Joint ERS/EACTS/ESTS clinical practice guidelines on adults with spontaneous pneumothorax

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Shareable abstract (@ERSpublications)
This update of an ERS Task Force statement from 2015 provides a concise comprehensive update of the literature base. 24 evidence-based recommendations were made for management of pneumothorax, balancing clinical priorities and patient views. https://bit.ly/3TKGp9e

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Abstract

Background The optimal management for spontaneous pneumothorax (SP) remains contentious, with various proposed approaches. This joint clinical practice guideline from the ERS, EACTS and ESTS societies provides evidence-based recommendations for the management of SP.

Methods This multidisciplinary Task Force addressed 12 key clinical questions on the management of pneumothorax, using ERS methodology for guideline development. Systematic searches were performed in MEDLINE and Embase. Evidence was synthesised by conducting meta-analyses, if possible, or narratively. Certainty of evidence was rated with GRADE (Grading of Recommendations, Assessment, Development and Evaluations). The Evidence to Decision framework was used to decide on the direction and strength of the recommendations.

Results The panel makes a conditional recommendation for conservative care of minimally symptomatic patients with primary spontaneous pneumothorax (PSP) who are clinically stable. We make a strong recommendation for needle aspiration over chest tube drain for initial PSP treatment. We make a conditional recommendation for ambulatory management for initial PSP treatment. We make a conditional

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recommendation for early surgical intervention for the initial treatment of PSP in patients who prioritise recurrence prevention. The panel makes a conditional recommendation for autologous blood patch in secondary SP patients with persistent air leak (PAL). The panel could not make recommendations for other interventions, including bronchial valves, suction, pleurodesis in addition to surgical resection or type of surgical pleurodesis.

Conclusions With this international guideline, the ERS, EACTS and ESTS societies provide clinical practice recommendations for SP management. We highlight evidence gaps for the management of PAL and recurrence prevention, with research recommendations made.

Introduction

This guideline examines the medical and surgical management of spontaneous pneumothorax (SP). It provides a concise comprehensive update of the literature base and provides recommendations for clinical practice (figure 1). It follows the 2015 European Respiratory Society (ERS) Task Force statement on diagnosis and treatment of primary SP (PSP) [1].

The guideline is divided into four sections containing nine PICO (Patient, Intervention, Comparison, Outcome) questions and three narrative questions. The first section describes the initial management of SP, with PICOs 1–4 summarising recent evidence from conservative care, needle aspiration (NA), ambulatory management and surgery at first presentation studies (figure 2). PICOs 5–7 analyse the management of persistent air leak (PAL). PICOs 8 and 9 address optimal recurrence prevention techniques. Three narrative

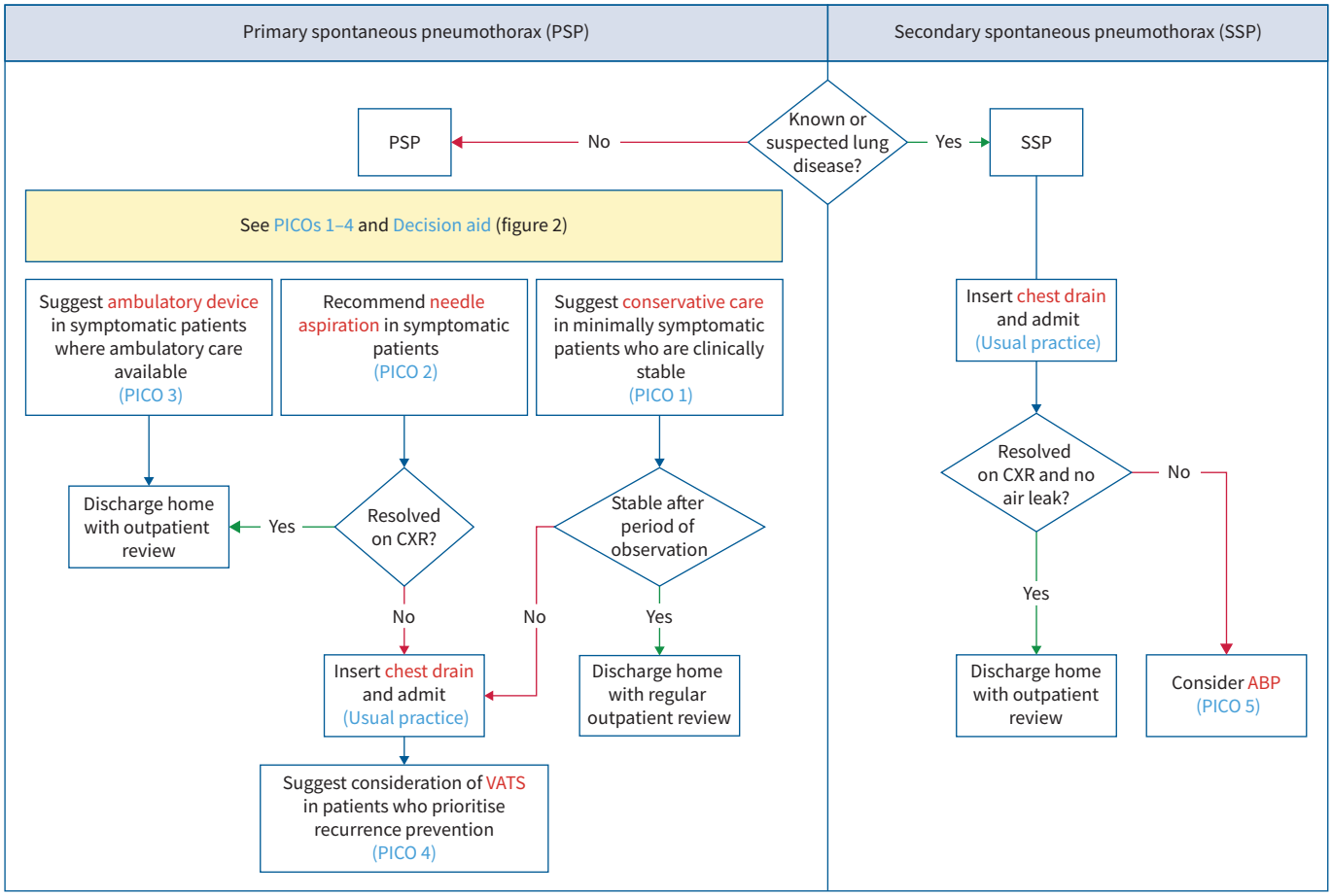

FIGURE 1 Approach for management of spontaneous pneumothorax. This figure is a combination of the recommendations made in this guideline and a description of the Task Force members' usual practice in situations where there was not enough evidence to warrant a recommendation or for questions for which a systematic review of the literature was not undertaken. Note that the information depicted as usual practice is not intended as a recommendation for clinical practice. PICO: Patient, Intervention, Comparison, Outcome; CXR: chest X-ray; ABP: autologous blood patch; VATS: video-assisted thoracic surgery.

Decision aid for initial management pathways for primary spontaneous pneumothorax
Note: this figure is to aid discussions with patients and should be done in conjunction with guidance within the text. The studies referenced used different designs and may not be directly comparable.

