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## Bilateral Lung Injury with Delayed Pneumothorax Following Preoperative Cryoanalgesia for Pectus Excavatum Repair in a 13-year-old Boy

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### Abstract:

A thirteen-year-old male patient with marfanoid features and pectus excavatum with Haller index 4 and correction index of 38% underwent a Nuss procedure with cryoanalgesia 9 days prior, which transpired uneventfully. Preoperative spirometry was normal and echocardiogram showed light aortic valve dilation. A month later, during a routine outpatient checkup, he referred middle abdominal pain, denying respiratory symptoms nor thoracic pain. He presented bilateral apical and right basal hypophonesis. Chest x-ray revealed bilateral pneumothorax and right pleural effusion. Consequently, the patient was admitted to the emergency room and a chest computed tomography was ordered, reporting right apical blebs. Bilateral thoracoscopy was performed and apexes were checked for pulmonary blebs to rule out primary pneumothorax. In the right chest, a wedge resection of a distorted area on the apex and pleuroabrasion were done. Four air-leaking eschars were found when performing lung expansion under water as leaking test, corresponding to cryoanalgesia intercostal eschars, and subsequently closed by primary suture. In the left chest there were no blebs. However, another four pleural lesions with intact pleura in the left lower lobe were also found. Postoperative course was uneventful and chest drains were removed 48 hours post-surgery. He remains asymptomatic 21 months after discharge.

Cryoanalgesia in pectus excavatum is spreading due to the improvement in postoperative pain control. However, some complications may occur. To the best of our knowledge, this is the first reported direct visualization of cryoanalgesia-induced lung injuries causing delayed pneumothorax. Regarding this complication, we modified the cryoanalgesia technique to prevent it.

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## Introduction

The repair of *pectus excavatum* (PE) with Nuss technique is a painful procedure<sup>1-4</sup>. In the last years, cryoanalgesia is spreading as it has shown benefits in postoperative pain management reducing the need of opioids<sup>5-11</sup>. Intercostal nerves' cryoneurolysis produces axonotmesis and initiates Wallerian degeneration distally to the site of nerve injury, resulting in temporary and reversible regional analgesia during weeks to months<sup>12, 13</sup>. Cold temperatures are applied to the targeted nerves, commonly from -70°C to -90°C in the case of *pectus excavatum*, causing a transitory and reversible axonal disruption that inhibits afferent signal to the brain and thus reducing the pain in the treated area. It can either be applied during the Nuss procedure<sup>7-9, 10, 11</sup>, which increases operative time but enables direct thoroscopic visualization (either unilateral or bilateral) and under only one general anesthesia, or ultrasound-guided a few days before surgery<sup>14-17</sup>. This second option ensures better analgesic control, as it takes from 6 hours up to 2 days to make maximum effect; but requires two general anesthesia and ultrasound-guided puncture expertise. So far, the most common reported complications of this procedure include neuropathic pain, prolonged regional numbness, wound infection and pneumothorax<sup>9, 18, 19</sup>. To the best of our knowledge, we report the first case of delayed pneumothorax caused by cryoanalgesia.

## Case report

A thirteen-year-old male patient with marfanoid features and PE (Haller index 4 and correction index of 38%), weighing 56kg, standing 180 cm tall, underwent Nuss procedure. In preoperative checkup, spirometry was normal and light aortic valve dilation was observed in echocardiogram. Also, preoperative genetic analysis for collagenopathies and overgrowth

