Pediatric primary spontaneous pneumothorax: a comparison of treatment at pediatric surgery *vs.* thoracic surgery departments

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Abstract

Management of pediatric Primary Spontaneous Pneumothorax (PSP) is controversial and based on guidelines on adults. Therapeutic strategies include: observation, needle aspiration, chest drain, or surgery. We aimed to assess: i) differences in the management of PSP in pediatric *vs.* adult departments; ii) risk of recurrence associated to each therapeutic choice; iii) management of "large" pneumothorax (*i.e.* >3cm at the apex on chest X-Ray); iv) role of CT scan in addressing the treatment. We reviewed all PSP treated at Pediatric Surgery Unit (PSU) and Thoracic Surgery Unit for adults (TSU) in a 10-year period (2011 to 2020). We included a total of 42 PSP: 30/42 1st episodes and 12/42 recurrences. Among the 30/42 1st episodes, 15/30 were managed in the PSU and 15/30 in the TSU. Observation was significantly most common among PSU patients (9/15, 60%) *vs.* TSU cases (1/15, 6.7%; p=0.005]. Chest drain placement was reduced in PSU (3/15, 20%) *vs.* TSU (12/15, 80%; p=0.002). Observational was associated with a reduced risk of recurrence (0/10, 0%) compared to chest drain (7/15, 46.7%; p=0.01). Management of 20/42 "large" pneumothorax was: 4/20 (20%) observation, 10/20 (50%) chest drain, 2/20 (10%) needle aspiration, 4/20 (20%) surgery. Twenty-three/29 PSP (79.3%) underwent CT-scan after the first episode. Bullae were detected in 17/23 patients and 5/17 (29.4%) had seven episodes of recurrence. PSP patients treated by PSU were more likely to receive clinical observation. Those managed by TSU were mostly treated by chest drain. Observation seems an effective choice for clinically stable PSP, with low risk of recurrence at a mid-term follow-up. CT-scan seems not to detect those patients at higher risk of recurrence.

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Introduction

Primary Spontaneous Pneumothorax (PSP) is defined as a Pneumothorax (PNX) occurring in the absence of pre-existing pathological lung conditions and/or without a known cause (such as traumas).[1]

The incidence of PSP in adults ranges between 18 and 28/100,000/year in men and 1.2-6/100,000/year in women. Approximately 85% of PSP patients have a characteristic phenotype: tall young males (between 18 and 40 years of age), with a low Body Mass Index (BMI) and smokers (<20 cigarettes/die).[1,2]

The presence of air-containing lesions (*i.e.* blebs or bullae) is considered the main pathogenic mechanism involved in the onset of PSP.[1]

Looking at the pediatric population, the incidence of PSP is lower, and it has been reported to be 3.4/100,000 children/year.[3,4] The male to female ratio in this population is 4:1 and it has been reported a peak of incidence in adolescence.[3,4] Moreover, it has been reported a higher recurrence rate of PSP in the pediatric population *vs.* adults (50-60% *vs.* 30-50%).[5]

Typically, patients present the following symptoms: chest pain, breathlessness, cyanosis or sub-cyanosis and coughing. However, sometimes they can be asymptomatic. When signs of respiratory distress are predominant in the clinical picture, a tension PNX should be suspected.[1]

Diagnosis is usually made through clinical findings and chest X-ray in two projections. CT scanning is usually performed only after the acute phase of the pathology, in order to assess the presence of pre-existing air-containing lesions (blebs or bullae).[1]

The size of PNX can be evaluated on standard chest X-ray. The British Thoracic Society (BTS) defined PNX as "large" when the gap between the chest wall and the lateral lung edge at the level of the hilum is >2cm.[1] The American College of Chest Physicians (ACCP) guidelines, instead, consider a large pneumothorax when there is an apical distance >3cm between the thoracic wall and the lung.[6]

Three more complex methods of quantifying PNX on chest X-ray in adult population are also reported: Light, Rhea and Collins algorithms.[7]

Different therapeutic approaches are described: i) non-surgical treatment (observation, needle aspiration, chest drain);[8] ii) surgical treatment (thoracotomy or video-assisted thoracoscopic surgery (VATS) to perform blebectomy ± pleurodesis).[8]

The choice of treatment is mainly based on the clinical condition of the patient, the size of the PNX and the presence of underlying lung conditions. In most cases, if the clinical conditions are favorable, a conservative treatment is preferable, and surgery should be performed only in those patients with recurrent PNX or persistent air leak.[8]

Looking at PSP in adults, guidelines on its management have been published from the British Thoracic Society and American College of Chest Physicians.[1,6] However, there is not a consensus on the management of PSP in the pediatric population.