The treatment options: from least invasive (left) to most (right)	Observational care (conservative)	Needle aspiration	Ambulatory care	Chest drain	Surgery
How long is the average (mean) initial hospital stay?	1.0 days[#]	2.6 days	0 days	4.8 days	4 days[¶]
What is the chance of a pneumothorax recurrence within a year?	9 patients in 100	25 patients in 100	24 patients in 100	21 patients in 100	6 patients in 100[+]
How often is a further pleural procedure required?	15 patients in 100 Note: no initial procedure with observational care	22 patients in 100	21 patients in 100	25 patients in 100	3 patients in 100 (Further video-assisted thoracic surgery)
What are the complication rates (%)					
Skin infection	1	0	1	3	0
Local bleeding	0	0	7	3	0
Surgical emphysema	0	1	6	6	0
Haemothorax	3[§]	1	3	6	3
Tube blockage or displacement	0	0	5	11	0
Number of studies	1	6	1	6	1[f]
Study reference(s)	[13]	[20–25]	[27]	[20–25]	[33]

[#]: initial length of stay obtained from supplementary appendix [13].
[¶]: does not include readmission for elective surgery, which increases hospital stay to 7.1 days [33].
[+]: 1-year recurrence rates obtained from communication from authors [33].
[§]: the three instances of haemothorax in the conservative management group were noted as a pleural effusion on the chest radiograph, before insertion of any chest tube [13].
[f]: the Al-Mourgi and Alshehri [31] study was not included in the decision aid as listed outcomes were non-comparable.

FIGURE 2 Decision aid for initial management pathways for primary spontaneous pneumothorax.

questions supplement the PICOs by addressing recurrence prediction, timing of surgical interventions and patient-centred implications.

This guideline was conducted by the ERS, in collaboration with the European Society of Thoracic Surgeons (ESTS) and the European Association for Cardio-Thoracic Surgery (EACTS).

Methods

Scope and purpose of the document

This guideline was developed by an ERS/EACTS/ESTS Task Force (TF 2019-05) including specialists in respiratory medicine and thoracic surgery. It included global leaders in pleural medicine and thoracic surgical interventions. Representatives from the European Lung Foundation (ELF) and patient representatives were integral in the guideline development process. The target audience are those involved in the care of adults with SP, including respiratory, general and emergency physicians and thoracic surgeons. The guideline subclassifies SP as either primary SP (PSP) in patients with no suspected lung disease or secondary SP (SSP) in patients with established lung disease. This guideline does not cover the management of iatrogenic or traumatic pneumothoraces.

Composition of the Task Force panel

This ERS/EACTS/ESTS Task Force consisted of a multidisciplinary group of clinicians from different countries. Professor Giuseppe Cardillo, Professor Nick Maskell and Professor Najib Rahman were Senior

Chairs. Dr Steven Walker was Junior Chair. 12 are clinical experts in the field of respiratory medicine, 12 are clinical experts in thoracic surgery and one is an ERS guideline methodologist. The panel included representatives from the ELF, who provided their viewpoints and experiences.

Formulation of questions and selection of outcomes

This ERS guideline was developed according to the ERS standards and methodology for guideline development [2, 3]. Two types of questions were addressed: 1) clinical questions formulated in the PICO (Patients, Intervention, Comparison, Outcomes) format, answered using systematic searches, risk of bias assessment, meta-analyses and certainty of evidence assessment with GRADE (Grading of Recommendations, Assessment, Development and Evaluations), and 2) narrative questions, used to supplement PICO questions, answered with systematic searches and narrative synthesis [3, 4]. A total of nine PICO questions were supplemented by three narrative ones. The questions proposed by the Task Force Chairs were discussed, edited and approved by the whole Task Force.

As required by the GRADE approach, the panel selected the patient-relevant outcomes and rated their importance for clinical decision using three levels of importance: 1) critical, 2) important but not critical and 3) of limited importance for clinical decision making [5]. Outcomes were rated by the panel members through online voting and discussion. Ratings were re-evaluated again after assessing the included evidence. Only outcomes rated as critical and important were analysed and are reported. Evidence summary tables and Evidence to Decision (EtD) frameworks were generated for each PICO, whilst only EtDs were generated for narrative questions (supplementary material: EtD frameworks).

Literature searches and evidence synthesis

Literature searches were performed by an information specialist on 9 March 2021. Ovid MEDLINE and Embase were searched from 2000 until 9 March 2021 (supplementary material). Non-English language excluded unless full English translation.

Screening for relevant studies was performed by two reviewers independently, in two phases (title/abstract and full-text screening), using Clarivate EndNote and Microsoft Excel. Differences between reviewers were resolved by discussion or by a third reviewer. The screening results are presented using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram (supplementary material) [6].

Two types of studies were considered for inclusion: 1) randomised controlled trials (RCTs), and 2) non-randomised studies of interventions (NRSIs) of more than 100 patients. When RCTs were available they were considered as the main body of evidence on which the recommendations were based, while NRSIs served as supplementary evidence.

Data extraction was performed by one reviewer and checked by another, for both bodies of evidence separately (RCTs and NRSIs). Piloted templates in Microsoft Word were used for data extraction (supplementary material).

Evidence synthesis for PICO questions was done using meta-analyses, when clinical and statistical preconditions were fulfilled [3, 7]. Narrative questions were addressed with narrative synthesis, without meta-analyses, according to ERS methodology [3, 4].

Assessment of quality of evidence and strength of the recommendations

RCTs were assessed for risk of bias using the Cochrane risk of bias tool for randomised trials [8]. NRSIs were assessed with the Newcastle–Ottawa Scale [9]. The certainty of evidence was assessed with GRADE [10] taking into consideration risk of bias, inconsistency, indirectness, imprecision and publication bias of included evidence, for each outcome separately. The overall certainty of evidence is a combined rating of the quality of evidence across all critical outcomes, determined by the lowest quality of evidence for any of the critical outcomes [11]. GRADE has four levels of certainty of evidence (very low, low, moderate and high), which reflect the degree of confidence we have in effect estimates to support a recommendation [10].

GRADE EtD frameworks were used to decide the direction and strength of recommendations for PICO and narrative questions [12]. Strong recommendations are presented as “we recommend”, while conditional recommendations are presented as “we suggest”.

Extracted data, risk of bias assessments, PRISMA flowcharts, GRADE evidence profiles and EtDs are presented in the supplementary material.

Each PICO and narrative question was addressed by a subgroup of at least four members. Final recommendations were discussed and agreed upon in a recommendations meeting.

Conflict of interest management

In accordance with the ERS rules, all guideline members signed a confidentiality agreement and declared potential conflicts of interest.

Results

The recommendations for the PICO and narrative questions are summarised in tables 1 and 2, respectively.

TABLE 1 PICO (Patient, Intervention, Comparison, Outcome) questions and recommendations

