



# An Alternative Lung Isolation Technique in Paediatric Pulmonary Alveolar Proteinosis

## Pulmoner Alveolar Proteinozis Tanılı Pediatrik Hastalarda Alternatif Akciğer İzolasyon Tekniği

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Lung isolation during the lung lavage of children with pulmonary alveolar proteinosis (PAP) poses challenges to anaesthesiologists. There is no established technique in the management of lung lavage in children; each described technique has its own advantages and disadvantages. We described a patient (2.5-year-old) with PAP, who has undergone left lung lavage. While his lung was isolated by a Fogarty catheter, lavage was performed via a feeding tube, and the right lung was ventilated with a rigid bronchoscope. We suggested that the technique we used was safe and effective because it enabled direct visualisation of both bronchi entrances, allowing early recognition of any possible catheter dislocations at the bronchus of the lavaged lung, completely eliminating the risk of contralateral lung contamination. This case reports an alternative unilateral lung isolation and lavage technique that may be applicable to other paediatric patients with PAP.

**Keywords:** Anaesthesia, bronchoscopy, pulmonary alveolar proteinosis, ventilation

Pulmoner alveolar proteinozis (PAP) tanılı çocuklara uygulanan akciğer lavajı sırasında akciğer izolasyonunun sağlanması anesteziyelere zorluklar yaşatır. Çocuklarda akciğer lavajının gerçekleştirilmesi için kabul edilmiş bir teknik mevcut değildir; tanımlanan her tekniğin kendine özgü avantaj ve dezavantajları vardır. Bu olgu sunumunda, sol akciğer lavajı gerçekleştirilen PAP tanılı 2,5 yaşında bir hastayı tanımladık. Akciğer izolasyonu "Fogarty" kateter ile sağlanırken lavaj "feeding" tüp aracılığıyla gerçekleştirildi; sağ akciğer rijid bronkoskop yardımıyla ventile edildi. Uyguladığımız tekniğin, iki bronş girişinin doğrudan görüntülenebilmesi sayesinde, lavaj yapılan akciğer bronşundaki olası kateter dislokasyonunun erken farkedilmesini sağladığını, dolayısıyla kontralateral akciğerin kontaminasyon riskini tamamen ortadan kaldırarak etkin ve güvenilir olduğunu düşünmekteyiz. Bu olguda tanımlanan tek taraflı akciğer izolasyonu ve lavaj tekniğinin PAP tanılı diğer pediatrik hastalarda da alternatif bir yöntem olarak uygulanabilirliği bildirilmiştir.

**Anahtar Sözcükler:** Anestezi, bronkoskopi, pulmoner alveolar proteinozis, ventilasyon

## Introduction

Pulmonary alveolar proteinosis (PAP) is a rare pathology in children, and the ideal treatment is sequential unilateral or bilateral lung lavages (1). PAP already impairs gas exchange, and lung lavage has further deteriorating effects. Lung lavage requires lung isolation to allow simultaneous lavage of one lung and ventilation of the other. Techniques for lung lavage in children are not standardised, all having their own disadvantages and limitations (1). In this case report, we describe a unilateral lung lavage technique in a child with PAP, which has not previously been reported and that may be applicable to other paediatric patients with PAP.

## Case presentation

A 2.5-year-old male patient with PAP was scheduled for unilateral (left) lung lavage. Standard non-invasive monitors and transcutaneous CO<sub>2</sub> (TC-CO<sub>2</sub>) monitor were applied. Anaesthesia was induced and maintained with infusions of propofol and remifentanyl. Left lung isolation and right lung ventilation were realised as follows. First, pulmonary artery catheter (PAC) was placed at the entrance of the left lung main stem with the aid of a foreign body removal forceps and 3.5-mm rigid bronchoscope was inserted into the trachea. Low-frequency jet ventilation (LFJV) was applied with Manujet III (VBM, Germany) that was adjusted to the bronchoscope adapter. As saline could not be removed back through the PAC, tip of a 6 French (F) Fogarty catheter (Edwards Lifesciences, Irvine, USA) was placed into the left main bronchus entrance, under

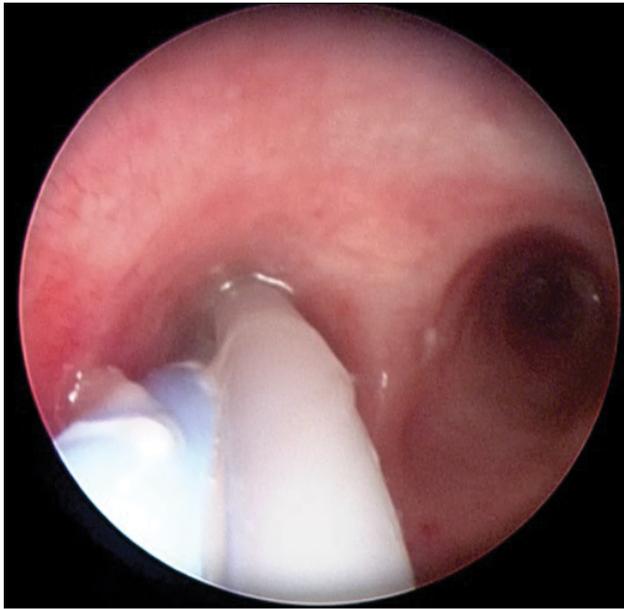


Figure 1. Bronchoscopic view of the Fogarty catheter and feeding tube inserted into left bronchial lumen. Image obtained at the 20<sup>th</sup> minute of the procedure

direct vision of the rigid bronchoscope. An 8F feeding tube was inserted alongside the Fogarty catheter to lavage the lung (Figure 1). Then, the balloon of the Fogarty catheter was inflated with 1.5 mL of air ensuring correct bronchial lumen occlusion.

