Brief Report

Needle aspiration versus tube thoracostomy in patients with symptomatic primary spontaneous pneumothorax: an updated meta-analysis of randomized controlled trials

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Abstract: Primary spontaneous pneumothorax (PSP) is an important disease commonly seen in young males. While incidentally diagnosed cases can be managed conservatively, symptomatic patients often necessitate intervention. Chest tube placement (tube thoracostomy) is commonly used, at least in the USA as a primary treatment modality, which requires hospitalization. On the other hand, needle aspiration (NA) has been widely adopted due to simplicity and reported efficacy and safety. No consensus is reached regarding superiority and/or preferred modality, with a lack of guidelines agreement. Therefore, we conducted an updated meta-analysis of randomized controlled trials comparing NA to tube thoracostomy in patients with symptomatic PSP. Prespecified outcomes were immediate success rate, 12-month recurrence rate, post intervention complications rate, and hospital length of stay. We identified and pooled data from six randomized trials, with a total of 759 patients and a median follow up of 12 months. Our analysis showed that NA and tube thoracostomy have similar immediate success rate and 12-month recurrence rate. We also found that NA has less complication rate, need for surgical intervention, and less hospital stays. In conclusion, our review showed that in symptomatic patients with PSP, NA is as effective as tube thoracostomy regarding immediate success rate and 12-month recurrence rate, with the added benefit of less complications rate and need for surgical intervention.

Keywords: Primary spontaneous pneumothorax (PSP); needle aspiration (NA); tube thoracotomy; chest tube; meta-analysis

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Spontaneous pneumothorax (SP) is a worldwide problem with significant impact on patients and society (1,2). It's defined as air accumulation in the pleural space with no obvious precipitating factor (1,2). The actual incidence remains unclear, but is estimated around 18–28 per 100,000 men and 1.2–6 per 100,000 women annually (3). Primary spontaneous pneumothorax (PSP) is a subtype of SP in which patients have no "known or apparent" underlying lung pathology. Asymptomatic and/or small size pneumothorax can be treated with observation and/or oxygen supplementation (1,2). On the other hand, when patients are symptomatic or have "large" pneumothorax, intervention is usually warranted, in the form of needle aspiration (NA), closed thoracostomy (CT), or surgical intervention, with the aim of lung-re-expansion and recurrence prevention (2-4). The newly released British

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Thoracic Society (BTS) pleural disease guidelines recommend symptom-based driven management regardless of the pneumothorax size, but they don't recommend one modality over the other (1). On the other hand, the American College of Chest Physicians (ACCP) recommends intervention based on pneumothorax size (>20%) in addition to symptoms, and endorses CT as a first modality (2), while the European Respiratory Society task force (ERS) recommend NA as a first modality of choice (4). CT, which necessitates hospital admission, is widely adopted as the first-line modality, especially in the USA (3,5). Despite that, NA gained more interest over the last decade, due to ease of application, less invasiveness, and good outcomes (1,3,5) Numerous studies investigated the two modalities (CT and NA), with no clear consensus regarding superiority (5-10). There are also few systemic reviews and meta-analyses with different results (3,11,12). Marx *et al.* published a new trial recently as an addition to existing literature (5). Therefore, we conducted an updated meta-analysis of only randomized controlled trials (RCTs) comparing NA to CT in patients with symptomatic PSP to provide a quantitative summary of current high-quality evidence.

We systematically searched multiple databases (PubMed/Medline, Cochrane, Embase) using pre-specified search terms (Primary Spontaneous Pneumothorax OR Non-traumatic Pneumothorax AND Needle Aspiration OR Needle Drainage OR Simple Aspiration AND Tube thoracostomy OR Chest tube placement OR Chest tube drainage), from inception till August 1st, 2023. Two investigators searched the literature, reviewed titles, abstracts, and full manuscripts, then if suitable extracted the data independently (M.M.G.M., S.P.). A third investigator (R.N.) reviewed and vouched for data accuracy. We included only RCTs comparing first line NA to first line chest tube insertion/CT in patients with symptomatic PSP. Trials including patients with tension pneumothorax, traumatic chest injury or known pre-existing lung disease, or studying conservative management were excluded. Eligible trials must report at least our stated primary outcomes to be included. Minimum follow-up was restricted to at least 12 months. Search was limited to English language.

Co-primary outcomes of interest were immediate success rate (defined as complete or near complete resolution of pneumothorax on chest X-ray, within 24-hour of intervention) and 12-months recurrence rate (detected by follow up chest X-ray). Secondary outcomes included hospital length of stay (LOS) measured in days.