	Question	Recommendations
PICO 1	Should conservative management be used for spontaneous pneumothorax (compared to needle aspiration/chest drain)?	• The panel suggests conservative management of primary spontaneous pneumothorax (PSP) in selected cases (minimally symptomatic and clinically and radiologically stable), regardless of size of pneumothorax. *(Conditional recommendation, very low certainty of evidence)* • The panel could not make a recommendation for conservative management in secondary spontaneous pneumothorax (SSP), due to lack of evidence.
PICO 2	Should needle aspiration be used in acute presentation of spontaneous pneumothorax (compared to chest drain)?	• The panel recommends needle aspiration (NA) over chest tube drain (CTD) for the initial treatment of PSP. *(Strong recommendation, low certainty of evidence)* • The panel could make no recommendation for or against NA as an effective alternative to CTD for SSP due to lack of conclusive evidence. *(No recommendation, very low certainty of evidence)*
PICO 3	Should ambulatory management be used in the acute presentation of spontaneous pneumothorax (compared to needle aspiration/chest drain)?	• The panel suggests ambulatory management for the initial treatment of PSP, in centres with appropriate expertise and pathways to manage patients as outpatients. *(Conditional recommendation, low certainty of evidence)* • The panel suggests against the use of small bore (8 Fr) ambulatory devices for the initial treatment of SSP. *(Conditional recommendation, very low certainty of evidence)*
PICO 4	Should early surgical management or medical management be used in the treatment of acute initial presentation of spontaneous pneumothorax?	• The panel suggests consideration of early surgical intervention for the initial treatment of PSP in patients who prioritise recurrence prevention. *(Conditional recommendation, low certainty of evidence)* • The panel could not make a recommendation for or against early surgical intervention for the initial treatment of SSP due to lack of evidence.
PICO 5	Should autologous blood patch (ABP) be used for management of persistent air leak (PAL) in spontaneous pneumothorax (compared to chest drain alone)?	• The panel could not make a recommendation for or against the use of ABP in adults with PSP with PAL who are not fit for surgery due to lack of evidence. • The panel suggests that ABP can be considered in adults with SSP with PAL who are not fit for surgery. *(Conditional recommendation, very low quality of evidence)*
PICO 6	Should bronchial valves be used for management of persistent air leak in spontaneous pneumothorax (compared to chest drain alone)?	• The panel could make no recommendation for or against bronchial valves in patients with PSP who are not fit for surgery due to lack of evidence. • The panel could make no recommendation for or against bronchial valves in patients with SSP who are not fit for surgery due to lack of conclusive evidence. *(No recommendation, very low quality of evidence)*
PICO 7	Should suction be used for management of persistent air leak in spontaneous pneumothorax (compared to chest drain alone)?	• The panel could make no recommendation to advise for or against suction in patients with PSP due to lack of conclusive evidence. *(No recommendation, very low quality of evidence)* • The panel could make no recommendation to advise for or against suction in patients with SSP due to lack of conclusive evidence. *(No recommendation, very low quality of evidence)*
PICO 8	Should treatment with pulmonary intervention (VATS) alone be used for recurrence prevention in spontaneous pneumothorax (compared with pulmonary intervention (VATS) plus pleurodesis)?	• The panel could make no recommendation for or against the intervention for PSP due to lack of conclusive evidence. *(No recommendation, very low quality of evidence)* • The panel could make no recommendation for or against the intervention for SSP due to lack of evidence.
PICO 9	Should surgical pleurectomy be used for recurrence prevention in spontaneous pneumothorax (compared to chemical pleurodesis, delivered surgically or medically)?	• The panel could make no recommendation to advise for or against surgical pleurectomy for PSP due to lack of conclusive evidence. *(No recommendation, very low quality of evidence)* • The panel could make no recommendation to advise for or against surgical pleurectomy for SSP due to lack of evidence.

TABLE 2 Narrative questions and recommendations

	Question	Recommendations
NQ 1	What are the optimal methods for predicting initial clinical course and recurrence?	• No recommendation can be made regarding the use of digital air leak measurement, pneumothorax size or symptom duration to predict the initial clinical course. • Radiological identification of large (>2 cm) bullae may be predictive of increased long-term recurrence risk but more evidence is required before recommending routine computed tomography scanning in all patients.
NQ 2	What factors influence determination of fitness for surgery and timing of surgical intervention for persistent air leak?	• When considering surgery in patients with secondary spontaneous pneumothorax and persistent air leak, we suggest that the following factors should be considered: age, comorbidities, type of underlying lung disease, performance status, ASA (American Society of Anesthesiologists) score and degree of emphysema on computed tomography. (*Conditional recommendation, stemming from narrative review of evidence*)
NQ 3	What are the patient-centred implications of a pneumothorax?	• Patients who smoke are more likely to have a recurrent episode. A pneumothorax is a "teachable moment" to emphasis importance of smoking cessation. *(Conditional recommendation, stemming from narrative review of evidence)* • Patients with untreated spontaneous pneumothorax should not fly. *(Conditional recommendation, stemming from narrative review of evidence)* • Patients should wait at least 7 days after radiological resolution of spontaneous pneumothorax before flying due to risk of early recurrence/treatment failure. *(Conditional recommendation, stemming from narrative review of evidence)*

Optimal management of acute presentation of pneumothorax

PICO 1: Should conservative management be used for spontaneous pneumothorax (compared to needle aspiration/chest drain)?

Recommendation

- The panel suggests conservative management of PSP in selected cases (minimally symptomatic and clinically and radiologically stable), regardless of size of pneumothorax. *(Conditional recommendation, very low certainty of evidence)*
- The panel could not make a recommendation for conservative management in SSP, due to lack of evidence.

Remarks

Patients should be observed for 4 h and must be able to walk comfortably around the emergency department to ensure that they are capable of undertaking routine activities of daily living. Early clinical follow-up should be available.

Summary of evidence

Seven studies met the criteria for inclusion: one RCT [13] and six non-randomised studies [14–19].

The main body of evidence was obtained from the RCT, which randomised patients (n=316) with large pneumothoraces to either Seldinger chest tube drain (CTD) insertion (n=154) or conservative management with oxygen and analgesia and clinical observation for at least 4 h (n=162) [13]. The primary outcome of resolution of the pneumothorax at 8 weeks was achieved by 129 (98.5%) in the CTD group *versus* 118 (94.4%) in the conservative management group (risk difference −4.1% points, 95% CI −8.6–0.5; p=0.02 for non-inferiority).

The relative risk of requiring a further pleural procedure in the initial management of pneumothorax was lower in the conservatively managed group (RR 0.29 (95% CI 0.15–0.56)), which equates to 152 fewer procedures per 1000 cases (from 182 fewer to 94 fewer) [16]. Length of stay (LOS) was significantly shorter with conservative management compared to CTD in the RCT (mean±SD 1.6±3.5 *versus* 6.1±7.6 days). Recurrence of pneumothorax at 12 months occurred in 8.8% (n=14) of conservatively managed participants *versus* 16.8% (n=25) of those managed with a pleural procedure (absolute risk difference 8.0% points (95% CI 0.5–15.4), RR 0.52 (95% CI 0.28–0.97) with conservative management). Complications occurred in 8.0% (n=13) of conservatively managed participants *versus* 26.6% (n=41) of those who underwent CTD insertion (RR 0.30 (95% CI 0.17–0.54)).

The included non-randomised studies were conflicting. Three of the six did not identify a difference between the two arms [16–18]. Complications tended to be fewer with conservative management in the non-randomised studies (RR 0.67 (95% CI 0.09–5.08)). Quality of life scores were slightly better with conservative management (mean difference 0.1 higher (0.14 lower to 0.34 higher)).

Justification of recommendation

A conditional recommendation with very low certainty of evidence could be made based on non-inferiority outcome in pneumothorax resolution, with secondary outcomes showing reduced length of hospital stay, better quality of life and no increase in adverse events in selected patients with pneumothorax who are minimally symptomatic with conservative care. Conservative management may be associated with reduced risk of pneumothorax recurrence, although there is conflicting evidence from non-randomised studies. The certainty of evidence was downgraded due to the unblinded study designs and large confidence intervals in several outcomes. The panel felt the high proportion of screen failures of the Brown *et al.* [13] study limited generalisability.

There was no evidence for or against the use of conservative management for patients with SSP.

Additional remarks or practical considerations

Implementation requires education of emergency and respiratory physicians to ensure safe application of the evidence. Cost was not studied but conservative management with earlier discharge and reduced procedures and readmissions is likely to be associated with lower cost. Very low evidence suggests that quality of life is better with conservative management, indicating that it may be acceptable to stakeholders.

Recommendations for future research

Real-world data regarding pneumothorax recurrence and adverse events should be collected to confirm the RCT findings.

Further RCTs on the effectiveness of conservative management with patients with moderate or high symptom burden should be conducted.