At the end of the second hour of the procedure, after the collected fluid became clear, the lavage was terminated. A total of 1000 mL of warmed normal saline was used. The effectiveness of ventilation was controlled by the degree of chest wall expansion, peripheral oxygen saturation (SPO<sub>2</sub>) and TC-CO<sub>2</sub> values. Frequency was administered manually between 35 and 50 ventilations/min. SPO<sub>2</sub> values were greater than 92%, and TC-CO<sub>2</sub> values were kept constant between 35 and 40 mmHg throughout the procedure. Driving pressure was regulated between 25 and 30 psi, as required. Heart rate, mean arterial blood pressure and rectal body temperature were within normal ranges throughout the procedure (80–110/min, 55–65 mmHg and 36°C–36.3°C, respectively). On periodical ultrasonographic examination of the lung, atelectasis was diagnosed in the lavaged lung.

The patient was successfully extubated after being mechanically ventilated for the following 24 hours, in ICU.

## Discussion

Whole lung lavage in small children at the same session is not always safe due to factors such as the occurrence of hypoxic episodes (1, 2). Consecutive unilateral lavage is an option for the surgeon.

Lung lavage is an absolute indication for anatomical separation of the lungs. Lung isolation in small children offers great

difficulties due to lack of compatible equipment. Size of the smallest commercially available double lumen endotracheal tube (ETT) is 26F, suitable only for patients older than 8 years (3). Univent tubes are alternative devices to double lumen ETTs, possessing a thin lumen in its blocker that allows lung lavage (3). Unfortunately, the smallest Univent tube (size 3.5) has a 7.5-mm external diameter (4), applicable only on patients older than 6 years (3). As a result, the aforementioned devices were not suitable in our patient.

Lung isolation could be achieved by advancing a single lumen cuffed ETT into the bronchus of the ventilated lung (3). Although some authors reported that they have successfully manipulated lung isolation by placing two cuffed ETTs in each bronchus (5) or by selectively ventilating the non-lavaged lung with a cuffed ETT (6), many others stated that these techniques resulted in intraoperative hypoxemia (1). Furthermore, placing two tubes was not practical and might injure laryngeal structures.

We used Fogarty catheter for lung isolation and feeding tube alongside the catheter for lavage. Non-lavaged lung was ventilated with Manujet through the rigid bronchoscope. In literature, there was a single case where rigid bronchoscope was used for lung ventilation and PAC for lavage (1, 7). Our method was similar to that method; the difference was in catheter types used for lung isolation. Reiter et al. (7) used successfully a balloon catheter for lavage in children with PAP. According to the Hagen-Poiseuille equation, the inner radius as well as the length of a catheter have great influences on flow (8). At the end, Reiter et al. (7) concluded that their technique might get improved by using a larger diameter catheter to decrease the resistance against suction. Although we used approximately the same-sized catheter with those of Reiter, the length of a 6F feeding catheter was shorter than the length of PAC (50 vs. 110 cm).

Single lung ventilation offers potential hypoxic and hypercapnic threats to children with PAP, by whom gas exchange was previously impaired. Ventilation with conventional methods such as insertion of a single lumen ETT in one bronchus may not prevent hypoxic or hypercapnic episodes during the procedure. Reiter et al. (7) had to apply high inspiratory pressures, high PEEP (8–14 cmH<sub>2</sub>O) and allowed hypercapnia up to 80 mmHg. Some children with PAP may not tolerate these high values. At this point, LFJV might be a good alternative in providing an effective ventilation at low peak airway pressures with moderately high frequencies and high pressure of airflow, providing better oxygenation with normocapnia while protecting some healthy alveoli. During LFJV, peak airway pressures were lower than in conventional ventilation methods (9). Disadvantages of this method were barotrauma, inability to monitor ET-CO<sub>2</sub> and humidify airways (9). During the procedure, we continuously monitored TC-CO<sub>2</sub>. Pneumothorax and hydrothorax were complications that were reported during lung lavage in children (1).

The presence of these complications was excluded with the use of intraoperative lung ultrasonography.

## Conclusion

Lung isolation with Fogarty catheter, lavage via feeding tube, and LFJV through the rigid bronchoscope were effective alternative methods in paediatric WLL. The main advantages were the early recognition of possible catheter dislocations and prevention of the non-lavaged lung contamination from the lavage fluid.

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