As a matter of fact, the strategy of treatment of PSP in children is essentially based on their clinical conditions. Moreover, it has been suggested an early surgical treatment on those patients, because of a higher risk of recurrence.[7,8] Contrariwise, also an initial non-operative strategy has been reported, reserving a surgical procedure only in those patients with a recurrence of the PNX or a persistent air leak.[7,8]

The aims of the present study were to assess: i) whether there are different therapeutic strategies for pediatric PSP in a pediatric *vs.* an adult Department; ii) the risk of recurrence associated to each therapeutic option; iii) the risk of recurrence associated to each therapeutic option in the management of PSP "large"; iv) the role of CT-scan in addressing treatment of PSP.

We did hypothesize that different therapeutic strategies for pediatric PSP could achieve diverse outcomes.

Materials and Methods

Patient selection and data collection

The present study was approved by the Institutional Review Board of the University of Chieti-Pescara (IRB approval number V1.0, approved on 04.02.2016), we performed a retrospective analysis of PSP treated in a 10-year period (from January 2011 to December 2020) in a Pediatric Surgery Unit (PSU) and a Thoracic Surgery Unit (TSU) for adults of an Italian General first level Hospital with a catchment area of nearby 300,000 inhabitants.

The decision to hospitalize the patient in pediatric or adult ward was based mainly on the age of the patient, according to our national regulations. Therefore, all pediatric patients under 17 years of age were managed by the PSU. However, those patients between 17 and 18 years of age were managed by the TSU.

Exclusion criteria were secondary pneumothorax, the presence of an isolated pneumo-mediastinum alone, or incomplete clinical data.

The primary outcome of the present study was to assess whether diverse therapeutic strategies for pediatric PSP among PSU and TSU could result in different incidence of recurrence. The secondary outcomes were to assess the risk of recurrence associated to each therapeutic option in the management of PSP "large" and the role of CT-scan in addressing treatment of PSP.

Data collection included gender, weight, age, height, risk factors and/or co-morbidities, onset symptoms (pain, cough, breathlessness, etc.), time-lapse between onset of symptoms and hospitalization, side of PNX, size of PNX (according to BTS and ACCP guidelines),[1,6] management (non-surgical treatment: observation with O_2-administration OB, needle aspiration NA, chest drain CD, surgical treatment S), length of stay, CT-scan findings (if performed), and complications. Hospital medical databases were interviewed to catch recurrence after the first episode and relative surgical department (PSU and TSU). Moreover, it was reported the incidence of recurrence of PNX according to the different management of the first episode of PSP (*i.e.* OB, NA, CD, or S).

Patients were invited to a telephonic interview asking for further episodes of PNX and related treatment, taken over by other hospitals.

The size of the PNX was assessed according to the American College of Chest Physicians (ACCP) guidelines, considering a "large" PNX when the apical distance between the thoracic wall and the lung was >3cm.[6]

Statistical analysis

Data are expressed as a mean±Standard Deviation (SD) for continuous variables or as percentages and Risk Ratio (RR) with 95% Confidence Interval (CI) for qualitative variables. Statistical analysis was performed using the "GraphPad" 8.0 software (San Diego, California), version, using t-test, Fisher's exact test and one-way ANOVA, when appropriate. We considered statistically significant a p-value <0.05.

We analyzed the overall data first and then data from the single Operative Units, comparing them.

Results

After medical records revision, we selected 36 patients aged £18 years with PNX. Among these, 29 patients were finally included in the present study, 15 from the PSU and 14 from TSU.

Demographic characteristics

Demographics are summarized in Table 1. Of the 29 patients included, 4/29 (13.8%) were female while 25/29 (86.2%) were males, with a male-to-female ratio of 6.5:1. The mean age at the first episode of spontaneous PNX was 16.23±1.7 years. The onset symptom was chest pain for 24/29 patients (82.6%). We found a left-sided PNX in 21/29 patients (72.4%) and a right-sided PNX in 8/29 patients (27.6%).