syndromes were normal. Ultrasound-guided percutaneous cryoanalgesia was performed 9 days before surgery in an outpatient basis, uneventfully. Under general anesthesia, ten percutaneous punctures were carried out, applying a temperature of  $-88^{\circ}\text{C}$  during a 2-minute cycle. The minimally invasive repair of PE was performed uneventfully and pleural drainage was left for 5 days. The patient was discharged with bilateral full lung expansion. A month later, in routine outpatient checkup, he referred middle abdominal pain, denying respiratory symptoms nor thoracic pain (although shortness of breath was noticeable). At physical exam, he presented bilateral apical and right basal hypophonesis. A chest x-ray was performed which showed bilateral pneumothorax and right pleural effusion (fig. 1). He was admitted to the emergency room and chest computed tomography was ordered, reporting right apical blebs (fig. 1). With the suspicion of primary bilateral simultaneous pneumothorax, bilateral thoracoscopy was performed. Apexes were checked for pulmonary blebs to rule out spontaneous pneumothorax. In the right chest, a wedge resection of a distorted area on the apex and pleuroabrasion were done. Four air-leaking eschars, corresponding to cryoanalgesia intercostal eschars, were found in the posterior surface of the right lower lobe when performing lung expansion under water as leaking test (fig. 2). They were closed by primary suture with a 3-0 absorbable braided material. In the left chest, there were no blebs and another four more superficial lesions with no pleural discontinuity in the left lower lobe were also found. As they did not present air leakage, they were not sutured. Bilateral chest drains were placed, which were removed at 48 hours. Postoperative course was uneventful. He remains asymptomatic 21 months after discharge.

## Discussion

At our institution, cryoneurolysis protocol in PE patients was established in October 2021. Ultrasound-guided percutaneous cryoanalgesia is performed on an outpatient basis a few days prior to surgery to ensure a proper analgesic effect<sup>12</sup>.

After this case, we examined for lung eschars in the successive procedures, noticing that another patient had the same lesions but more superficial, without air leakage as the visceral pleura was intact. Therefore, the technique was modified to avoid lung damage. Nowadays, cryoneurolysis is applied in 10 intercostal spaces: 5 in every side, starting at the level of the deepest chest depression, from two spaces above to two spaces below, which are marked with a surgical marker. The probe is introduced through a 14-gauge beveled intravenous catheter that serves as a guide-through. To make sure the probe will not go too deep, a mark made with adhesive skin closure is placed on the probe at the point where only its tip overtakes the catheter (fig. 3). We aim to place the probe's tip between intern and innermost intercostal muscles and avoid going underneath the rib. Ultrasound-guided percutaneous puncture is done, leaving the catheter in place and replacing the needle by the probe (fig. 3). Freezing is applied for two minutes at  $-88^{\circ}\text{C}$ . Color Doppler twinkling artifact to delineate the probe's contour and hypoechoic image corresponding to the ice ball are ultrasound signs that help locating the probe's position. The same process is repeated for each intercostal space. While the cryoprobe is performing the cycle, the next intercostal space is punctured with the intravenous catheter to optimize time. Once the cycle is finished, the catheter is already placed and ready to introduce the cryoprobe through it. At the end of the procedure a lung ultrasound and a chest x-ray are performed to rule out immediate complications. Ever since the technique was modified by puncturing more superficially with the angiocath and marking the probe; no more lung eschars have been observed.

## Conclusion

The use of cryoanalgesia in pectus excavatum is increasing due to the improvement in postoperative pain control management. However, some complications may occur. To the best of our knowledge, this is the first reported direct visualization of cryoanalgesia lung injuries causing delayed pneumothorax. Regarding this complication, adjustments were made to the ultrasound-guided percutaneous cryoanalgesia technique, employing a more superficial approach. Thus far, we have not observed any additional occurrences of lung lesions.