PICO 2: Should needle aspiration be used in acute presentation of spontaneous pneumothorax (compared to chest drain)?

Recommendation

- The panel recommends needle aspiration (NA) over chest tube drain (CTD) for the initial treatment of PSP. *(Strong recommendation, low certainty of evidence)*
- The panel could make no recommendation for or against NA as an effective alternative to CTD for SSP due to lack of conclusive evidence. *(No recommendation, very low certainty of evidence)*

Summary of evidence

Eight studies met the criteria for inclusion: six prospective RCTs [20–25] and two non-randomised studies [15, 26].

Studies randomised between CTD between 12 and 28 Fr and needle aspiration (NA), a 16-gauge plastic catheter or small bore (8 Fr) pleural catheter. Four studies allowed a second aspiration in the NA cohort.

Meta-analysis of RCTs comparing NA to CTD demonstrated a shorter LOS of 2.21 fewer days (from 2.92 lower to 1.49 lower) with NA. There was a lower risk ratio for complications of 0.13 (95% CI 0.03–0.48) with NA, which equates to 133 fewer complications per 1000 cases (from 148 fewer to 80 fewer). No other reported outcome reached significant difference.

Only one study examined SSP, as part of a subgroup analysis [25]. The median (interquartile range (IQR)) LOS in the NA arm was 2.5 (1.2–7.8) *versus* 5.5 (3.6–9.2) days in the CTD arm (p=0.049). NA was also associated with higher rates of immediate success in the SSP subgroup: 59% for NA compared to 23% in the CTD group (p=0.011).

Justification of recommendation

A strong recommendation could be made with low certainty of evidence based on six RCTs and two observational studies in patients with PSP. This recommendation was based on significant shorter length of hospital stays and fewer complications in the NA group. The panel felt these were important clinical and patient-focused outcomes.

All studies suffered from serious risks of bias of participants, personnel and outcomes. This was in part due to the invasive nature of the intervention, which makes blinded studies unfeasible. Studies were of reasonable size, although a number did not meet calculated sample sizes to support the main outcomes. There were large confidence intervals in several outcome measures.

Only one RCT examined patients with SSP, as part of a small subgroup analysis. The SSP population was not well defined; it is not possible to determine the severity of the patients' underlying lung disease [25].

Additional remarks or practical considerations

Four of the six RCTs allowed a second aspiration in the NA cohort. The panel feels that clinicians can choose to perform a second NA attempt.

Recommendations for future research

Further studies comparing NA to standard care for treatment of SSP should be undertaken.

There is a need for agreement and standardisation of several outcomes, *e.g.* the timing of "immediate success".

Further studies should focus on the best treatment when NA or CTD fails or if further pleural procedures are required.

PICO 3: Should ambulatory management[#] be used in the acute presentation of spontaneous pneumothorax (compared to needle aspiration/chest drain)?

Recommendations

- The panel suggests ambulatory management[#] for the initial treatment of PSP, in centres with appropriate expertise and pathways to manage patients as outpatients. *(Conditional recommendation, low certainty of evidence)*
- The panel suggests against the use of small bore (8 Fr) ambulatory devices for the initial treatment of SSP. *(Conditional recommendation, very low certainty of evidence)*

[#]: ambulatory management is defined as the use of a Heimlich (one-way) valve device inbuilt or attached to a drainage device.

Summary of evidence

Three studies were eligible for inclusion for this PICO question: two were RCTs, one in patients with PSP and one with SSP [27, 28], and one was a non-randomised study [29].

In the PSP study, 114 patients received ambulatory treatment with an 8 Fr ambulatory pneumothorax device and 113 received standard care with available data to inform the primary outcome [27]. The median (IQR) hospitalisation (up to day 30) was significantly shorter in the ambulatory group (0 (0–3) days) than in the standard care group (4 (0–8) days; $p<0.0001$; median difference 2 (95% CI 1–3) days). 110 (47%) of 236 patients had adverse events, including 64 (55%) of 117 patients in the ambulatory care group and 46 (39%) of 119 in the standard care group. All 14 serious adverse events (defined as those requiring hospital readmission) occurred in patients who received ambulatory care, eight (57%) of which were related to the intervention, including an enlarging pneumothorax, asymptomatic pulmonary oedema and the device malfunctioning, leaking or dislodging.

In the SSP study, 41 patients were randomised between ambulatory care or standard care. The ambulatory care group consisted of either an 8 Fr ambulatory pneumothorax device or attachment of a flutter valve system to 12 Fr CTD. Standard care was 12 Fr CTD attached to an underwater seal. The study found no difference in length of hospital stay between the two groups [28]. This likely reflected the high rate of failure of the 8 Fr ambulatory pneumothorax device. The failure rates and LOS were much lower with the flutter valve system than the 8 Fr pleural vent or standard care, although this study was not powered or designed to compare these two approaches.

Justification of recommendation

A conditional recommendation with low certainty of evidence could be made for ambulatory management in PSP. The data suggest that there was a significant reduction in the duration of hospitalisation including readmissions in the first 30 days. The recommendation is also conditional to specific centres which have the capacities to provide ambulatory care. The certainty of evidence was downgraded due to the unblinded study designs and large confidence intervals in several outcomes. The SSP study was underpowered for the primary outcome and at high risk of both type 1 and 2 errors.

Additional remarks or practical considerations

Ambulatory management with a device incorporating a Heimlich (one-way) valve potentially removes the need for admission, thereby allowing outpatient treatment. A cost-effective analysis of the RCT comparing an 8 Fr ambulatory pneumothorax device to standard care found that outpatient ambulatory management is

highly likely to be a cost-effective option in the management of primary pneumothorax [30]. In general, the ambulatory management pathway requires appropriate expertise and facilities to allow outpatient follow-up. In order to make informed decisions, patients should be aware of the *potential* need for future admission with an ambulatory device. Whilst the evidence suggested potential harm for patients with SSP managed with an 8 Fr ambulatory pneumothorax device, there may be a role for a flutter valve system attached to a drainage device of ⩾12 Fr CTD.

Recommendations for future research

We suggest research should be conducted to identify and characterise a subgroup of patients with SSP who may safely benefit from ambulatory management. We also suggest a study to further explore the potential of larger bore drains attached to Heimlich devices in SSP as suggested in a subgroup of the WALKER *et al.* [28] study.

PICO 4: Should early surgical management or medical management be used in the treatment of acute initial presentation of spontaneous pneumothorax?

Recommendation

- The panel suggests consideration of early surgical intervention[#] for the initial treatment of PSP in patients who prioritise recurrence prevention. *(Conditional recommendation, low certainty of evidence)*
- The panel could not make a recommendation for or against early surgical intervention for the initial treatment of SSP due to lack of evidence.

[#]: early surgical intervention refers to surgery at first presentation for pneumothorax, after stabilising with a chest drain, with the aim of recurrence prevention.

Summary of evidence

Five studies met the criteria for inclusion: two RCTs and three observational and non-randomised studies [31–35].

One RCT randomised 41 patients with PSP to either video-assisted thoracic surgery (VATS) stapled blebectomy with apical pleurectomy (n=19) or chest tube drainage (n=22), both within 24 h after presentation [31]. It was a single-centre trial, and patients with unexpanded lung after CTD were excluded. A second RCT randomised 181 patients with a first episode of PSP to either VATS resection of bullae/blebs and mechanical pleurodesis (n=88) or chest tube drainage (n=93) with stratification on the presence of bleb size ⩾10 mm [33]. Surgery was offered within 5 days after presentation.