The time-lapse between onset of symptoms and access to the emergency room was 38.6±77.2 hours, longer for the PSU patients than for those admitted in the TSU, although not statistically significant (64.4±109.8 *vs.* 17.2±20.4 hours, respectively; p=0.21).

However, a single patient treated at the PSU was hospitalized for a persistent cough lasting for 15 days, without airways inflammation, with a Chest X-Ray showing a PNX. Excluding this single patient, we have found a shorter interval between onset of symptoms and hospitalization (22.36±28.8 hours) and the difference among Units remained statistically insignificant (PSU 28.6±36.7 hours *vs.* TSU 17.2±20.4 hours; p=0.4).

The mean Length of hospital Stay (LoS) was 6.4±2.3 days, without statistically significant difference between the two Units (PSU 6.1± 2.8 *vs.* TSU 6.7±1.7; p=0.41).

After discharge, the mean follow-up time is 58.4±33.3 months, significantly longer in Thoracic Surgery (PSU 45.3±28.6 months *vs.* TSU 70.2±33.9 months; p=0.03).

Management of the first episode and the recurrence

We identified 29 patients, with 30 first episodes of PSP, 15/30 (50%) treated at the PSU and 15/30 (50%) at the TSU.

Seventeen/30 first PNX episodes were classified as "large" according to ACCP guidelines (10 in PSU, 66.7%; 7 in TSU, 46.7%; p=0.46).

In detail, 8/15 (53.3%) patients belonging to the PSU were treated with clinical observation, 2/15 (13.3%) with needle aspiration, 4/15 (26.7%) with chest drain, and 1/15 (6.7%) underwent emergency surgery, according to the clinical conditions, the size of PNX and the preference of the surgeon. In those patients managed by chest tube insertion at the first episode, the drain was left closed for 3-4 hours and then removed on the 4th post-operative day. Discharged usually occurred the day after drain removal (range 1-3 days). Those patients surgically managed after the first episode of PSP underwent chest tubes removal on post-operative day 8 (basal tube) and day 9 (apical tube). Discharged usually occurred 2 days later (range 2-3 days).

None of the 8/15 patients managed with clinical observation went through recurrence, however 1/8 (12.5%) underwent a scheduled surgery. One/2 (50%) patients treated with needle aspiration had a recurrence treated by surgery in the TSU; following this episode, the same patient reported a second ipsilateral recurrence, successfully treated with clinical observation. One/4 (25%) patients undergoing chest drain experienced a recurrence of PNX managed with surgery. The remaining 3/4 (75%) did not have any recurrence. Nonetheless, 1/3 of these patients (33.3%) underwent a scheduled surgery. After this episode, the same patient experienced a first recurrence with a further surgical procedure, and a second episode of recurrence, treated by chest drain in the TSU. The single patient treated with surgery at the first episode did not experience any recurrence.

Twelve/15 (80%) patients from the TSU were treated with chest drain; among these 12 cases, 6/12 (50%) had a recurrence, all surgically managed. Moreover, 1/6 patient who experienced a recurrence (16.7%) presented a first contralateral episode and underwent a second surgery. One/15 patients (6.7%) from the TSU was treated with clinical observation and 1/15 (6.7%) was managed with surgery: none of them experienced recurrences.

The treatment of the first episodes of PNX is shown in Table 2. In most cases, the first management was a chest drain insertion (15/30; 50%), followed by observation (10/30; 33.3%). Three/30 episodes (10%) needed emergency surgical treatment. Among the 3 episodes of PNX who needed surgical intervention, 1/3 (33.3%) presented a massive hemopneumothorax with hemodynamic instability while the other 2 (66.7%) had a previous diagnosis of contralateral PSP. The remaining two patients (2/30; 6.7%) were treated with needle aspiration.

Patients with PSP admitted to the PSU were more likely to be clinically observed [Odd Ratio (OR) 21, p=0.005], compared to those admitted to the TSU, which were more frequently treated with a chest drain placement (OR=0.0625, p=0.002; Table 2).

