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Operative Techniques

Early use of autologous blood patch pleurodesis in children is successful in resolving persistent air leaks

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ABSTRACT

Purpose: Experience with autologous blood patch (ABP) pleurodesis for persistent air leak in the pediatric population is limited. The purpose of this series was to describe the experience with ABP at a single tertiary children's hospital.

Methods: A retrospective study was performed of all thoracic procedures done by the pediatric surgery service over three years.

Results: Ten patients underwent a total of 17 ABPs. The median age of patients was 12 years (IQR 6–16). The most common underlying reasons for a thoracic procedure included: blebectomy for spontaneous pneumothorax (2), need for lung biopsy (2), resection of known malignant tumor (2), and empyema (2). The median number of days of persistent air leak before first ABP was 7.5 days (IQR 7–10). A second ABP was performed in 6 cases with a third procedure performed in one case. None of the patients developed respiratory compromise during ABP and no infectious complications were identified following ABP.

Conclusions: Our cohort demonstrates that ABP for persistent air leak following thoracic surgery is effective with minimal morbidity in children. We believe ABP can be used early and in patients with a broad range of underlying lung pathology.

1. Introduction

Persistent air leak is a known complication following thoracic surgical procedures with an incidence in adult patients ranging from 3.3% following wedge resection to up to 24% following lung volume reduction surgery [1]. There is no universal definition of persistent air leak with varying definitions of 3–7 days following surgery [2]. However, the Society of Thoracic Surgeons database uses a definition of 5 days [3]. Persistent air leak is associated with increased morbidity, as well as, increased cost of care [3]. In the adult populace chemical pleurodesis, autologous blood patch (ABP) pleurodesis and endobronchial valve placement are all established treatments for patients who have failed conservative management of a persistent air leak [4].

Autologous blood patch (ABP) pleurodesis for persistent air leak has been well described in adults with a success rate reported of 92–93% following lung resection or spontaneous pneumothorax [5]. In adult ABP pleurodesis 50 to 100 ml of peripheral blood is infused via the patient's chest tube followed by injection of 10 ml of saline to prevent clotting of the blood in the tube; the chest tube is then clamped [6]. ABP is an attractive treatment option in children as it straightforward and avoids exposure to exogenous substances that may limit future lung expansion by causing increased scarring [7]. Despite its use in adults since 1987 [8], the experience in the pediatric population with ABP is limited. There is a single published case series, Lillegard et al., in the pediatric population with 8 patients and a median time to ABP of 21 days [9].

Therefore, given the small number of pediatric patients studied the safety and effectiveness profile of ABP in pediatric population is not well known. Neither the optimal blood volume to infuse based on weight nor the appropriate timing of ABP has been established. While the median days to ABP in Lillegard et al. is 21 days, adult studies have demonstrated that ABP can be effective much earlier, with some advocating for ABP pleurodesis as soon as 6–7 days after surgery [10]. Whether or not early ABP is effective in a pediatric population with attendant differences in lung pathology is not currently known. The purpose of this patient series was to describe the experience with early ABP at a single tertiary children's hospital.

2. Methods

2.1. Introduction of autologous blood patch

Based on the surgeons' experiences during their general surgery residencies, ABP for persistent air leak was instituted at our hospital in 2015 according to a previously described protocol [9]. The implementation of the ABP is based on the clinician's judgement

Level of Evidence: IV, Case series with no comparison group

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Table 1
Patient Demographics and Results Following Autologous Blood Patch.

	Gender	Age (years)	Presenting Diagnosis	Initial Procedure	Air leak duration prior to initial blood patch	Blood instilled (ml/kg)	Blood instilled (ml)	# Blood patch procedures	Time to removal of chest tube from final blood patch (days)
#1	Female	11	Cavitary lung lesion concerning for lymphoma	Thoracoscopic lung biopsy	10	2	50	1	6
#2	Female	16	Pneumothorax after central line placement	Tube thoracostomy	7	1.2	60	1	1
#3	Female	3	Multifocal lung nodules concerning for lymphoid granulomatosis	Thoracoscopic lung Biopsy	9	1.3	20	2	4
#4	Male	20	Yolk sac tumor	Thoracotomy and wedge resection	12	1	80	3	4
#5	Male	13	Spontaneous pneumothorax	Tube thoracostomy	7	2	100	2	2
#6	Female	14	Empyema	Tube thoracostomy	7	2		1	2
#7	Male	17	Spontaneous pneumothorax	Thoracoscopic blebectomy	8			2	2
#8	Female	11	Endobronchial tumor	Lobectomy	12	1.1	50	1	3
#9	Male	1 day	Congenital lobar emphysema	Lobectomy	7	3.6	5	2	17
#10	Male	6	Necrotizing pneumonia	Tube thoracostomy	7	2	40	2	18

if an air leak remains persistent without signs of improvement following a thoracic procedure. Briefly, a persistent air leak was defined as presence of bubbling leak in the waterseal chamber (Pleuovac®) 7 days following index operation/procedure. The blood patch was performed as a bedside procedure without sedation by a member of the surgical team. Two (2) ml/kg of whole blood was withdrawn by the phlebotomist at the time of the procedure and used immediately for the blood patch. The chest tube was prepared in a sterile fashion and the blood was instilled either through an existing three-way stopcock (in the case of pigtail catheters), with the addition of a new three-way stopcock, or directly through the tube device with a hypodermic needle at an oblique angle (in the case of standard tube thoracostomy). The chest tube was then clamped for 4 h and then placed back to water seal. Chest x-ray was obtained the following morning. If a recurrent pneumothorax or air leak was noted the chest tube was placed back to suction. A repeat ABP was then performed on the following day.

