# 咳嗽強度的評估，可預測拔管失敗嗎?

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# 評讀文章

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## Predictive power of extubation failure diagnosed by cough strength: a systematic review and meta-analysis

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# 前言

1. 使用自主呼吸試驗 (SBT)已證實可評估患者是否可脫離呼吸器。
   (Schonhofer B, et al. Respiration 2020:1-102)
2. 有10-20%的患者成功通過SBT後，拔管仍失敗，且此類病人有較高的住院中死亡率。
   (Kaur R, et al. Respir Care. 2021)
3. 早期評估高風險的拔管失敗患者，拔管後使用NIV或HFNC可降低住院中死亡率。
   (Hernandez G,et al. JAMA. 2016;316(15):1565－74)
4. 咳嗽能力評估是否可當作辨識高風險拔管失敗患者?

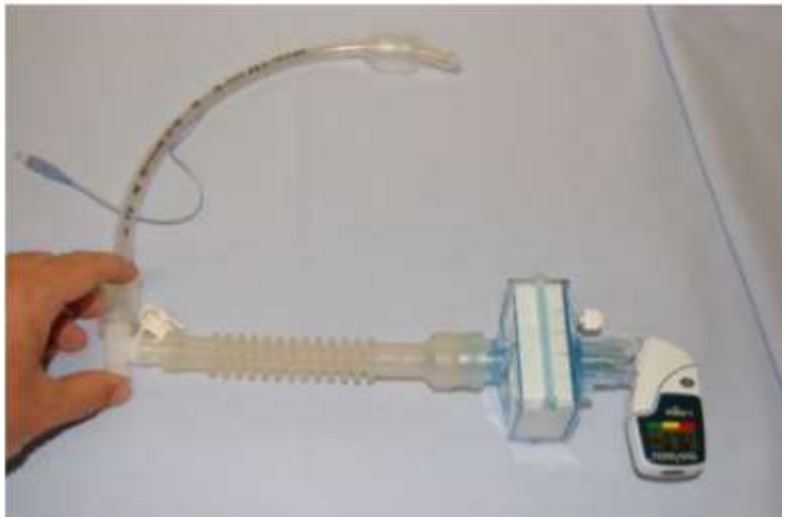
# 咳嗽能力評估方法

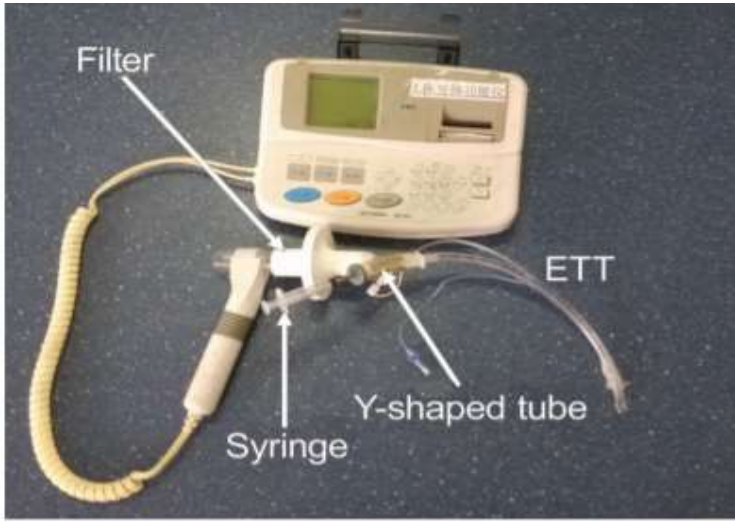
1.Cough peak flow ( CPF)

半坐臥下，使用外接肺活量計或使用呼吸器測量咳嗽尖峰流量

–可配合之病患:盡可能用力咳嗽

–不可配合之病患:滴入 2 mL生理鹽水刺激咳嗽






Duan J, et al. Respir Care. 2014;59(11):1643-51.