Nine/30 patients (30%) had at least one recurrence of PNX on the same side after the first treatment, for a total of 12 episodes of recurrent PNX. Univariate analysis showed that recurrence was significantly increased among large PNX (9/17, 52.9%) compared to those not large (0/13, 0%; p=0.003; Table 3).

Table 1. Demographic data of the patients with PSP.

	Total (A)	Pediatric Surgery (B)	Thoracic Surgery (C)	p-value (B *vs.* C)
M (%)	25	12 (48)	13 (52)	0.59§
F (%)	4	3 (75)	1 (25)	
Age (months)	16.2±1.7	15.3±1.7	17.1±1.2	**0.002***
Left pnx (%)	21	11 (52.4)	10 (47.6)	1§
Right pnx (%)	8	4 (50)	4 (50)	
Δ time symptoms onset - hospitalization (hours)	38.6±77.2	64.4±109.8	17.2±20.4	0.21*
LoS (days)	6.4±2.3	6.1±2.8	6.7±1.7	0.41*
Follow-up (months)	58.4±33.4	45.3±28.6	70.2±33.9	**0.03***

LoS, length hospital stay; §Fisher's exact test; *Student's t-test; Bold values, statistical significance.

Table 2. Management of the first episode of PSP, comparing the Pediatric Surgery Unit and the Thoracic Surgery Unit of the adults.

	Total	Pediatric Surgery	Thoracic Surgery	p-value§	Odd Ratio (95% CI)
PTS symptomatic at first episodes (%)	30	15 (50)	15 (50)	-	-
Observation (%)	10	9 (90)	1 (10)	0.005*	21 (2.465-242.9)
Needle aspiration (%)	2	2 (100)	0	0.48	∞ (0.473 to infinity)
Chest drain (%)	15	3 (20)	12 (80)	0.002*	0.0625 (0.013-0.346)
Surgery(%)	3	1 (33.3)	2 (66.7)	>0.99	0.4643 (0.030-4.46)
Recurrence (%)	9	3 (33.3)	6 (66.7)	0.42	-

§Fisher's exact test; *statistical significance.

Nine/12 episodes of recurrence were managed with surgery, while the remaining 3 episodes were treated by a chest drain insertion (1/3) or by clinical observation (2/3).

Seven/9 patients who had a recurrent PNX underwent a chest CT scan after the first episode of PSP, which showed air-containing lesions in 6.

We compared the different procedures used to manage the first episode of PNX in order to assess the risk of recurrence and we found that observational treatment appears to be associated with a lower risk of recurrence than chest drain placement (OR=0, p=0.01; Table 4).

Management of PSP "large"

We have managed 20 (47.6%) "large" PNX out of 42 total episodes of PNX (considering both the first episode and the recurrence). A chest drain was placed in 10/20 (50%) episodes, 2/20 (10%) underwent needle aspiration, while 4/20 (20%) were treated conservatively. Four/20 (20%) patients with large PNX underwent surgery (Table 5).

Patients undergoing surgery and chest drain placement came exclusively from the TSU (4/20), while clinical observation (4/20) and needle aspiration (2/10) were only performed at the PSU.

Analysis of length of hospitalization showed that observational treatment resulted in significantly shorter hospital stay than other procedures in patients with "large" PNX (days; mean±SD; OB 4.5±1.0 *vs.* NA 6.0±1.4 *vs.* CD 7.3±1.8 *vs.* S 11.0±0; One-way ANOVA p=0.0137).

We also analyzed the risk of recurrence depending on the type of management of the "large" PNX. Data are reported in Table 6.

Comparing the various type of treatment, we found that clinical observation is poorly associated with the risk of recurrence when

Table 3. Risk of recurrence of pneumothorax according to its size at the first episode.

	Recurrence (%)	No recurrence (%)	p-value§
Male Female	8 (32) 1 (25)	17 (68) 3 (75)	>0.99
<17 years ≥17 years	6 (37.5) 3 (23.1)	10 (62.5) 10 (76.9)	0.45
Left side Right side	6 (28.6) 3 (37.5)	15 (71.4) 5 (62.5)	0.67
PNX large PNX not large	9 (52.9) 0 (0)	8 (47.1) 13 (100)	0.003*

§Fisher's exact test; *statistical significance.

Table 4. Risk of recurrence of pneumothorax according to the management of the first episode.