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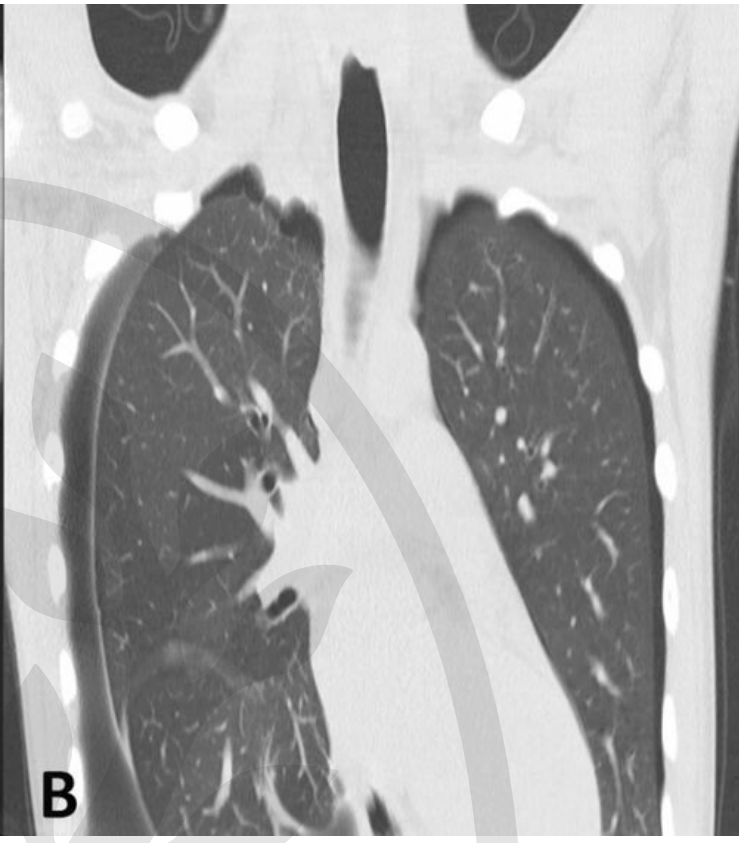
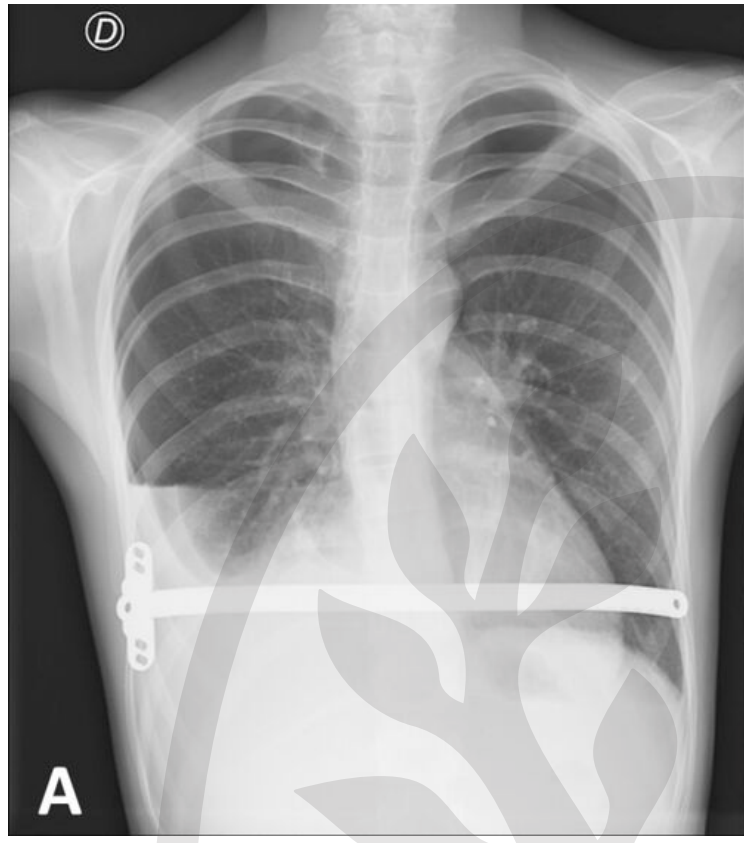
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