# 咳嗽能力評估方法

2. Semi-quantitative Cough Strength Score（SCSS）

| 咳嗽強度評分 | |
|---|---|
| 0 | 無咳嗽反應 |
| 1 | 有空氣通過氣管內管，但聽不到咳嗽聲 |
| 2 | 可聽見微弱的咳嗽聲 |
| 3 | 可聽見清楚的咳嗽聲 |
| 4 | 強烈咳嗽 |
| 5 | 多次連續劇烈咳嗽 |

*若病患無法配合，則抽痰刺激後評分
*有些文獻使用「強、弱、無咳嗽反應」評分

Abdelrady S. Ibrahim,et al. Neurocrit Care (2018) 29:273-279

# 咳嗽能力評估方法

3. White card test (WCT)

對著距離氣管內管1-2 公分的白卡咳嗽，最多3-4次。如果卡片上出現任何潮濕，則結果為陽性。



Elkholy MM,et al.Egypt J Chest Dis Tubercul.2021;70(2):288 – 94.

# 步驟1：系統性文獻回顧探討的問題為何？

| | |
|---|---|
| 研究族群/問題 (Population/ Problem)： | 成人患者插管使用呼吸器，通過SBT準備移除氣管內管 |
| 介入措施 (Intervention)： | 咳嗽能力評估 |
| 比較 (Comparison)： | 1.Cough peak flow (CPF)<br>2. Semi-quantitative Cough Strength Score (SCSS)<br>3. White card test (WCT) |
| 結果 (Outcomes)： | 藉由咳嗽能力評估來預測拔管失敗 |

# 表1試驗特徵

- 人群分布：34 meta-analysis (8684 test)
- 咳嗽能力評估方法：

  Cough peak flow：共19篇（3018 test）

  SCSS(評分數)：共8篇（1342 test）

  SCSS(評強度)：共10篇（3918 test）

  White card test：共4篇（406 test）

# 方法

- 搜尋至2021年6月文獻
- 由審查員JD和XFZ, 兩人進行文獻篩選
- 任何意見不一致時，由第三人(JPS)審查與確認

# 結果

- 可否使用CPF、SCSS、WCT評估咳嗽能力。
- 咳嗽能力與拔管失敗關聯性。
- 其敏感性、特異性、相似比、勝算比、預測能力之差異。
- 診斷能力(Diagnostic power)：良好為AUC大於0.8，中等為AUC介於0.7和0.8之間，差為AUC小於0.7。