2.2. Patient identification

A list of all patients who underwent a thoracic procedure at our institution was identified using CPT codes for thoracic procedures including chest tube placement from January of 2015 until March of 2018. All children treated by the pediatric general surgery service were eligible regardless of age. Patients who underwent an ABP were identified using a text search of all notes in the electronic medical record. Each case was manually confirmed by chart review.

2.3. Data extraction

Patient medical records were reviewed by two individuals (LP, SSS) for documentation of ABP including: reason for the initial thoracic procedure, timing of ABP, volume of blood used, and time to removal of chest tube.

3. Results

3.1. Patient demographics

In this 39-month period we identified 10 patients who underwent a total of 17 ABPs. The median age of patients was 12 years (IQR 6–16). The underlying reasons for a thoracic procedure included: blebectomy for spontaneous pneumothorax (2 patients), need for lung biopsy (2 patients), resection of known malignant tumor (2 patients), empyema (2 patients), resection of a congenital lobar emphysema (1 patient), and iatrogenic pneumothorax after central line placement (1 patient) (Table 1).

3.2. Results and characteristics of autologous blood patches performed

The median number of days of persistent air leak before first ABP was 7.5 days (IQR 7–10). A second ABP was performed in 6 cases with a third procedure performed in one case. In this case series 9/10 patients had complete resolution of leak; 1 had placement of an endobronchial valve. The median volume of blood instilled via the chest tube was 2 ml/kg (IQR 1.3–2). The tube was clamped for 4 h following ABP and then returned to water seal. The median number of days after last blood patch before chest tube removal was 3.5 days (IQR 2–6) (Table 1). None of the patients developed respiratory compromise during ABP and no infectious complications were identified following ABP. The patient who failed ABP was eventually determined to have a perforin gene mutation causing a variant of hemophagocytic lymphohistiocytosis (HLH) resulting in abnormal lung tissue.

4. Discussion

4.1. Summary of results

Our case series of 10 patients demonstrates that early ABP is an effective treatment for persistent air leak in a pediatric population with a wide range of underlying pulmonary pathology. The

median days of the persistent air leak prior to ABP was 7.5. Nevertheless, multiple patients (4/10) in our series did require a second ABP due to failure of initial ABP to resolve their persistent air leak. No significant safety events or complications were observed in our cohort.

4.2. Comparison to the existing literature

The initial success rate of ABP (40%) is lower than what has been reported in Lillegard et al's previous pediatric case series of 63% [9]. Of note their patient population contained more patients with necrotizing pneumonia (38%) than our patient population (10%) and longer time to ABP (median 21 days vs 7 days). The single patient in our case series with necrotizing pneumonia had the longest duration prior to chest tube removal, so this may reflect that this technique is not effective for necrotizing pneumonia. The resolution rates after a single ABP in both pediatric cases series are lower than the rates established in the adult literature of 92–93% in studies that use this technique routinely [5]. This difference in initial success rate may be due to the fact that the underlying pulmonary pathology in a pediatric population is significantly different than the adult population undergoing thoracic surgical procedures.

In our case series there was a wide range of underlying lung pathology in those patients who failed initial ABP: multifocal lung nodules due to HLH, yolk sac tumor, spontaneous pneumothorax, congenital lobar emphysema, and necrotizing pneumonia. There was also little consistency in the age range of patients who failed their initial blood patch, which ranged from 1 day to 20 years of age. The one patient who failed multiple ABP and eventually required endobronchial valve placement had an underlying genetic mutation that affected her lung tissue and her immune response. Given the novelty of this technique in a pediatric population, it is possible that the technique needs to be further refined in terms of the type of underlying pathology suspected when selecting candidates, repositioning the chest tube at the time of the patch to create a landing pocket, and the volume of blood infused to maximize likelihood of success. Nevertheless, with the use of multiple ABPs both of these pediatric studies report excellent success of 90% or greater.

One of the significant developments in our case series in comparison to Lillegard et al. is the timing of initial use of ABP. We used ABP after a median of 7 days in comparison to the 21 days reported by previously [9]. While there is not a definitive consensus on the optimum timing of ABP in the adult population the recommendations from various trials range from 5 to 9 days, which is consistent with the timing in our study [11]. The significant advantage of this early intervention is the potential reduction in hospital stay and associated cost.

4.3. Limitations

The main limitation of our case series is our relatively small sample size of 10 patients and the lack of a comparison group. This is particularly true in our analysis of possible adverse events. Even in an adult population the reported incidence of serious complications, including development of tension pneumothorax secondary to clotting of blood in the chest tube, are relatively rare. The reported complication rates in the literature are 0–9% [11]; if a similar rate of complications exist in a pediatric population it is likely that we would fail to capture this in our sample size of 10. We attempted to obtain a comparison group of children undergoing thoracic procedures in the two years prior to the introduction of the blood patch technique at our institution, however, given the variability in the age of the patients and the underlying lung pathology we were unable to identify a meaningful group for comparison.

One challenge of translating the use of this technique to the pediatric population is the lack of an established volume of blood to be administered given the wide range of weight and size in pediatric patients. The one previous study in children used a weight-based volume of 1–2.5 ml/kg. In our sample there was similar variation in the weight-based volume from 1 to 3.6 ml/kg. All teenage patients received a volume of blood consistent with the total volume used for adult patients. It is possible that the reduced efficacy in the pediatric population compared to the adult population is related to insufficient volume of blood being instilled.

4.4. Conclusions

Our cohort demonstrates that ABP for persistent air leak following thoracic surgery is effective with minimal morbidity in children. We believe ABP can be used early and in patients with a broad range of underlying lung pathology.

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