TITLE

EUROPEAN PEDIATRIC SURGEONS' ASSOCIATION SURVEY ON THE MANAGEMENT OF PRIMARY SPONTANEOUS PNEUMOTHORAX IN CHILDREN

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ABSTRACT

Aim: To evaluate the practice patterns of the European Pediatric Surgeons' Association (EUPSA) members regarding the management of primary spontaneous pneumothorax (PSP) in children.

Methods: An online-survey was distributed to all members of EUPSA.

Results: In total, 131 members from 44 countries participated in the survey. Interventional approach (78%) is the most common choice of treatment in the first episode and most commonly chest tube insertion (71%) is performed. In the case of a respiratory stable patient, 60% of the responders insert chest tubes if the pneumothorax is >2cm. While 49% of surgeons prefer surgical intervention in the second episode, 42% still prefer chest tube insertion. Main indications for surgical treatment were the presence of bullae >2 cm (77%), and recurrent pneumothorax (76%). 84% of surgeons prefer thoracoscopy and perform excision of bullae with safe margins (91%). In order to prevent recurrences, 54% of surgeons perform surgical pleurodesis with pleural abrasion (55%), and partial pleurectomy (22%). The responders who perform thoracoscopy use more surgical pleurodesis and prefer shorter chest tube duration than the surgeons performing open surgery ($p < 0.05$).

Conclusion: Most of the responders prefer chest tube insertion in the management of first episode of PSP and perform surgical treatment in the second episode in case of underlying bullae >2 cm and recurrent pneumothorax. The surgeons performing thoracoscopy use more surgical pleurodesis and prefer shorter chest tube duration than the responders performing open surgery. The development of evidence-based guidelines may help standardize care and improve outcomes in children with PSP.

Key words: primary spontaneous pneumothorax, children, survey, pleurodesis

INTRODUCTION

Spontaneous pneumothorax was firstly described in 1819 by Laennec and was subsequently classified into primary, with no obvious precipitating factor, or secondary, due to underlying lung disease.[1,2] Although rare, primary spontaneous pneumothorax (PSP) typically affects adolescents and young adults with a reported incidence of 7.4 to 18 per 100 000 individuals per year in males, and 1.2 to 6 in females.[3,4] Observational studies demonstrate extensive variation in practice for the management of PSP. To address this variation, clinical guidelines and consensus reports have been developed for adult patients. The American College of Chest Physicians (ACCP) reported a consensus statement in the treatment of PSP in 2001.[5] Subsequently, the British Thoracic Society (BTS) released a guideline for the management of spontaneous pneumothorax in adults in 2010.[6] Although, the AACP consensus report recommends more aggressive approach with chest tube drainage in large pneumothorax, BTS focuses on more conservative approach based on clinical symptoms. Despite advances in both diagnosis and treatment of spontaneous pneumothorax, none of those approaches are applied as standard in clinical practice. Moreover, there are no evidence-based recommendations for children. Here, we aim to evaluate practice patterns of the European Pediatric Surgeons' Association (EUPSA) members in the management of PSP in children.

Methods

Questionnaire

An on-line survey was designed by using Google forms (Supplement 1). The questionnaire consisted of 28 questions, including the subheadings of descriptive information (n=5), management of first episode of PSP (n=9), surgical treatment (n=7), and pleurodesis (n=3) and postoperative management (n=4). Except one demographic question, all other questions were closed questions. **Twelve members of EUPSA Network Office members developed the survey and five experts prior sending tested the questionnaire**.

Participants

All members of the EUPSA were invited to respond to the on-line survey starting in December 2020, and the responses that were received until 14th March 2021 were included.

Analysis and statistics

The completed surveys with 100% of answers were considered as eligible for analysis. Responses on each item are displayed as follows: In case of categorical statements, results are displayed in number (%) and in case of numeric variables as means (95% confidence interval) and medians (extremes). For statistical analysis, Statistical Package for the Social Sciences (SPSS) version 20.0 (IBM, USA) was used. Comparison of responses between groups was compared with Chi-square test. The p values <0.05 were considered as statistically significant. The Local Ethical Committee approved the study (HU, GO/2020-20-92).

RESULTS

Among 133 responses, 131 of them were found eligible for analysis.