# Table 1. 34篇資料分析（一）

| Author | Year | Country | Design | Method of SBT | Measurement of cough strength | Definition of weak cough | Total tests | TP | FP | FN | TN | Time and definition of extubation failure | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Beuret | 2009 | France | Prospective | T-piece | Voluntary CPF tested with an external flowmeter | CPF ≤ 35 L/min | 130 | 11 | 34 | 3 | 82 | 48 h | Reintubation |
| Duan | 2014a | China | Prospective | PSV | Voluntary CPF tested with an external flowmeter | CPF ≤ 62.4 L/min | 115 | 17 | 34 | 3 | 61 | 72 h | Reintubation |
| Duan | 2014b | China | Prospective | PSV | #Involuntary CPF tested with an external flowmeter | CPF ≤ 49.8 L/min | 115 | 14 | 32 | 6 | 63 | 72 h | Reintubation |
| Gao | 2009a | China | Prospective | PSV/CPAP | Voluntary CPF tested with a ventilator | CPF ≤ 58.5 L/min | 200 | 20 | 55 | 8 | 117 | 72 h | Reintubation/death |
| Gao | 2009b | China | Prospective | PSV/CPAP | SCSS (strong, moderate, weak) | Weak | 200 | 13 | 3 | 15 | 169 | 72 h | Reintubation/death |
| Salam | 2004a | USA | Prospective | T-piece/PSV | Voluntary CPF tested with an external flowmeter | CPF ≤ 60 L/min | 88 | 11 | 25 | 3 | 49 | 72 h | Reintubation |
| Salam | 2004b | USA | Prospective | T-piece/PSV | WCT | Negative | 88 | 10 | 36 | 4 | 38 | 72 h | Reintubation |
| Smailes | 2013 | UK | Prospective | T-piece | Voluntary CPF tested with an external flowmeter | CPF ≤ 60 L/min | 125 | 10 | 7 | 7 | 101 | 48 h | Reintubation |
| Smina | 2003 | USA | Prospective | T-piece/PSV | Voluntary CPF tested with an external flowmeter | CPF ≤ 60 L/min | 111 | 9 | 25 | 4 | 73 | 72 h | Reintubation |
| Su | 2010a | China | Prospective | T-piece/PSV/CPAP | #Involuntary CPF tested with an external flowmeter | CPF ≤ 58.5 L/min | 150 | 25 | 25 | 7 | 93 | Hospital stay | Reintubation |
| Su | 2010b | China | Prospective | T-piece/PSV/CPAP | SCSS (strong, weak, no cough) | Weak or no cough | 150 | 25 | 47 | 7 | 71 | Hospital stay | Reintubation |
| Khamiees | 2001a | China | Prospective | T-piece/PSV/CPAP | SCSS (grade 0 to 5) | Grade 0 to 2 | 100 | 10 | 14 | 8 | 68 | 72 h | Reintubation |
| Khamiees | 2001b | China | Prospective | T-piece/PSV/CPAP | WCT | Negative | 100 | 9 | 16 | 9 | 66 | 72 h | Reintubation |
| Huang | 2013 | China | Retrospective | T-piece/PSV | SCSS (effective and ineffective) | Ineffective | 119 | 23 | 27 | 4 | 65 | 7 d | Reintubation |
| Gobert | 2017 | France | Prospective | PSV | Voluntary CPF tested with a ventilator | CPF ≤ 60 L/min | 92 | 7 | 24 | 4 | 57 | 48 h | Reintubation/death |
| Liu | 2014 | China | Prospective | PSV | Voluntary CPF tested with a ventilator | CPF ≤ 60 L/min | 102 | 8 | 36 | 7 | 51 | 48 h | Reintubation |
| Duan | 2015a | China | Prospective | PSV | SCSS (grade 0 to 5) | Grade 0 to 2 | 186 | 16 | 52 | 12 | 106 | 72 h | Reintubation |
| Duan | 2015b | China | Prospective | PSV | Voluntary CPF tested with an external flowmeter | CPF ≤ 60 L/min | 186 | 23 | 71 | 5 | 87 | 72 h | Reintubation |
| Bai | 2017a | China | Prospective | PSV | Voluntary CPF tested with an external flowmeter | CPF ≤ 56.4 L/min | 126 | 11 | 14 | 4 | 97 | 72 h | Reintubation |
| Bai | 2017b | China | Prospective | PSV | Voluntary CPF tested with an external ventilator | CPF ≤ 56 L/min | 126 | 11 | 16 | 4 | 95 | 72 h | Reintubation |
| Xiao | 2018 | China | Prospective | PSV | Voluntary CPF tested with an external flowmeter | CPF ≤ 60 L/min | 139 | 15 | 36 | 7 | 81 | 72 h | Reintubation |
| Duan | 2017 | China | Prospective | PSV | Voluntary CPF tested with an external flowmeter | CPF ≤ 70 L/min | 356 | 61 | 119 | 15 | 161 | 7 d | Reintubation |
| Thille | 2015 | France | Prospective | PSV | SCSS (grade 0 to 4) | Grade 0 to 2 | 223 | 10 | 15 | 20 | 178 | 7 d | Reintubation |
| Kutchak | 2015 | Brazil | Prospective | T-piece | $Involuntary CPF tested with an external flowmeter | CPF ≤ 80 L/min | 135 | 35 | 20 | 10 | 70 | 48 h | Reintubation |