Meta-analysis of RCTs demonstrated lower risk ratio for rates of recurrence with early surgical intervention compared to CTD (0.24 (95% CI 0.05–1.13)), which equates to 271 fewer recurrences per 1000 (from 339 fewer to 46 more). No other reported outcome reached significant difference.

The RCT by OLESEN *et al.* [33] only enrolled patients with a first episode. Furthermore, the authors used pleural abrasion (mechanical pleurodesis of all visible pleura parietal with a dedicated tool "MICTEC Pleural abrader"). This technique may well explain the high recurrence rate (6%) compared to the 1.9% recurrence rate reported with talc poudrage in the largest case series [36].

All other included studies were non-randomised (supplementary material: EtD frameworks) [32, 34, 35]. Hospital LOS was lower in the VATS cohort in the two studies which reported it [32, 34]. Recurrence was statistically lower in both studies with VATS [34, 35].

Justification of recommendation

A conditional recommendation with low certainty of evidence could be made for early surgical intervention for the initial treatment of PSP. The data suggest that less recurrence occurs with the surgical intervention; however, due to the low number of patients analysed and lack of other outcomes the panel can only make a conditional recommendation. The strength of the recommendation is lowered by the lack of patient-related outcomes, and application to all patients presenting with PSP will result in over-treatment of patients who would never recur.

The certainty of evidence was downgraded due to the unblinded study designs and large confidence intervals in several outcomes. In total, the two RCTs included 222 patients with PSP [31, 33]. The studies were non-blinded to participants and clinicians. Neither study included patient-related outcome measures such as pain and quality of life, which limits interpretation. The observational studies included 1372 patients but with uneven reporting, patient selection and patient flow. As all studies have the same

direction of results, there is sufficient evidence to evaluate the impact of early surgery in a first episode of PSP on both length of hospital stay and recurrence rate.

Despite inclusion of a total of 481 patients with a first episode of SSP in two studies [34, 35], no data are available to evaluate the effect of early surgery in SSP.

Additional remarks or practical considerations

Implementation of early surgical management of SP requires thorough collaboration between experts in emergency care, respiratory medicine and thoracic surgery. Early surgical management is not readily implementable in low-economy countries. There was no evidence for or against early surgical management for patients with SSP.

The panel also noted that while surgical management in all PSP cases resulted in clearly lower recurrence rates compared to "medical" (chest tube drainage) management, it should be noted that only around 25% of patients with PSP will experience a recurrence. Hence, surgical management of all comers with PSP during the first episode could result in significant over-treatment.

Recommendations for future research

In a first episode of PSP, whilst there is evidence that surgery will reduce overall recurrence, there is a need to robustly identify those patients at greatest risk of short-term (PAL) and long-term treatment failure (recurrence). Research should focus on effectiveness related to outcomes important to patients, including quality of life, overall costs, impact on lung function and work capability.

In a first episode of SSP, there is a need for RCTs to evaluate efficacy defined as length of hospital stay, recurrence rate, preservation of lung function, adverse events including mortality and patient-reported outcomes.

Optimal management of PAL in patients with a pneumothorax deemed not fit for surgery

PICO 5: Should autologous blood patch (ABP) be used for management of persistent air leak (PAL) in spontaneous pneumothorax (compared to chest drain alone)?

Recommendation

- The panel could not make a recommendation for or against the use of ABP in adults with PSP with PAL who are not fit for surgery due to lack of evidence.
- The panel suggests that ABP can be considered in adults with SSP with PAL who are not fit for surgery. *(Conditional recommendation, very low quality of evidence)*

Summary of evidence

Six studies in patients with SSP met the criteria for inclusion: three RCTs and three prospective non-randomised studies [37–42].

Meta-analysis was not performed due to heterogeneity of trial interventions and study designs.

The first RCT randomised 47 patients with 3 days of PAL due to SSP despite CTD to either ABP (n=23) or continued CTD (n=24) [38]. The ABP group received 50 mL ABP at day 0 (n=6) and repeated 2 (n=12) and 4 days (n=5) later if persistent pneumothorax. The control group received ABP at day 10 if persistent pneumothorax (n=16). Resolution of air leak at day 7 was achieved in 78% in the ABP group *versus* 8% in the control group ($p<0.01$). Likewise, the ABP group experienced significantly fewer days in hospital (10.0 *versus* 15.0), days with chest tube (7.9 *versus* 12.8) and days with air leak (5.4 *versus* 10.5; all p-values <0.001).

Another RCT randomised 44 patients with 7 days of PAL due to SSP to either of three doses of ABP (0.5, 1.0 or 2.0 $mL \cdot kg^{-1}$) or placebo (1 $mL \cdot kg^{-1}$ saline water) with 11 patients per group [37]. At day 6, resolution of air leak was observed in 27%, 82%, 82% and 9%, respectively (1.0+2.0 $mL \cdot kg^{-1}$ *versus* placebo, $p<0.01$, or *versus* 0.5 $mL \cdot kg^{-1}$, $p<0.01$).

Both Cao *et al.* [37] and Ibrahim *et al.* [38] found no effect of ABP in patients with grade 3 air leak, defined as "large continuous air leak on gentle respiration" [43]. Occurrence of grade 3 air leak was evenly distributed between groups [37, 38].

The third RCT randomised 150 patients with 7 days of PAL due to SSP to either endobronchial autologous blood plus thrombin patch (ABP_{endo}), bronchial occlusion using silicone spigots (not considered further here) or continued chest tube drainage with 50 patients per group [39]. The ABP group underwent bronchoscopy to identify the leaking bronchus, and then received a bronchial sealant with autologous blood (20–30 mL) and thrombin solution (3 mL) containing 2000–3000 IU of thrombin for each segment of lung. At 14 days, air leak was resolved in 82% in the ABP group *versus* 60% in the control group ($p<0.02$). The ABP group had fewer days in hospital (8.1 *versus* 10.0) and days with air leak (6.0 *versus* 8.4; all p-values <0.02).

There was no significant differences in complications rates between the intrapleural ABP and chest drain groups for fever or pleural infection [37, 38].

Justification of recommendation

There was no evidence for or against the use of ABP for patients with PSP, therefore the panel could not make a recommendation.

A conditional recommendation with very low certainty of evidence could be made for ABP in adults with SSP with PAL. ABP in RCT studies reduced the duration of air leak and length of hospital stay compared to standard care, with no difference in complications rates.

For patients with SSP, the certainty of the evidence is low, given the small number of patients in the identified studies and inconsistencies in the interventions. The certainty of evidence was downgraded due to the unblinded study designs, large confidence intervals and heterogeneity in several outcomes. The heterogeneous interventional approaches and the low number of studies limits the overall strength of evidence. Two studies addressed intrapleural ABP delivered *via* a CTD, while one study investigated intrabronchial ABP *via* a bronchoscope [39]. The studies were heterogeneous in intrapleural ABP dosage.

Additional remarks or practical considerations

ABP is easily implemented in both low- and high-income countries since technical requirements to perform ABP are few, low cost and easy to learn/integrate into the usual care of SP. So far, studies have not shown an increased risk of infection or need for further pleural procedures compared to standard care.

When considered for use, the panel recommends an ABP dose of between 1 and 2 $mL \cdot kg^{-1}$ based on the available literature.

There was no evidence for or against ABP in PSP. As primary pneumothorax patients are generally well enough for surgery, it is unlikely that studies of ABP in this population will be conducted.

Recommendations for future research

In SSP, there is a need for standardised definitions of several outcomes including agreed definitions of pneumothorax resolution, timing for removing CTD, definition of PAL, and optimal ABP dose and timing. There is a need for a sufficiently powered RCT evaluating the effect of ABP on short- and long-term objectives and subjective and health economical outcomes, as well as adverse events including pneumothorax recurrence rates.