Descriptive information

Members from 44 countries responded the survey. 84% of the responders (n= 110) were from academic hospitals and 16% (n= 21) from non-academic hospitals. Among responders, 24% (n=31) were head of department, 62% (n=82) consultants and 14% (n=18) trainees. In 54% (n=71) of the centers, there are more than 5 consultants and in 42% (n=55) 2 to 5 consultants. 5 responders (4%) work as the only pediatric surgeon in that center. **43% (n=56) of the responders had 2 to 5 new cases per year, 31% had 5 to 10 (n=43), and 15% had only one (n=19). Thirteen (11%) of the participants manage more than 10 cases per year.**

The management of the first episode of PSP

In symptomatic patients, interventional approach was the most common choice of treatment in the first episode (78%). The rest of the responders suggested to watch-and-wait (14%, n=18), and surgical treatment after chest tube drainage (8%, n=10) as the first line of treatment in a symptomatic patient. **We also compared the response of participants with different caseloads (<1 case per year, 2 to 5 cases, 5 to 10 cases and > 10 cases) for the management of first episode. There was no difference between groups for the management of first episode including interventional treatment (chest tube insertion, pigtail and etc.), watch and wait and surgical treatment (p> 0.05). When we compare the results of management of first episode among participants from European centers (n=106) and non-European centers (n=25), we found that participants from non-European centers have significantly prefers 'watch and wait' (p<0.05) more than participants from European centers. For other management preferences (intervention and surgical treatment), there was no difference between European and non-European centers (p> 0.05).**

Responders who perform interventional treatment preferred chest tube insertion (72%, n=73), pigtail insertion (15%, n=15), puncture and aspiration (13%, n=14). Indications of interventional approach (chest tube or pigtail) were listed in Table 1.

In a respiratory stable patient (no signs of breathlessness and clinical findings of tension pneumothorax), most of the responders (60%, n=77) inserted a chest tube only if the pneumothorax (the distance between chest wall and lung parenchyma) is > 2 cm. However, 15% of the surgeons did not insert chest tube in a respiratory stable patient regardless of pneumothorax size (Figure 1). Forty percent of responders started empiric antibiotics in patients with chest tube, 40% did not and the rest (20%) were unsure about the use of antibiotics after chest tube insertion. The use of empiric antibiotics was similar between responders who prefer chest tube insertion and puncture and aspiration (p = 0.23).

Indications for CT scans, in responders who use chest tube insertion are shown in Table 2. CT scan was performed in all cases for 29% of responders, in cases with persistent air leaks by 40% and in those with possible bullae by 35% of responders. The use of CT scans at initial assessment was similar between responders who prefer chest tube intervention and

pigtail intervention and aspiration (p=0.09). Chest CT scans were obtained by 93% (n=122) of surgeons as the routine investigation in preoperative period. Chest X-rays, ultrasound and MRI were also preferred for preoperative assessment by 65%, 8% and 3% of the surgeons, respectively.

Only 18% of the members used digital systems for monitoring air leaks. The most common indications for drain removal were the absence of residual pneumothorax on the chest x-ray (57%, n=75), and the absence of air leak in the drain (38%, n=30). Eighty-four (67%) responders preferred to remove chest tubes 24 hours after the complete closure of the air leak; 14% of them removed it in the first 24 hours, and 22% remove it later than 48 hours.

For a second episode in a patient for whom the previous treatment was watch-and-wait, 49% of the surgeons preferred surgical intervention, 42% performed chest tube insertion, and 9% still preferred a watch-and-wait approach.

Surgical treatment

The main indications for surgical treatment were presence of bullae > 2 cm for 77% (n=101) of responders and recurrent pneumothorax for 76% (n=101) (Table 3).

Thoracoscopy was the preferred surgical approach for 85% of the responders (n=111), whereas 15% performed open thoracotomy. Multiport thoracoscopy was performed by 92% (n=102) of the surgeons and single port by 8% of them. In case of apical bullae larger than 2 cm, the excision of the lesion with safe margins was the preferred surgical treatment and was reported by 92% of the members, whereas 3% of the surgeons performed lobectomy in the same situation, and 5% punctured the bullae without excising a lung parenchyma. Surgical pleurodesis as the only approach without lung resection and puncture was reported as the choice of treatment by 2% of the members.

Endo-GIA staplers (76%) were used for bullae > 2 cm. For the same size of lesions, 19% used LigaSure™ and 2% used endo-loop for excision. For smaller bullae (< 1 cm), endo-GIA staples were still the first choice by 43% of surgeons. In contrast to large ones, in smaller bullae LigaSure™ and endo-loop use were used by 39% and 16% of responders, respectively.