# Table 1. 34篇資料分析（二）

| Author | Year | Country | Design | Method of SBT | Measurement of cough strength | Definition of weak cough | Total tests | TP | FP | FN | TN | Time and definition of extubation failure | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Almeida | 2020a | Brazil | Prospective | T-piece/PSV | Voluntary CPF tested with an external flowmeter | CPF ≤ 45 L/min | 81 | 23 | 3 | 10 | 45 | 48 h | Reintubation |
| Almeida | 2020b | Brazil | Prospective | T-piece/PSV | #Involuntary CPF tested with an external flowmeter | CPF ≤ 60 L/min | 81 | 29 | 4 | 4 | 44 | 48 h | Reintubation |
| Almeida | 2020c | Brazil | Prospective | T-piece/PSV | $Involuntary CPF tested with an external flowmeter | CPF ≤ 55 L/min | 81 | 30 | 7 | 3 | 41 | 48 h | Reintubation |
| Aziz | 2018 | Egypt | Prospective | Not reported | SCSS (grade 0 to 5) | Grade 0 to 2 | 80 | 18 | 3 | 19 | 40 | 72 h | Reintubation |
| Vivier | 2019a | France | Prospective | T-piece | SCSS (ineffective, moderate, and effective) | Ineffective | 181 | 6 | 7 | 27 | 141 | 7 d | Reintubation/death |
| Vivier | 2019b | France | Prospective | T-piece | Voluntary CPF tested by an external flowmeter | CPF ≤ 60L/min | 160 | 18 | 74 | 10 | 58 | 7 d | Reintubation/death |
| Wang | 2019 | China | Retrospective | Not reported | SCSS (with or without spontaneous cough) | Without spontaneous cough | 86 | 19 | 0 | 6 | 61 | Hospital stay | Reintubation |
| Ma | 2018 | China | Retrospective | Not reported | SCSS (strong, weak, no cough) | Weak or no cough | 108 | 11 | 6 | 8 | 83 | 48 h | Reintubation |
| Frutos-Vivar | 2006 | Canada | Prospective | T-piece/PSV/CPAP | SCSS (poor, moderate, or excellent) | Poor | 900 | 33 | 178 | 88 | 601 | 72 h | Reintubation |
| Jaber | 2018 | France | Prospective | T-piece/PSV/CPAP | SCSS (weak and strong) | Weak | 1505 | 116 | 811 | 32 | 546 | 48 h | Reintubation |
| Dos | 2017 | Brazil | Prospective | T-piece/PSV | SCSS (grade 0 to 5) | Grade 0 to 2 | 311 | 8 | 21 | 35 | 247 | 48 h | Reintubation |
| Michetti | 2018 | USA | Prospective | PSV/CPAP | SCSS (not strong and strong) | Not strong | 464 | 11 | 142 | 24 | 287 | 96 h | Reintubation |
| Abbas | 2018 | Egypt | Prospective | Not reported | SCSS (grade 0 to 5) | Grade 0 to 2 | 90 | 7 | 11 | 19 | 53 | 48 h | Reintubation/NIV |
| Norisue | 2020 | Japan | Prospective | PSV | Voluntary CPF tested with a ventilator | CPF ≤ 50 L/min | 252 | 8 | 62 | 4 | 178 | 72 h | Reintubation |
| Sanson | 2018 | Italy | Prospective | Not reported | SCSS (strong, weak, no cough) | Weak or no cough | 205 | 21 | 121 | 5 | 58 | ICU stay | Reintubation/NIV |
| Wang | 2009a | China | Prospective | PSV | SCSS (grade 0 to 5) | Grade 0 to 2 | 68 | 9 | 9 | 11 | 39 | 72 h | Reintubation |
| Wang | 2009b | China | Prospective | PSV | WCT | Negative | 68 | 10 | 11 | 10 | 37 | 72 h | Reintubation |
| Elkholy | 2021 | Egypt | Prospective | PSV | WCT | Negative | 150 | 21 | 24 | 1 | 104 | 72 h | Reintubation |
| Lu | 2010 | China | Prospective | PSV | Voluntary CPF tested with an external flowmeter | CPF ≤ 29.35 L/min | 19 | 7 | 4 | 0 | 8 | 72 h | Reintubation |
| Liang | 2019 | China | Prospective | PSV | #Involuntary CPF tested with a ventilator | CPF ≤ 71.15 L/min | 48 | 8 | 4 | 2 | 34 | 48 h | Reintubation/death |
| Thille | 2020 | France | Prospective | T-piece/PSV | SCSS (grade 0 to 4) | Grade 0 to 1 | 284 | 11 | 16 | 45 | 212 | 7 d | Reintubation/death |

# 步驟2：系統性文獻回顧的品質如何？(FAITH)

## F - 研究是否找到 (Find) 所有的相關證據？

1. 至少包括二個主要的資料庫，並加上文獻引用檢索且應不只限於英文
2. 應同時使用 MeSH 字串及一般檢索詞彙(text words)。在文章的方法(Methods)章節，可以找到詳細搜尋策略的說明

Search techniques and selection criteria
We searched pertinent research published before June 2021 in PubMed, Web of Science, the Cochrane library,and some Chinese databases (CBM, Wanfang Data, and CNKI) without any language limitations.
The studies were searched with the following key words: ( "weak cough" OR "ineffective cough" OR "cough peak flow" OR "cough peak expiratory flow" OR "cough strength" ) and ( "ventilator weaning" OR "wean from mechanical ventilation" OR "weaning from mechanical ventilation" OR "liberation from mechanical ventilation" OR "liberate from mechanical ventilation" OR "withdrawal of mechanical ventilation" OR "extubation failure" OR "postextubation failure" OR "postextubation respiratory failure" OR "reintubation" )