PICO 6: Should bronchial valves be used for management of persistent air leak in spontaneous pneumothorax (compared to chest drain alone)?

Recommendation

- The panel could make no recommendation for or against bronchial valves in patients with PSP who are not fit for surgery due to lack of evidence.
- The panel could make no recommendation for or against bronchial valves in patients with SSP who are not fit for surgery due to lack of conclusive evidence. *(No recommendation, very low quality of evidence)*

Summary of evidence

Two studies were eligible for inclusion: one randomised and one non-randomised [39, 44].

The three-arm multicentre RCT of 150 patients compared underwater seal drainage (n=50) with bronchial occlusion using silicone spigots (BOS) (n=50) and ABP (n=50) in patients with SSP and a PAL (>7 days post drain insertion). 84% in the BOS group had resolution of their pneumothorax, compared with 60% in the CTD group (RR 1.4 (95% CI 1.08–1.81)). The air leak duration was 5.21 and 8 days, respectively, and

the length of hospital stay was 7.31 *versus* 10.06 days [39]. The reported incidence of chest pain, cough and fever was similar in both arms of the RCT, and all 50/50 (100%) patients who underwent BOS had temporary haemoptysis, compared to six (12%) in the control arm. In four patients in the BOS group, the spigot became displaced [39].

One retrospective, multicentre series of 112 patients was identified, 75/112 (67%) of whom had intrabronchial valves placed, with a median (range) time to air leak resolution of 16 (2–156) days [44]. The only reported complications in the 75 patients were empyema (1/75) and contralateral pneumothorax (1/75) [44].

Justification of recommendation

No recommendation can be given due to insufficient study data. The certainty of evidence was downgraded due to the unblinded study designs and small study populations. Given the small number of identified studies and the GRADE assessment, which highlighted the serious risk of bias, inconsistency and impression in the complication data, the certainty of the evidence is low.

These studies suggested some potentially desirable effects, but there was minimal data and undoubtedly insufficient for a subgroup analysis or definitive recommendation.

Additional remarks or practical considerations

There was no data on the costs of the interventions.

There was no evidence for or against endobronchial valves in PSP. As PSP patients are generally well enough for surgery, it is unlikely that studies of bronchial valves in this population will be conducted.

Recommendations for future research

An RCT comparing endobronchial valve to standard management of prolonged air leak, particularly in SSP, focused on patient-related outcome measures.

PICO 7: Should suction be used for management of persistent air leak in spontaneous pneumothorax (compared to chest drain alone)?

Recommendation

- The panel could make no recommendation to advise for or against suction in patients with PSP due to lack of conclusive evidence. *(No recommendation, very low quality of evidence)*
- The panel could make no recommendation to advise for or against suction in patients with SSP due to lack of conclusive evidence. *(No recommendation, very low quality of evidence)*

Summary of evidence

One RCT was eligible for inclusion [45].

This single-centre RCT of 29 patients compared standard CTD with suction (either −10 or −20 cmH_2O) and included patients with both iatrogenic (n=12) and spontaneous (n=17) pneumothoraces [45]. Chest tubes were removed at 48 h in 57% (4/7) in the −20 cmH_2O suction arm, 73% (8/11) in the −10 cmH_2O suction arm and 45% (5/11) in the underwater seal (p=0.48) arm. Only 5/29 (17%) patients had a PAL, making the effect estimation and certainty of evidence very imprecise. The relative risk of pneumothorax resolution was 1.45 (95% CI 0.7–2.97) in favour of suction but the confidence intervals are wide, and the GRADE assessment showed a very low overall certainty in the evidence given serious risk of bias and extremely serious imprecision.

Justification of recommendation

No recommendation can be given due to the poor quality of the data. Only a single study was eligible for inclusion. This contained a small heterogeneous population of both iatrogenic and spontaneous pneumothoraces. Additionally, the study was underpowered, recruiting only 29 of an intended target of 120 patients. The study was unblinded, even though this would have been feasible in this trial design. The certainty of evidence is very low with serious risk of bias, and imprecision in the estimates.

Recommendations for future research

An RCT comparing suction and standard chest tube drainage in patients with SP with a PAL with a focus on patient-related outcome measures and time to resolution of air leak is warranted. The potential benefit of digital suction is also uncertain and a comparative study comparing it to standard suction would be beneficial.

Optimal recurrence prevention in SP

PICO 8: Should treatment with pulmonary intervention (VATS) alone be used for recurrence prevention in spontaneous pneumothorax (compared with pulmonary intervention (VATS) plus pleurodesis)?

Recommendation

- The panel could make no recommendation for or against the intervention for PSP due to lack of conclusive evidence. *(No recommendation, very low quality of evidence)*
- The panel could make no recommendation for or against the intervention for SSP due to lack of evidence.

Remarks

Pulmonary intervention was considered to be any intervention on the lung itself (*e.g.* bullectomy or wedge resection), undertaken alone or in combination with an attempt at pleural symphysis for recurrence prevention.

Summary of evidence

Of the screened studies, five met the criteria for inclusion: two RCTs [46, 47] and three large retrospective studies [48–50].

The first RCT [46] randomly assigned 141 patients with PSP in two centres to three groups: thoracoscopic procedure only (group A, n=50), thoracoscopic procedure and pleurodesis with dextrose solution (group B, n=49), and thoracoscopic procedure and pleurodesis with talc–dextrose mixed solution (group C, n=42). The second RCT [47] randomised 289 PSP patients in two centres to either thoracoscopic wedge resection only (WR group, n=144) or thoracoscopic wedge resection and mechanical pleurodesis (WRMP group, n=145).

Meta-analysis of RCTs found no difference in recurrence rates or LOS between VATS pulmonary intervention plus pleurodesis and VATS pulmonary intervention alone, with pooled risk ratio difference for recurrence of 0.85 (95% CI 0.33–2.14) and mean difference in LOS of 0.72 days (from 0.75 lower to 2.19 higher).

All other studies were retrospective (supplementary material: EtD frameworks) [48–50]. One study showed no differences in recurrence rate between intervention and control [49], the two others [48, 50] favoured control.

Justification of recommendation

The panel could not make a recommendation as the evidence is scarce and inconclusive. Our results showed no differences between the intervention and the control for two outcomes analysed, recurrence and LOS. Furthermore, the studies were non-blinded to participants and personnel. Neither study contained patient-related outcome measures such as quality of life or overall costs.

For patients with SSP there was no evidence available, so we could not assess the effect of intervention over control in this population. No recommendation could be made.

Recommendations for future research

Surgical treatment of PSP is traditionally based on bullectomy plus pleurodesis. In the analysed studies, out of a total of 1110 patients, only 42 received talc pleurodesis (talc plus dextrose solution, as opposed to abrasion, *etc.*), hence the efficacy of chemical pleurodesis in recurrence prevention over bullectomy alone should be investigated.

RCTs that evaluate long-term patient-related outcome measures, overall costs, impact on lung function and quality of life are required.

PICO 9: Should surgical pleurectomy be used for recurrence prevention in spontaneous pneumothorax (compared to chemical pleurodesis, delivered surgically or medically)?

Recommendation

- The panel could make no recommendation to advise for or against surgical pleurectomy for PSP due to lack of conclusive evidence. *(No recommendation, very low quality of evidence)*
- The panel could make no recommendation to advise for or against surgical pleurectomy for SSP due to lack of evidence.

Remarks

Apical parietal surgical pleurectomy and chemical pleurodesis are both acceptable treatments and appear to have comparable recurrence of pneumothorax.

Summary of evidence

13 studies were eligible for inclusion: three randomised and 10 non-randomised [46, 51–61].