The excision of asymptomatic contralateral bullae in thoracoscopic intervention during the same general anesthesia was only performed by 21% of the responders, including 19% performed the excision, if preoperative CT confirmed contralateral bullae and 2% who performed contralateral exploration in all cases.

Pleurodesis/ Pleurectomy

Sixteen percent of responders did not perform any type of pleurodesis to prevent recurrence, 54% performed surgical pleurodesis at the time of bullae excision, and 19% performed surgical pleurodesis without pulmonary resection **(Figure 2)**. During interventional treatment with only chest tube insertion, 25% of responders used chemical pleurodesis through the chest tube. The surgeons who use chemical pleurodesis preferred talc powder (17%), tetracycline/doxycycline (12%), and autologous blood (11%).

For surgical pleurodesis, pleural abrasion was preferred by 55% of the surgeons, whereas 22% performed partial pleurectomy. The responders performing thoracoscopy use more surgical pleurodesis than surgeons who perform open surgery ($p = 0.03$).

Fifty-three percent of the surgeons reported that that they never performed chemical pleurodesis. In addition, 23% of the surgeons reported that they did not use surgical pleurodesis either.

Postoperative management

Table 3 summarizes the practice of responders about chest tube duration, indications of chest tube removal and suction. For patients with no persistent air leak few hours after surgery, 68% of the responders reported that the duration of stay of chest tube is 1 to 2 days postoperatively, 24% removed the chest tubes 3 to 7 days postoperatively, and 6% preferred to remove the drains in the first day. Surgeons performing thoracoscopic surgery report shorter (1-2 days) chest tube duration than surgeons performing open surgery ($p=0.009$). There was no difference for other chest tube durations (3-7 days, > 1 week). After chest tube removal, 75% of responders routinely obtained chest X-rays.
Indications to clamp the chest tube was no air bubble in the chest drainage system for 17% of the surgeons and no pneumothorax on the chest X-rays for 13% of them, 49% of

the responders clamp chest tubes according to both criteria, while 22% never clamped chest tubes before removal.

Suction on chest tubes was performed by 51% of the responders. However, 49% never applied suction in their practice. 54% applied suction on chest tubes in all cases, whereas 44% used suction only if there were persistent air leaks.

DISCUSSION

The results of this survey confirm that there is no standard care and treatment algorithm for PSP in children. **Although, adolescents, especially with Marfanoid phenotype have relatively higher risk for pneumothorax when compared to adults, most of the current treatment recommendations are based on adult observational studies and it is difficult to extrapolate optimal treatment options to pediatric patients.** Besides, the treatment selection for PSP varies widely and physicians' choices of treatment often are based on experience rather than evidence-based pediatric guidelines.[7] Although PSP is a relatively rare condition in pediatric population, nearly half of the responders attend to 2 to 5 new patients per year.

The treatment of PSP has two goals; the evacuation of air if necessary, and the prevention of recurrences and also closure of parenchyma.[8] Both conservative and surgical treatment alternatives exist for PSP in children. Non-operative treatment options include oxygen supplementation with watch-and-wait option, or needle aspiration. Surgical approach ranges from chest tube insertion to more invasive interventions such as atypical-lung resection, pleurodesis or bullae excision though thoracoscopy or thoracotomy. Although, there is no clear recommendation for selecting a treatment option, previous adult guidelines are predominantly based on clinical symptoms, size of pneumothorax and number of episodes. The AACP consensus reports suggest more invasive approach considering the size of pneumothorax, whereas, the BTS guidelines recommend conservative approach based on clinical symptoms.[5-6]

It has been suggested that clinically stable adult patients with small pneumothoraxes should be observed in the emergency room for 3 to 6 hours and discharged home, if there is no progression in pneumothorax in the repeated chest-X rays.[5,9] The ACCT report

recommends re-expansion of lungs with chest tube insertion in stable patients with large pneumothorax (pneumothorax ≥ 3 cm apex to cupola distance).[5] An additional suggestion is inserting a chest drain in pneumothorax larger than 20% of hemithorax in chest x-ray irrespective of symptoms.[5] These guidelines claim that the size of pneumothorax is less important than the degree of clinical symptoms.[5] In our survey, 60% of the responders preferred interventional treatment with chest tube insertion if the pneumothorax is > 2 cm in a stable patient. Among the responders, 15% of the surgeons did not insert chest tube in a stable patient regardless of size. On the other hand, 6% inserted chest tubes irrespective of size.