	Observation (%) Group A (10 pts)	Needle Aspiration (%) Group B (2 pts)	Chest Drain (%) Group C (15 pts)	Surgery (%) Group D (3 pts)	p-value§
Recurrence (%)	0	1 (50%)	7 (46,7%)	1 (33.3%)	A *vs.* B = 0.1 A *vs.* C = 0.01*
No recurrence (%)	10 (100%)	1 (50%)	7 (46.7%)	2 (66.7%)	A *vs.* D = 0.2 B *vs.* C = 1
Unknown (%)	0	0	1 (6.6%)	0	B *vs.* D = 0.4 C *vs.* D = 0.2

§Fisher's exact test; *statistical significance.

Table 5. Management of PSP "large" (apical distance >3 cm).

	Total	Pediatric Surgery	Thoracic Surgery	p-value§	Odd Ratio (95% CI)
PNX large	20	10	10	-	-
Observation (%)	4	4 (100)	0	0.08	0.06878 (0.003155 to 1.499)
Needle aspiration (%)	2	2 (100)	0	0.47	0.1619 (0.006808 to 3.851)
Chest drain (%)	10	4 (40)	6 (60)	0.66	2.250 (0.3758 to 13.47)
Surgery (%)	4	0	4 (100)	0.09	14.54 (0.6669 to 316.9)

§Fisher's exact test.

Table 6. Risk of recurrence of Large Pneumothorax comparing the different management options.

	Observation (%) Group A (4 pts)	Needle aspiration (%) Group B (2 pts)	Chest drain (%) Group C (10 pts)	Surgery (%) Group D (4 pts)	Total (%)	p-value§
Recurrence (%)	0	1 (50)	6 (60)	1 (25)	8 (40)	A *vs.* B = 0.33 A *vs.* C = 0.08
No Recurrence (%)	4 (100)	1 (50)	4 (40)	3 (75)	12 (60)	A *vs.* D = 1 B *vs.* C = 1
						B *vs.* D = 1 C *vs.* D = 0.3

§Fisher's exact test.

compared to needle aspiration, chest drain and surgical treatment, even if without a statistical significance. Chest drain, needle aspiration and surgery, on the other hand, when compared to each other, are associated with a higher risk of recurrence, although not statistically significant.

Role of CT

Twenty-three/29 patients underwent a chest CT scan following the first episode of PSP (79.3%). Among the 6 patients who did not perform a CT scan, 2 cases were operated during the first admission, 2 pts had a recurrence before undergoing CT scan, and 2 pts did not give their consent to perform the CT scan (both cases with small PNX).

In 17/23 patients CT scan showed air containing lesions (blebs or bullae). Five/17 (29.4%) patients with documented air containing lesions on CT scan had a total of 7 episodes of recurrence (3 ipsilateral, 1 patient with two ipsilateral recurrence, 1 patient with an ipsilateral recurrence and a contralateral pneumothorax). Six/7 episodes of recurrent PNX were surgically managed as emergency, while 1/7 was a second recurrence in a patient already treated with an apicectomy, thus underwent a conservative management.

All the 5 patients surgically treated belong to the group of TS patients. Two more patients with air containing lesion at CT scan underwent elective surgery (apicectomy), both in the group of PS patients. Overall, 7 out of 23 patients (30.4%) who underwent a CT-scan had surgery: 2 (28.6%) underwent a scheduled intervention, 5 (71.4%) underwent an emergency surgery (Figure 1). The remaining 10 patients with air containing lesion, as we write this manuscript, neither experienced recurrence nor underwent elective or emergency surgery. No recurrences have been observed to date in the 6 patients with a CT-scan negative for blebs or bullae. Six/29 patients have not undergone a CT scan, of which 3 have experienced recurrences, surgically treated with apicectomy. No statistically significative difference in the risk of recurrences has been observed between patients with CT scan positive for blebs or bullae compared to patients with a negative CT scan (Fisher's test, p=ns), also including patients who have not undergone CT scan (p=ns).