Safety was assessed as rate of major complications post intervention (as reported by each trial individually) and/or need for any operation/surgical intervention after the first index procedure. We reported odds ratio (OR) and mean difference (MD) with 95% confidence interval (CI). Heterogeneity was assessed using the I^2 statistic. All the statistical analysis was conducted using random-effects model via RevMan 5.4 software.

We identified six eligible RCT with a total of 759 patients (NA =372, CT =387), and a median follow up duration of 12 months (5-10). The patients mean age was 29.7±10.7 years, with a mean BMI of 21.0±3.0 kg/m^2, and a male predominance of 84%. Patients with current or ex-smoking history represented 70%. Patients with complete pneumothorax, and right sided pneumothorax represented 58% and 59% respectively. Symptoms on presentation were chest pain and/or dyspnea.

All studies followed standardized protocols for NA and CT interventions. If 2 attempts of NA were unsuccessful (clinically and/or radiographically) patient receives a CT and follows that arm protocol. More details of the procedure/intervention are provided in *Table 1*.

Our analysis showed that regarding coprimary outcomes, no statistically significant difference between NA and CT regarding immediate success rate and 12-month recurrence rate (OR 0.67, 95% CI: 0.42–1.07, P=0.09, I^2=32%; OR 0.87, 95% CI: 0.60–1.26, P=0.45, I^2=7%, respectively) (*Figure 1*).

Regarding secondary outcomes, complications rate and/or need for surgical intervention, and hospital LOS, there was statistically significant difference favoring NA over CT (OR 0.29, 95% CI: 0.14–0.58, P<0.001, I^2=0%; MD =–2.22, 95% CI: –2.86 to –1.58, P<0.001, I^2=52%, respectively) (*Figures 1*,*2*).

All the included trials reported (although differently) patient's tolerability and pain experience favoring NA compared to CT.

Our study compared first-line NA to first line CT in patients with symptomatic PSP in RCTs. We found that NA is comparable to CT regarding immediate success rate and 12-months recurrence rate, albeit there is a significant difference regarding complications rate and hospital LOS favoring NA over CT.

Patient's demographics were consistent with PSP patients in literature. A young male with low normal BMI and a history of smoking is the norm (1-4). Regarding management options, our findings are also in line with the current literature. Tan and colleagues conducted a meta-analysis that was not exclusive only on PSP, but they

Table 1 Characteristics of interventions and/or procedures in individual studies

Study	NA[†]	CT	PAL/rescue therapy
Ayed *et al.*, 2006 (8)	Catheter size 16 G, applied –10 to 15 mmHg pressure, till bubbling stop or 30 min, allowed 2 attempts	Size 20 F, under water seal suction –20 mmHg pressure, left for 24 hours after resolution	PAL >7 days, proceed to VATS
Harvey *et al.*, 1994 (10)	Catheter size 16 to 18 G, 3 ways tap exit to tube under water, continued till no more air, or patient discomfort, or 3 L aspirated	No data	No data
Kim *et al.*, 2019 (6)	Catheter size 16 G, then applied mechanical suction followed by manual aspiration till no more air, allowed 2 attempts	Size 12 F, under water seal, applied –10 to 15 mmHg pressure, discharge 12 hours after CT removal	Surgery if PAL >5 day
Marx *et al.*, 2023 (5)	Single use commercial trocars, noncompartmental suction bottles, aspiration –25 mmHg pressure for 30 min, allowed 2 attempts	Size 16 to 20 F, Pleur-evac tricompartmental chambers, removed 72 hours after procedure	No data
Noppen *et al.*, 2002 (9)	Cather size 16 G, applied manual aspiration till no more air aspirated, allowed 2 attempts	Size 16 to 20 F to water seal, left for 24 hours after resolution	PAL >7 days, up to treating physician
Ramouz *et al.*, 2018 (7)	Catheter size 16 G, applied manual aspiration till no more air or 3.5 L drained, allowed 2 attempts	Size 16 to 20 F to water seal for 24 hours, discharge after 24 hours from CT removal if stable	Talc pleurodesis

[†], if 2 attempts of NA failed patient receive CT and then follow respective protocol. NA, needle aspiration; CT, chest tube; PAL, persistent air leak; VATS, video-assisted thoracoscopic surgery; G, gauge; F, French.