評讀結果：□ 是 □否□不清楚

# 步驟2：系統性文獻回顧的品質如何？(FAITH)

## F - 研究是否找到 (Find) 所有的相關證據？

3. 是否評估的摘要及全文文獻數目、文獻納入與排除的數量及原因。

Inclusion criteria：

34 meta-analysis

(1)成人插管病患 (2)拔管前完成SBT (3)拔管前評估咳嗽能力(4)有可用數據

評讀結果: ■是 □否 □不清楚

Exclusion criteria：

The following works were excluded:

(1)reviews, case reports, editorials, letters, and conference abstracts; (2)沒有可用數據 (3)沒有拔管失敗的定義

評讀結果：■是 □否 □不清楚

# 步驟2：系統性文獻回顧的品質如何？(FAITH)

## F - 研究是否找到 (Find) 所有的相關證據？

4. 有圖表或PRISMA的流程圖呈現。

評讀結果：■是 □否 □不清楚

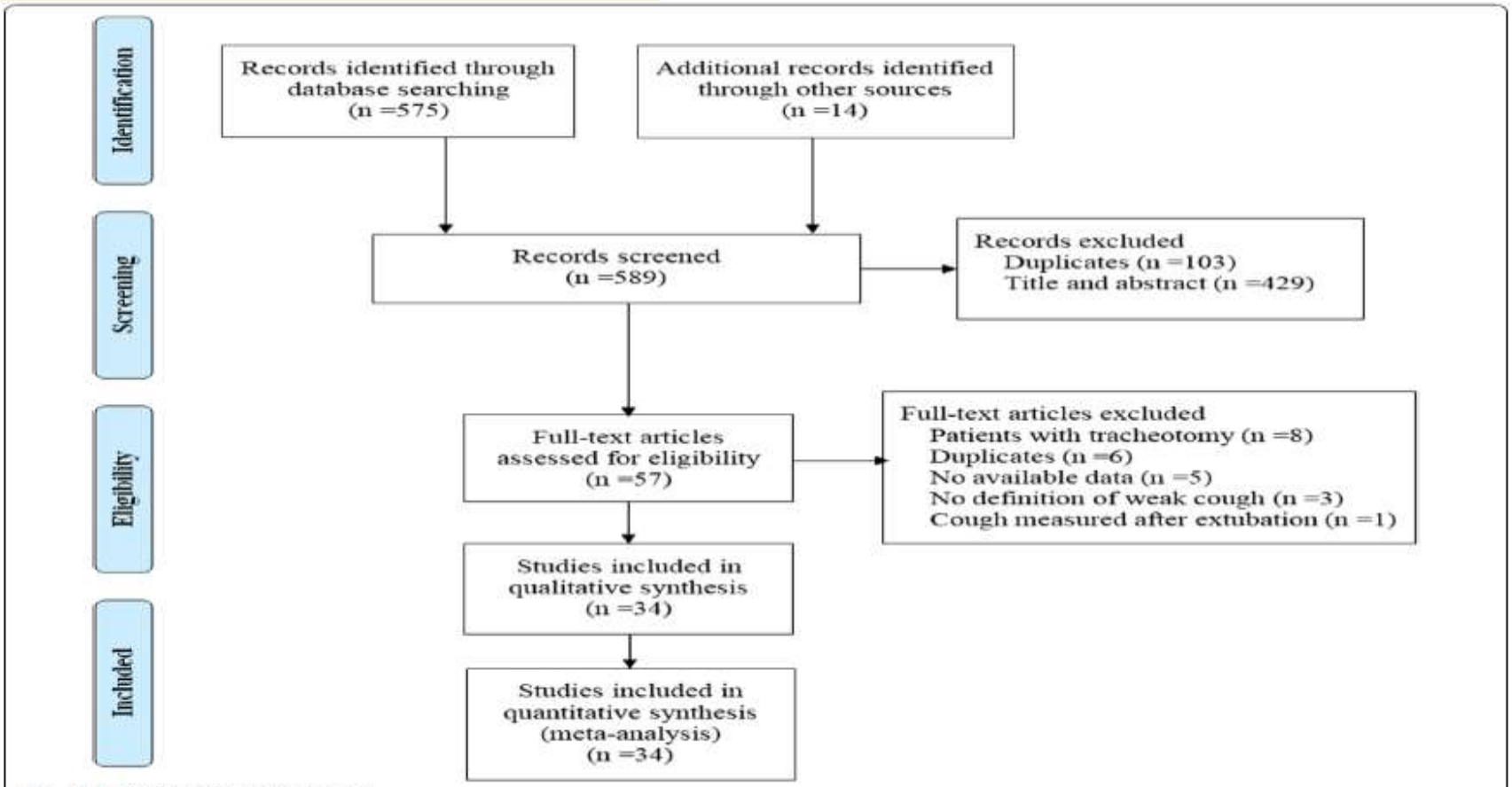



