmatic hernia. Diaphragmatic injury may occur during the laparoscopic procedure if the holding or dissecting instrument slips off, particularly in difficult cases where significant traction is necessary.

Our patient fully recovered in a short time, he became asymptomatic regarding the respiratory problems, cough and chest pain. The right-sided pleural effusion resolved spontaneously in a month, which was confirmed on a repeated chest X-ray, but the right diaphragm was still elevated.

## Conclusion

This paper presented a rare and unusual case of a young male patient, who suffered a right-sided diaphragmatic paralysis soon after an uncomplicated laparoscopic appendectomy and Meckel diverticulum excision. Diaphragmatic paralysis is described in the literature and can occur after anatomically distant abdominal surgery, without direct phrenic nerve injury. The cause is most likely neuralgic amyotrophy with temporary and self-limiting phrenic nerve paralysis, as probably occurred in our patient. The diagnostics did not establish the exact cause of diaphragmatic paralysis in our patient; phrenic nerve injury was excluded with EMG. The patient fully recovered in a relatively short time, without specific treatment.

## ORCID iD

Jurij Janež  <https://orcid.org/0000-0003-2543-5003>

## Ethical considerations

Our institution does not require ethical approval for reporting individual cases or case series.

## Consent for publication

Written informed consent was obtained from the patient for their anonymized information to be published in this article.

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