The management of the first episode in a symptomatic patient is more precise. According to the BTS guideline, breathlessness is an indication for active intervention in an adult with PSP.[5] The size of pneumothorax is considered as an indicator for resolution rate and a relative indication for intervention.[5] The ACCTS consensus does not only focus on symptoms and categorize patients as stable or unstable.[6] It suggests that not only symptomatic but also unstable patients should be hospitalized with chest tube insertion. Similar to previous systematic reviews in adults, our survey confirms that interventional approach with chest tube and/or pigtail insertion (78%) was the most common choice of treatment in the first episode.[10] Interestingly, 14% of the responders preferred watch-and-wait as the first line of treatment in the first episode, even if the patient is symptomatic. **Participants from non-European centers prefer 'watch and wait' more than participants from European centers. In this study, we also found that preference of treatment options for of first episode of PSP did not show statistical difference fro centers with different caseloads**.

Another debate exists about the use of chest tubes, pigtails and needle for removal of air from the pleural space. The BTS guidelines highlight the use of needle aspiration as an initial intervention in large and/or symptomatic patients, whereas the ACCP report does not suggest this.[5,6] In a systematic review, it was shown that the chest tube drainage produced higher rates of immediate success, whereas the needle aspiration resulted in shorter duration of hospitalization.[11] Both procedures showed similar long-term outcomes in terms of recurrence.[12] However, Gariepy *et al.* showed that in contrast to the adult series,

there was no advantage of the use of needle aspiration in children.[13] Our results showed that pediatric surgeons, who responded to our survey, mostly prefer chest tube and pigtail insertion instead of simple aspiration.

CT scans are gold standard in detection of small pneumothoraxes and in size estimation. In addition, they can be used for defining an underlying lung pathology and bullous lung disease.[14] In a multivariate analysis, Choi et *al*. found that the presence of air-containing lesions on high resolution CT scans and bullae on chest X-rays were independent risk factors for ipsilateral recurrence.[15] The European Respiratory Society (ERS) task force statement indicates that cross sectional imaging can be useful in complicated cases, where underlying disease is suspected, and in patients requiring surgery.[8] The ACCT consensus panel did not recommend the routine use of CT imaging for the patients with first episode of PSP.[6] In addition, no consensus has been achieved by the experts, regarding the utility of CT scans for evaluating the patients with recurrent pneumothorax, persistent air leaks, and as a preoperative imaging modality.[6] In our survey, responders suggested that they obtained CT scans only in cases of persistent air leaks (40%) and presence of possible bullae (35%). Our results suggest that the use of CT scans in PSP mostly depends on the surgeon's personal preference instead of evidence-based recommendations.

Chest tubes should be removed after ensuring that there is no air leak in the pleural space. In our survey, responders reported that they removed the chest drains if there was no air in the chest X-ray (57%), and if there was no air in the drain (38%). We found that surgeons performing thoracoscopic surgery significantly prefer shorter duration of chest tube drainage when compared to responders who perform open surgery.

The objectives of surgical treatment are surgical repair of persistent air leaks and prevention of recurrence. The ERS task force statement suggests that second episode of PSP, persistent air leaks more than 3 to 5 days, bilateral pneumothorax and hemopneumothorax should be considered as indications for definitive treatment.[8] In our survey, we found that presence of bullae > 2 cm (77%) and recurrence (76%) were accepted as the most common indications for surgical treatment. The ACCT panel reported a very good consensus on thoracoscopy in the treatment and prevention of recurrence.[6] In

contrast; some clinical trials including PSP patients showed that thoracoscopy offered no superiority over limited thoracotomy.[16] The BTS guidelines suggest that open thoracotomy with pleurectomy results in lower recurrence rates than video-assisted thoracoscopic surgery.[5] In the current survey, 84% of surgeons preferred thoracoscopy (92% use multiport), whereas 14% performed open thoracotomy in the surgical treatment. Although few responders preferred other options, excision of bullae with safe margins were well accepted by the majority of the pediatric surgeons