**Fig. 1** Flowchart of study selection

# 步驟2：系統性文獻回顧的品質如何？(FAITH)

A-文獻是否經過嚴格評讀 (Appraisal)？

I -是否只納入 (Included) 具良好效度的文章？

1.使用QUADAS-2 評讀

2.分為誤差風險(四部分評核) 與臨床運用疑慮兩部分(三部分評核)

3.每個評核部分皆有關鍵性問題，以High、Low、nuclear回答

評讀結果：■是 □否 □不清楚

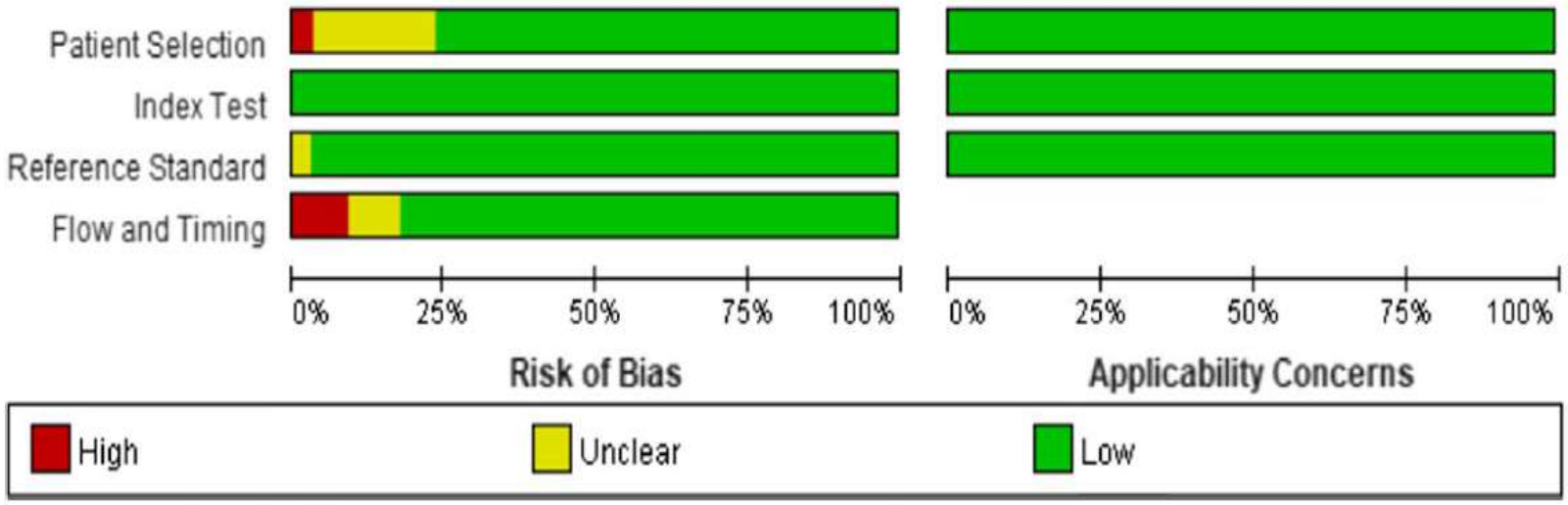



**Fig. 2** Quality Assessment of Diagnostic Accuracy Studies criteria for the included studies

# 步驟2：系統性文獻回顧的品質如何？(FAITH)
# T—作者是否以表格和圖表「總結」（Total up）試驗結果？

應該用至少1個摘要表格呈現所納入的試驗結果。可針對結果進行統合分析(meta-analysis)，並以「森林圖」(forest plot)呈現研究結果，最好再加上異質性分析。