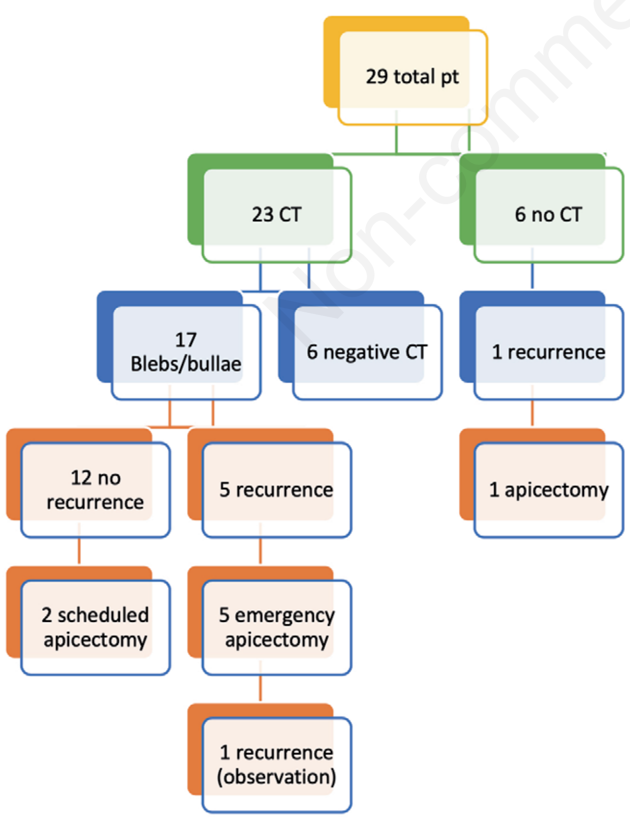

Figure 1. Diagram of workflow in the systematic review and meta-analysis.

Discussion

Management PSP

Treatment of spontaneous primary PNX in children is still debated in literature.[4] Data on pediatric patients are indeed scarce and often mixed with cohorts of adult patients. Guidelines on the management of pediatric PSP are not yet available and are currently based on the guidelines drawn up for adults.[1,6,8]

In literature, two different approaches have been proposed. Some Authors support the choice of a primary surgical treatment, as it is associated with a lower risk of recurrence than chest drainage.[7] A recent retrospective multicenter study suggested that the early surgical treatment of PSP in the pediatric population is feasible and safe, with significantly decreased recurrence rate.[9] Recent papers have reported an incidence of recurrence after VATS between 7 and 13%.[10,11] Moreover, either mechanical or chemical pleurodesis have been considered. It has been reported that blebectomy plus chemical pleurodesis seemed to reduce the incidence of recurrence. However, this technique required a chest tube drainage and a consequent longer postoperative stay.[12]

Furthermore, adolescents with Marfan syndrome revealed an increased risk of recurrences following conservative treatment. Therefore, it has been recommended a surgical intervention as the first line of therapy to treat PNX in those patients.[13]

To the best of our knowledge there are no pediatric guidelines for the management of PSP, therefore, we support the need for prospective studies to create the evidence-based pillars for correct and standardized management of this condition.

On the other hand, there are those who support non-surgical treatment as first approach, reserving surgery only in those patients with recurrence or persistent air leak. In a recent paper, small PSP or clinically stable larger PSP were treated conservatively.[14] Operative management were considered only in those cases with large symptomatic PSP, persistent air leak, and/or relapse after chest drain insertion. Those supporting the non-surgical management, in fact, state that surgery reduces but does not eliminate the risk of recurrence.[8]

Data from our study seem to support the idea that a non-surgical management could be safe and effective when approaching a first episode of primary spontaneous pneumothorax, reserving surgery only for those cases of persistent air-leaking, unstable clinical conditions, and/or recurrence.[1,6,8] Moreover, among non-surgical managements, clinical observation seems to be associated to a lower risk of recurrence than chest tube insertion and needle aspiration. In the present study, the overall incidence of recurrence of PSP (9/30 patients, 30%) seemed to be lower compared to known literature (50-60%).[5] This data, as stated below, could be merely related to the small cohort of patients included.