Bullectomy can be performed by electrocoagulation, laser ablation, stapler, Ligasure, endo-loop or hand-sewn depending on the expertise of the institution. Onuki et *al*. suggested that a 5 mm area around the bullae should be resected using a stapler.[17] For large and multiple bullae, Endo-GIA® staplers are used for resection, whereas smaller ones are removed with Endo-loop® ligatures.[18] In the current survey, most of the responders (75%) also preferred Endo-GIA staplers for large bullae. In addition to Endo-GIA staplers, more responders use ligasure and endo-loop (39% vs 16%, respectively) for smaller bullae. Of note, there were no clear conclusions from a systematic review about the use of surgical devices in pediatric population.[18] In our survey, it was also aimed to evaluate the attitudes of responders towards asymptomatic contralateral bullae; 79% did not perform routine thoracoscopic evaluation on the contralateral side during the same anesthesia. Only 18% performed it, if preoperative CT scans revealed bullae on contralateral side. In contrast, and 2% of the responders routinely performed thoracoscopic evaluation regardless of preoperative CT scan findings. Since the development of blebs is a dynamic process and continues throughout the adolescence, there is no rationale to perform routine contralateral thoracoscopic evaluation in patients with ipsilateral bullae/blebs.[18]

The second objective of surgery is to prevent recurrences. In order to prevent recurrence, creating a symphysis between the two opposing pleura should be achieved.[5] Pleurodesis can be obtained by instilling a chemical agent, performing a mechanical abrasion, or via partial pleurectomy.[7] Both ACCP statement and BTS guidelines strongly suggest that chemical pleurodesis should be reserved for patients who are unwilling or unable to undergo surgery.[5,6]

In the past, pleural abrasion was commonly used for surgical pleurodesis. Some studies showed that partial pleurectomy has advantages over pleural abrasion and combinations of both techniques lead to better outcomes.[19] On the other hand, pleural abrasion found superior to apical pleurectomy in a meta-analysis.[20] In this survey, 16% of responders did not perform any pleurodesis to prevent recurrence. The ones, who preferred to perform pleurodesis, mostly chose surgical pleurodesis at the time of bullae excision (54%), whereas 19% performed surgical pleurodesis without lung excision. The results of this survey revealed that surgeons performing thoracoscopy significantly use more surgical pleurodesis than the responders who perform open surgery. These results also suggest that there is yet no standard surgical approach adopted for children.

Chest tubes should be removed after ensuring that there is no air left in the pleural space and that air leaks have been resolved.[6] The BTS guidelines recommend avoiding the routine use of suction on chest tubes.[5] They may cause re-expansion pulmonary edema.[5] In case of persistent air leaks, high volume low-pressure suction systems are recommended.[5] No recommendations have been made by systematic reviews and meta-analysis about the use of routine suction in PSP.[21] In this study, 51% of members reported that they used suction on chest tubes, whereas 49% never performed suction.

Another controversy exists about clamping a chest tube before removal. Among the panel members of ACCT, 53% of them never clamped chest tubes. In our study, 22% of our responders never clamped chest tubes before removal either. Half of the responders clamped chest tubes after they found no air in the chest X-rays and no air-bubble in the chest drainage systems and 75% of them routinely obtained chest X-rays after removing chest tubes.

As in other survey studies, our study has some limitations as well. Since survey studies are based on personal practice of responders, it is difficult to obtain evidence-based results. Different responders may interpret answer options differently. Therefore, responses of participants may show extensive variations. In addition, it is difficult to analyze the results in this heterogeneous sample size. Specific to this study, there is no clear definition of stable patient, size of pneumothorax and persistent air leak. Finally, in same centers children with PSP are managed by a multidisciplinary team, which may include chest physician, adult

thoracic surgeon, and/or interventional radiologists that were not invited to complete the survey. Despite these limitations, we suggest that survey studies may help to understand what the common practices among physicians are, and at which stage of the disease a standardized care of treatment will be needed.

In conclusion, since each surgeon manages limited number of patients per year, there is no consensus about the management of childhood PSP, particularly for different episodes. The management of pediatric PSP shows variability not only in conservative management, but also in surgical treatment. Most of the responders prefer chest tube insertion in the management of first episode of PSP and perform surgical treatment in the second episode in case of underlying bullae > 2 cm and recurrent pneumothorax. The surgeons performing thoracoscopic surgery use more surgical pleurodesis and prefer shorter chest tube duration than the responders performing open surgery. Evidence-based guidelines may help standardize care and improve outcomes of children with PSP.

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TABLES

Table 1. The number of responders for each indication of surgical treatment (multiple choice question).

Table 2: The indications of CT scans during the interventional treatment with chest tube insertion (multiple choice question).

Table 3. The practice of responders regarding the chest tube duration, indication for removal and suction.

FIGURE LEGENDS

Figure 1. The preferences of the participants for chest tube insertion in a stable patient.

Figure 2. The type of pleurodesis to prevent recurrence.