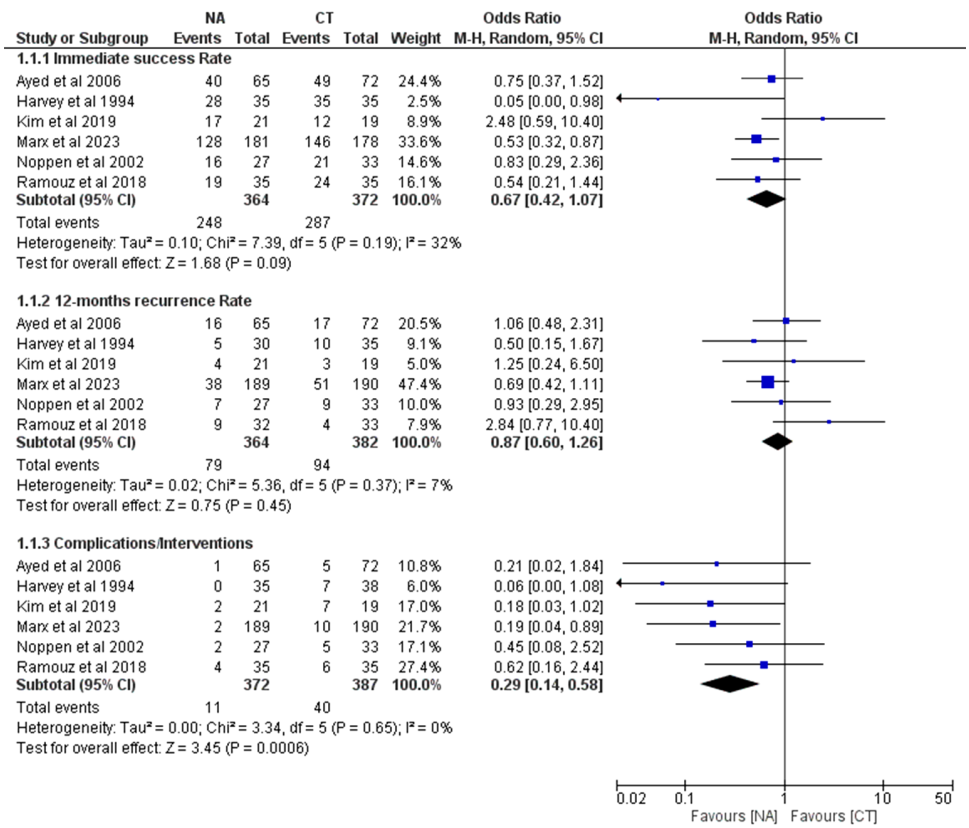

Figure 1 Clinical outcomes (immediate success rate, 12-month recurrence rate, complications/surgical intervention rate). NA, needle aspiration; CT, closed thoracostomy; CI, confidence interval; M-H, Mantel-Haenszel.

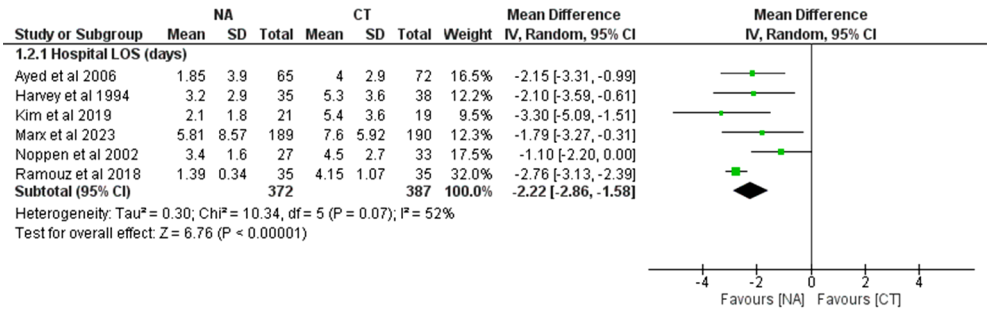

Figure 2 Clinical outcome (hospital LOS/days). LOS, length of stay; NA, needle aspiration; CT, closed thoracostomy; CI, confidence interval; SD, standard deviation.

also compared NA to CT (3). They found no statistically significant difference between NA and CT regarding initial success rate. Also, Muhetaer and colleagues investigated surgical interventions in addition to NA and CT in patients with PSP (11). They showed in their network meta-analysis that there is no statistically significant difference between NA and CT in terms of recurrence rate. They also found a lower rate of hospitalization and complications rate favoring NA.

Our findings slightly differ from a Cochrane data base review that was published in 2017 (12). The Cochrane review found that CT produces a higher rate of immediate success, while NA led to shorter hospitalization (12). We think the difference with our findings stems from the different studies included, (as we restricted our inclusion criteria to solely PSP, while the Cochrane review included a heterogeneous study that combined PSP with traumatic pneumothorax). In addition, we had the advantage of including the recently published trial by Marx *et al.* (5) few months ago. Noteworthy, the abovementioned study had 379 patients, accounting for half (49.9%) of this meta-analysis total population. Despite that, our study, and the Cochrane study both agreed that NA leads to less complication rate and hospitalization.