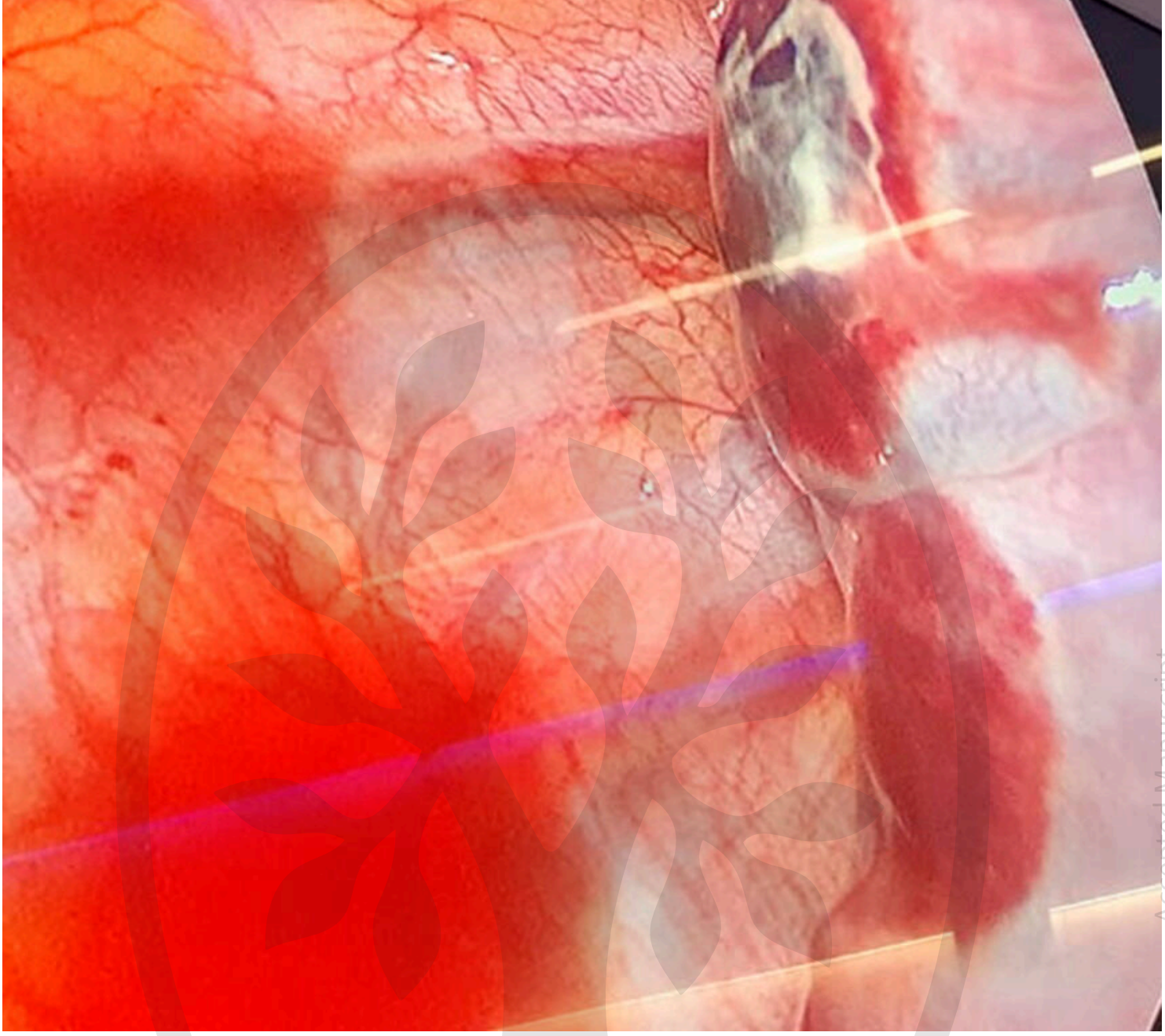
Figure 1: A: Chest x-ray displaying bilateral pneumothorax and right pleural effusion. B: Chest CT presenting right apical blebs.