A single-centre RCT randomised 160 patients with no identifiable bleb or multiple blebs (⩾3) to undergo apical pleurectomy (80 patients) or pleural abrasion with 300 mg of minocycline (80 patients) alongside stapled bullectomy [51]. Another RCT compared thoracoscopic bleb resection or electrocoagulation (TBR-E) (without pleurectomy) *versus* TBR-E plus pleurodesis in two hospitals [46]. 50 patients were randomised to TBR-E only, *versus* 49 patients to TBR-E+pleurodesis with dextrose 20%, *versus* 42 patients to TBR-E+pleurodesis with dextrose 20%+2 g talc. A third RCT investigated whether an additional coverage procedure on the staple line after thoracoscopic bullectomy prevents post-operative recurrence compared with additional pleurodesis [52].

Meta-analysis of these RCTs found no difference in recurrence rates, symptom scores or complications, with risk ratios of 0.94 (95% CI 0.73–1.22), 0.33 (95% CI 0.02–4.86) and 0.69 (95% CI 0.29–1.66), respectively. There was also no difference in operative time or LOS, with pooled mean differences of 11.92 (95% CI −14.54–38.38) min and −0.52 (95% CI −1.27–0.22) days, respectively.

There were 10 non-randomised studies comparing surgical pleurectomy to chemical pleurodesis in patients with PSP. Five outcome domains were suitable for meta-analysis. There were no differences in pooled recurrence (1.19 (95% CI 0.60–2.36)), complication (2.40 (95% CI 0.89–6.46)) or mortality rates (10.44 (95% CI 0.15–713.62)). There was a trend towards shorter operation time (9.36 (95% CI 0.52–18.20) min) with chemical pleurodesis. There were shorter lengths of hospital stay (0.59 (95% CI 0.34–0.84) days) with surgical pleurectomy.

Justification of recommendation

Given the limitations and uncertainties in the available evidence, the panel was unable to make a recommendation either in favour or against surgical pleurectomy for the treatment of PSP.

Meta-analyses showed no differences between treatment groups for analysed clinical outcomes. Furthermore, the included RCTs were assessed to have a serious risk of bias due to unblinded study design, unblinded outcome assessment and allocation concealment. There was serious risk of imprecision within most outcomes, due to large confidence intervals, including benefits and harms. Additionally, there was a high degree of heterogeneity of interventions between the three studies, with only one RCT directly comparing surgical pleurectomy and chemical pleurodesis.

For SSP, no evidence was available, therefore the panel could not make any assessment and did not make a recommendation.

Additional remarks or practical considerations

No RCTs compared surgical pleurectomy with medically delivered pleurodesis. Extrapolating the results of surgical pleurodesis to medically delivered pleurodesis should be done with caution.

Recommendations for future research

More multicentre RCTs directly comparing surgical pleurectomy and chemical pleurodesis are warranted. Future studies should also focus on medically delivered *versus* surgically delivered pleurodesis.

Narrative questions

Narrative question 1: What are the optimal methods for predicting initial clinical course and recurrence?

Recommendation

- No recommendation can be made regarding the use of digital air leak measurement, pneumothorax size or symptom duration to predict the initial clinical course.
- Radiological identification of large (>2 cm) bullae may be predictive of increased long-term recurrence risk but more evidence is required before recommending routine computed tomography scanning in all patients.

Summary of evidence

Predicting initial clinical course. Two studies were included: one prospectively collected cohort study [62] and one retrospective case series [63].

HALLIFAX *et al*. [62] reported on 81 PSP patients as part of an RCT who had digital air leak measurement *via* their chest tube. A digital measurement of air leak >100 mL·min^{-1} on day 1 (24 h after CTD insertion) was associated with an increased risk of failure of initial treatment by day 4/5 (PAL or non-expanded lung) and hence referral for surgery.

LAW *et al*. [63] investigated risk factors for treatment failure (n=196) and found that a larger size of pneumothorax on initial chest X-ray and shorter duration of symptoms prior to presentation were associated with failure of needle aspiration.

Predicting recurrence. 14 studies were included: one RCT [33], two prospective cohort studies [64, 65] and 11 retrospective single-centre case series [18, 66–76].

The RCT of early surgery for PSP by OLESEN *et al*. [33] included stratification by the presence of blebs/bullae (⩾1 cm) to ensure an equal proportion in both trial arms (early VATS *versus* standard care with CTD only). VATS was equally effective in the presence or absence of 1 cm blebs/bullae in reducing ipsilateral recurrence. In Cox regression analysis, the presence of blebs ⩾2 cm was associated with a significantly increased risk of recurrence (adjusted hazard ratio 3.2) but only in the CTD group (p=0.045).

The case series did not consistently report an association between blebs and ipsilateral recurrence (supplementary material: EtD frameworks). Five studies found an association between radiological findings, and three studies did not.

Three case series, including patients post-VATS for recurrence prevention, found an association between c*ontralateral* blebs/bullae and recurrence [65, 69, 71, 76].

One other retrospective study reported that the size of the initial pneumothorax (n=91) was not predictive of long-term recurrence [67].

Justification of recommendation

Findings from these studies regarding blebs/bullae are inconsistent, and most of the data are from retrospective case series with a high risk of bias. However, data from an RCT suggested that patients with large blebs (⩾2 cm) were associated with higher recurrence. There are few studies investigating predictors of initial clinical course, so that no conclusions can be drawn.

Recommendations for future research

Prospectively collected observational studies are required to predict those patients at risk of PAL (short term) and recurrence (long term).

RCTs should assess the utility of prediction models on the patient pathway with patient-important outcomes.

Narrative question 2: What factors influence determination of fitness for surgery and timing of surgical intervention for persistent air leak?

Recommendation

- When considering surgery in patients with SSP and persistent air leak, we suggest that the following factors should be considered: age, comorbidities, type of underlying lung disease, performance status, ASA (American Society of Anesthesiologists) score and degree of emphysema on computed tomography. *(Conditional recommendation, stemming from narrative review of evidence)*

Summary of evidence

Fitness for surgery. Four studies were eligible for inclusion in this narrative question: three were non-randomised retrospective studies [77–79] and one was a non-randomised prospective study [58].

A retrospective study by ICHINOSE *et al*. [77] reviewed 183 patients who underwent surgery for SSP. The study assessed risk factors for unsuccessful treatment. Successful surgery was defined as surgery without hospital mortality, post-operative complications, death within 6 months or ipsilateral recurrence of pneumothorax within 2 years. Underlying lung disease was found to be a risk factor for unsuccessful treatment, with SSP caused by interstitial pneumonia more likely to have unsuccessful surgery compared to SSP caused by COPD (OR 3.7; p=0.0041).

A retrospective study by ISAKA *et al.* [78] examined factors associated with mortality, morbidity and recurrence in 94 patients with SSP who had emphysema. Each patient had a pre-operative chest computed tomography,

and the extent of emphysematous change was scored with a visual scoring system described by GODDARD *et al.* [80]. Post-operative mortality was higher in older patients (p=0.040), those with higher Eastern Cooperative Oncology Group (ECOG) performance status ⩾3 (p=0.0011) and patients with pre-operative pneumonia (p=0.0001). In multivariate analysis post-operative morbidity was associated with a Goddard score ⩾7 (OR 8.93; p=0.033) and treatment of bullae without the use of staplers (OR 11.57; p=0.019).