The fewer complications rate noted with NA is probably due to the nature of the procedure, being less invasive, and shorter intervention time. When combined with better tolerability and less painful experience, one can argue that NA is more attractive than CT regarding equivalent efficacy, ease of application, less rate of complication and more patient tolerability. As such, the recently published BTS pleural disease guidelines recommended that in patients with PSP, if intervention is warranted, both NA and CT are safe, effective, and reasonable options to consider, with low evidence to recommend one modality over the other. But we argue that NA can be considered as the first modality for treating patients with symptomatic PSP, unless other conditions prevail.

Nonetheless, provider comfort level, institutions, and health system protocols, follow up systems, and patient's factors (high risk occupations) all are factors to be considered in the decision-making process. More importantly, patients' preferences and choices should be a major determinant for the management when suitable, as conservative management is now a valid option based on the recent trial by Brown *et al.* (13), as well as the ambulatory drain if a good follow up system is feasible. Both options were endorsed by BTS in their last guidelines (1). Further research is needed to explore the interplay of those factors.

Our study has several limitations; we used only published population level data. Also, included studies have relatively small sample size, with one study accounting for about half of the total sample (5). Moreover, there is heterogeneity and inconsistencies in reporting important endpoints, like pain scale and analgesia requirement. Despite that, we believe that our study has the advantage of summarizing updated rigorous evidence of an important topic.

To conclude, in patients with symptomatic PSP, first-line NA is as effective as closed thoracotomy, with less complication rate and hospital LOS.

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

References

1. Roberts ME, Rahman NM, Maskell NA, et al. British Thoracic Society Guideline for pleural disease. Thorax 2023;78:s1-s42.
2. Baumann MH, Strange C, Heffner JE, et al. Management of spontaneous pneumothorax: an American College of Chest Physicians Delphi consensus statement. Chest 2001;119:590-602.
3. Tan J, Chen H, He J, et al. Needle Aspiration Versus Closed Thoracostomy in the Treatment of Spontaneous Pneumothorax: A Meta-analysis. Lung 2020;198:333-44.
4. Tschopp JM, Bintcliffe O, Astoul P, et al. ERS task force statement: diagnosis and treatment of primary spontaneous pneumothorax. Eur Respir J 2015;46:321-35.
5. Marx T, Joly LM, Parmentier AL, et al. Simple Aspiration versus Drainage for Complete Pneumothorax: A Randomized Noninferiority Trial. Am J Respir Crit Care Med 2023;207:1475-85.
6. Kim IH, Kang DK, Min HK, et al. A Prospective Randomized Trial Comparing Manual Needle Aspiration to Closed Thoracostomy as an Initial Treatment for the First Episode of Primary Spontaneous Pneumothorax. Korean J Thorac Cardiovasc Surg 2019;52:85-90.
7. Ramouz A, Lashkari MH, Fakour S, et al. Randomized controlled trial on the comparison of chest tube drainage and needle aspiration in the treatment of primary spontaneous pneumothorax. Pak J Med Sci 2018;34:1369-74.
8. Ayed AK, Chandrasekaran C, Sukumar M. Aspiration versus tube drainage in primary spontaneous pneumothorax: a randomised study. Eur Respir J 2006;27:477-82.
9. Noppen M, Alexander P, Driesen P, et al. Manual aspiration versus chest tube drainage in first episodes of primary spontaneous pneumothorax: a multicenter, prospective, randomized pilot study. Am J Respir Crit Care Med 2002;165:1240-4.
10. Harvey J, Prescott RJ. Simple aspiration versus intercostal tube drainage for spontaneous pneumothorax in patients with normal lungs. British Thoracic Society Research Committee. BMJ 1994;309:1338-9.
11. Muhetaer M, Paerhati K, Sun Q, et al. Effects of Different Treatment Regimens on Primary Spontaneous Pneumothorax: A Systematic Review and Network Meta-Analysis. Ann Thorac Cardiovasc Surg 2022;28:389-402.
12. Carson-Chahhoud KV, Wakai A, van Agteren JE, et al. Simple aspiration versus intercostal tube drainage for primary spontaneous pneumothorax in adults. Cochrane Database Syst Rev 2017;9:CD004479.
13. Brown SGA, Ball EL, Perrin K, et al. Conservative versus Interventional Treatment for Spontaneous Pneumothorax. N Engl J Med 2020;382:405-15.

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