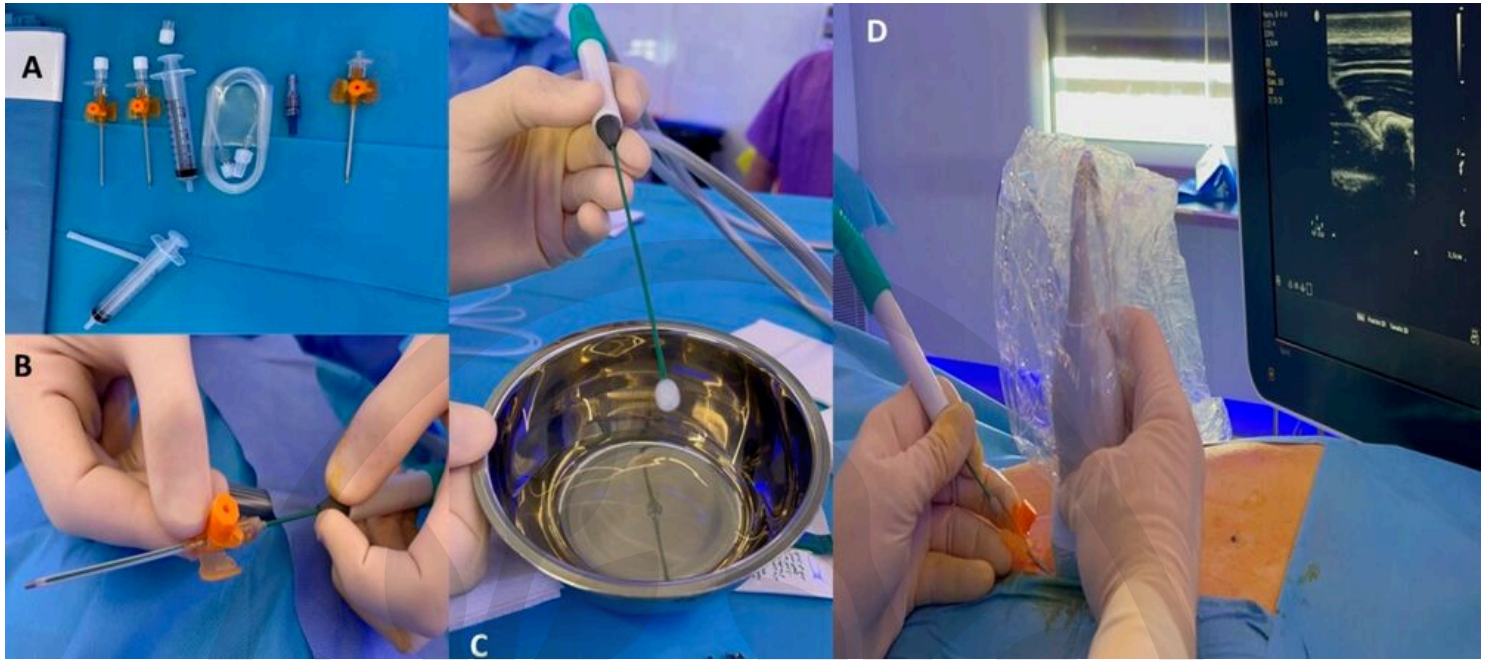
Figure 2: Thoracoscopic view revealing lung eschars secondary to cryoanalgesia. The right portion of the image displays the lung surface, with two rounded eschars that showed air-leakage and were sutured.

Figure 3: Ultrasound-guided percutaneous cryoanalgesia procedure. A: Material used in the procedure. B: Marking of the probe with adhesive tape. C: Ice ball created with the cryoprobe. D: Ultrasound-guided percutaneous puncture observing a round hypoechoic image corresponding to the ice ball.









## Delayed Pneumothorax Following Preoperative Cryoanalgesia for Nuss procedure

- 13-year-old boy with *pectus excavatum*
  - Nuss procedure with preoperative ultrasound-guided cryoanalgesia 9 days prior
  - Routine checkup 1 month later: middle abdominal pain, no reported respiratory symptoms but noticeable shortness of breath at physical exam
  - Chest X-ray and low-dose CT: bilateral pneumothorax and right pleural effusion
  - Bilateral thoracoscopy: four round parenchyma lung injuries in both lower lobes corresponding to **cryoanalgesia eschars**, those with air leakage were sutured
- Modification of cryoanalgesia technique** → cryoprobe's tip between intern and innermost intercostal muscles