A prospective study by JIANG *et al.* [58] followed 1800 patients with PSP and 492 patients with SSP to determine risk factors for PAL in patients who underwent VATS. Post-operative air leak was more common in older patients (p<0.05), in patients with SSP compared to PSP (p<0.05), in patients with a higher ASA (American Society of Anesthesiologists) score (p<0.05) and larger diameter of bullae (p<0.05). When these factors were entered into multivariate analysis, four variables (age, ASA scores, bilateral procedures and diameter of bullae) were found to be independently associated with PAL (p<0.05).

Timing of surgery. None of the studies in the literature search examined timing of surgery.

Justification of recommendation

The evidence for determining factors for fitness and timing of surgery is very low and there is likely a large selection bias in the available observational data. However, the data from the studies are consistent in their support for risk stratification of patients, and in keeping with current standards of care. However, there have been no randomised trials or comparative studies examining outcomes when selection criteria are used.

Additional remarks or practical considerations

The common LVRS (lung volume reduction surgery) lung function exclusion criteria cannot be applied in patients with an indwelling drain to determine fitness for surgery, as a pneumothorax is a contraindication for most measurements of lung volumes and diffusion capacity. Nevertheless, the panel felt that some selection criteria could be reasonably extrapolated from LVRS and the following could be considered relative contraindications to surgery for SSP: type II (hypercapnic) respiratory failure, right ventricular dysfunction or clinically significant pulmonary hypertension. These patients will be at high risk from general anaesthesia and the single lung ventilation necessary for minimally invasive surgical intervention.

Whilst there were no studies examining the timing of surgery in patients with SSP, the panel felt the timing of intervention is determined by the potential infective risks of leaving a drain in an elderly immobile patient against the risks of general anaesthesia in a patient with severe underlying lung disease. The general decision to operate is determined by several factors which may stimulate early or delayed intervention. A large air leak with a non-expanding lung is likely to need early intervention to avoid an empyema developing. If the lung is expanded, then one may be more likely to suggest closed chemical pleurodesis *via* a chest drain, particularly if the patient is deemed high risk (as defined above).

Recommendations for future research

Prospectively collected and randomised studies should be considered in patients with SSP. This could include surgical *versus* non-surgical management of PAL in SSP.

Narrative question 3: What are the patient-centred implications of a pneumothorax?

Recommendations

- Patients who smoke are more likely to have a recurrent episode. A pneumothorax is a "teachable moment" to emphasise importance of smoking cessation. (*Conditional recommendation, stemming from narrative review of evidence*)

Based on the evidence and current guidance, the panel agrees with other recommendations that state:

- Patients with untreated spontaneous pneumothorax should not fly. *(Conditional recommendation, stemming from narrative review of evidence)*
- Patients should wait at least 7 days after radiological resolution of spontaneous pneumothorax before flying due to risk of early recurrence/treatment failure. *(Conditional recommendation, stemming from narrative review of evidence)*

Summary of evidence

Smoking. There is strong evidence supporting the link between smoking and developing a pneumothorax, with a clear dose–response relationship [81, 82]. A systematic review of recurrence rates in PSP suggests a correlation between smoking cessation and reduced recurrence risk (OR 0.26 (95% CI 0.10–0.63)) [83]. Smoking at time of VATS for PSP has been shown to increase recurrence risk, with higher incidence of recurrence in smokers (24/575 (4.2%)) compared to non-smokers (2/805 (0.2%)) (p<0.001) [83]. This

finding was not universal, with another study examining life-style predictors for post-surgical recurrence finding no difference between smokers and non-smokers [84].

Flying. Previous guidance recommends patients who have had a SP must have a chest X-ray to confirm resolution prior to flight and should wait a further 7 days before embarking upon flight [85, 86]. Although the risk of readmission within a week of discharge of SP is small and there is evidence that suggests recently treated or small pneumothoraces are unlikely to cause significant issues in patients with normal underlying lung function, this remains pragmatic advice [87, 88]. There have been case reports of uncomplicated air travel of patients with chronic pneumothoraces. However, this was only after extensive investigations had confirmed stability of their condition, including hypoxic challenge test and exposure to a hypoxic hypobaric environment in a decompression chamber [89]. Patients with cystic lung disease, particularly lymphangioleiomyomatosis, may have their relatively high baseline risk of pneumothorax increased with air travel [90]. These patients should have a lower threshold to have a chest X-ray if before, during or after a flight they develop chest pain or shortness of breath [90].

Physical activity. There are case reports of pneumothoraces following physical activity, including playing musical instruments, shouting or blowing up balloons [91]. Whilst these cases may highlight the possible physical effect of the Valsalva manoeuvre on transpulmonary pressure and the potential risk of developing pneumothorax, there is not a strong enough correlation to make any recommendations about activity avoidance. This guideline supports the recommendation from the British Thoracic Society Fitness to Dive Group, that diving after a pneumothorax should be discouraged permanently unless a very secure definitive prevention strategy has been performed such as surgical pleurectomy [92, 93].

Justification of recommendation

The evidence for determining the patient-centred implications of a pneumothorax is extremely low and is largely anecdotal from small case series or clinical reviews. The panel has acknowledged other international guidelines to support recommendations.

Recommendations for future research

Research is required to study patient priorities and provide more evidence for patient-centred implications.

Discussion

The optimal management for SP remains contentious despite a wealth of new evidence published since the previous ERS Task Force [1]. This reflects diverse opinions on what an effective intervention is, with priorities ranging from recurrence prevention, minimising hospital bed days to minimising number of interventions. Additionally, the strength of individual recommendations is moderated by the small number of studies available to each PICO.

This guideline strengthens the support of conservative care for PSP in minimally symptomatic patients, compared to previous guidance. The Brown *et al.* [13] study demonstrated conservative care can be applied safely in a selected population, regardless of size of pneumothorax. A significant development is the recommendation for ambulatory management for PSP. This recommendation does not extend to use of ambulatory care for SSP at initial presentation. Needle aspiration remains a viable option for patients with PSP, with pooled analysis demonstrating shorter lengths of stay. Another advancement is the consideration of early surgical intervention for the initial treatment of PSP in patients who prioritise recurrence prevention. Previously, surgical (VATS) procedures were typically offered in the stable phase to prevent recurrence in patients with prior SP events.

This is the first guideline to have specific PICO questions addressing the challenging clinical problem of PAL. The panel made a conditional recommendation that ABP could be considered in adults with SSP with PAL who are not fit for surgery. The small trial populations and differing techniques in ABP studies limit the overall strength of recommendation for ABP. There was insufficient evidence to recommend for or against endobronchial valves or thoracic suction, with a small number of identified studies and serious risk of bias. All these techniques remain at the discretion of the treating physician, and better quality evidence is clearly needed.

This guideline addresses whether the surgical pulmonary intervention (apical resection/bullectomy) is the important aspect of the surgery, or whether it is the intervention on the pleura (pleural symphysis) that contributes most to prevention. This is an extension of the question of mechanism of pneumothorax formation: does the air leak originate from the ruptured bleb or instead from abnormal inflamed visceral pleural as described by Noppen *et al.* [94]. Analysis of the available literature found no difference in patients managed with a pulmonary surgical intervention and those managed with a pulmonary surgical

intervention and a pleurodesis procedure. A further aspect to this discussion is the optimal approach to pleurodesis. Three RCTs examining heterogeneous surgical pleurectomy and chemical pleurodesis found no difference in recurrence between the two approaches.

Conclusion

With this international guideline, the ERS, EACTS and ESTS societies provide evidence-based clinical practice recommendations for the initial management of pneumothorax. We also highlight evidence gaps for the management of PAL and recurrence prevention, with research recommendations made.

This document was endorsed by the ERS Executive Committee on 29 February 2024, by ESTS on 18 March 2024 and by EACTS on 19 March 2024.

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