Although NA is recommended by BTS as a first-line treatment in spontaneous PNX of adults,[1] a multicenter retrospective study conducted by Robinson *et al.* showed a failure rate of this procedure reaching up to 53%, with the need to insert a chest drain.[15] Taking into account the need to avoid repeated invasive procedures in children, it seems that in pediatric patients in which observation alone cannot suffice to resolve the pneumothorax, the treatment of choice could be chest tube insertion.[16-18]

Surgical treatment is reserved for cases of recurrent or persistent PNX.[17]

Another element to consider is the size of the PNX. In our univariate analysis, large PNX seemed to be at higher risk of recurrences. However, it has been reported that the size of PNX does not influence the management.[1] Both the ACCP and BTS guidelines, in fact, suggest a conservative treatment in the presence of a PNX even large, in conditions of clinical stability of the patient.[1,6] This is consistent with our results: in the presence of a "large" PNX, the treatment of choice in both the surgical units analyzed was the non-surgical, mainly chest drain insertion compared to medical observation.

The good results obtained from the non-surgical management in our cohort also raise the question of the appropriateness of the hospitalization of teens in Departments of the adults. In Italy, in fact, teens aging from 16 to 18 could be hospitalized either in a pediatric or in an adults' Department, mainly if there isn't a Pediatric Hospital or pediatric surgical facilities in the neighborhoods.

Adult's thoracic surgeons, however, in our series tend to prefer a more aggressive management of the first episode of PSP, as shown from our results. On the other side, Pediatric Surgeons have a less aggressive first-choice management of PSP followed by the same good results as adult's Thoracic Surgeons. Moreover, pediatric Departments would be more suitable for children and teens, that would face with other pediatric patients. That would make hospitalization more easily accepted for children and teens.

Role of CT-scan

The role of CT scan to detect the presence of air-containing lesions (blebs/bullae) in patients after the first episode of PSP is controversial.[3,8,19] In literature, the incidence of these lesions at CT scan has been reported to range between 30.8 to 100%, and the risk of recurrence in patients with documented air-containing lesions ranges from 50% to 100%.[17] In our study, 74% of children who underwent a CT scan had documented air containing lesions, and among this group of patients only 30.4% had an episode of recurrence.

Furthermore, it has been reported an increased risk of recurrence in those patient <17 years of age.[10,20] As a consequence, a recent paper suggested that one-stage bilateral VATS may significantly decrease future contralateral recurrence in those patients with contralateral blebs at CT-scan, without compromising their safety.[20]

However, the role of this diagnostic examination is not well defined in literature yet. Currently, there is no scientific evidence to support the routine use of CT in all early episodes of PSP.[14] In literature, some Authors suggest that the presence of air-containing lesions may be associated with increased risk of recurrence;[21,22] conversely some others state that a pathologic CT scan is not predictive of the risk of recurrence.[8,23,24] Moreover, it is reported that the "fear of recurrence" in patients with a CT scan suggestive for air containing lesions could limit their normal activity.[25] In our series, we actually observed this event in one patient who was practicing competitive sport and asked to undergo elective surgery to avoid the recurrence.

To further corroborate these data, a recent meta-analysis performed from our group showed the same incidence of recurrence in patients a CT scan with documented bullae *vs.* pediatric cases without bullae detection.[17]

Furthermore, it must be considered the biological invasiveness due to the high dose of radiation to which the pediatric patient is exposed during the CT scan, which does not make it a good screening exam.[3]

Limitations of the study

The statistical validity of the results could be influenced by several factors. The small cohort of patients included could have weakened the statistical validity of the results. Moreover, the retrospective nature of the study could have negatively influenced the accuracy and completeness of data collection. Furthermore, patients were managed at two different Units by different surgeons with different approaches. Finally, there is small yet statistically significant difference in the age of the patients treated in the two Units. Thus, the present results could be biased from these differenced among the two cohort.

Conclusions

Management of primary spontaneous pneumothorax is still debated. Due to the lack of pediatric guidelines, the management of children with pneumothorax depends on the surgeon's choice and experience.

Given the retrospective nature and the small number of patients in the present study, observational treatment seems to be a safe and effective choice for clinically stable pediatric primary spontaneous pneumothorax. A chest tube insertion could be required in persistent pneumothorax. A surgical treatment could be reserved only in those recurrent pneumothoraxes. The role of CT scan remains controversial. As a matter of fact, CT scan showing air containing lesions does not seem to predict the risk of recurrence of PNX.

Therefore, in order to corroborate our data, further high-quality and larger prospective studies would be required in order to achieve standardized management of this condition in the pediatric population.

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