評讀結果：■ 是 □否 □不清楚

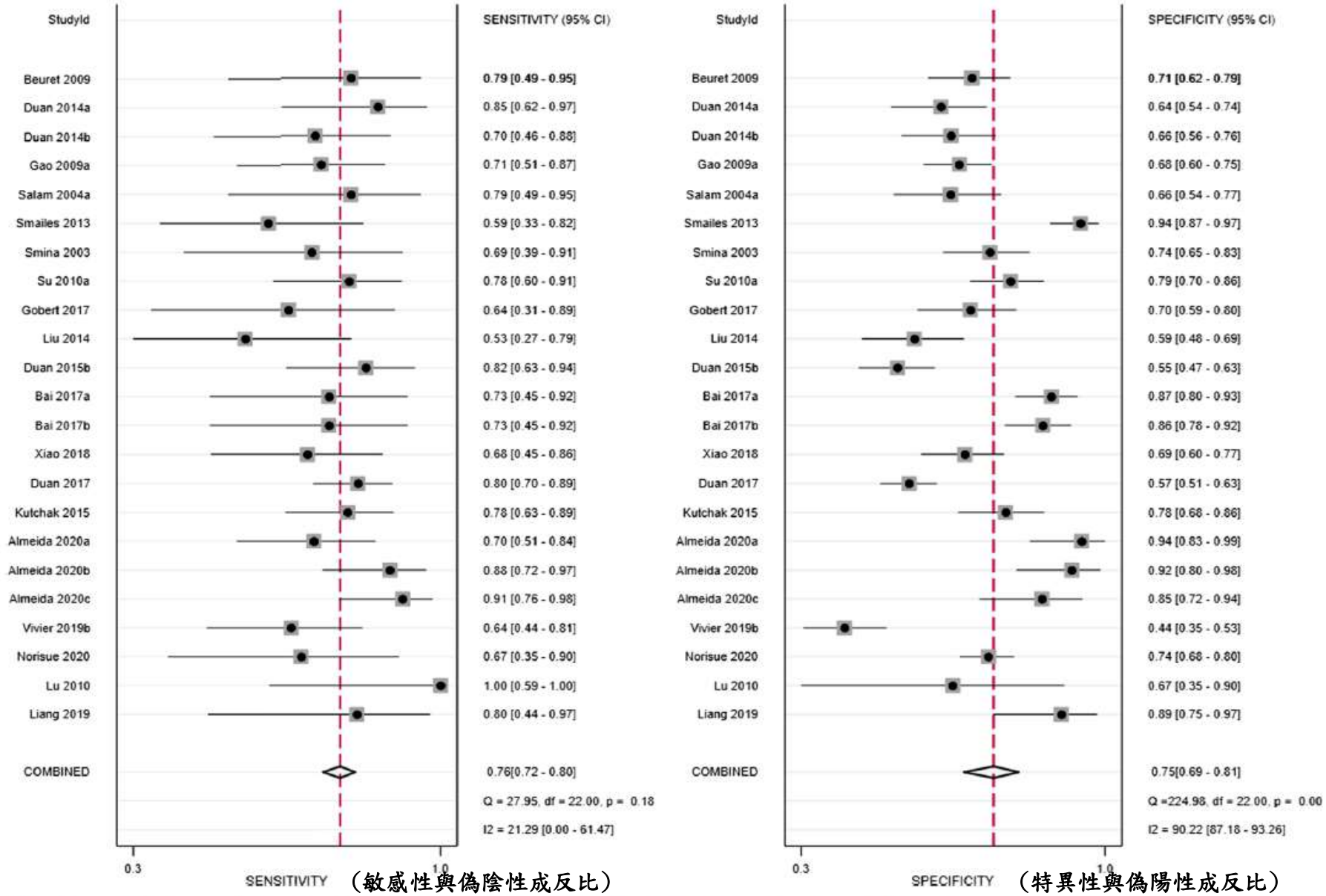



**Fig. 3** Forest plot of sensitivity and specificity in the diagnosis of extubation failure tested by cough peak flow. CI = confidence interval

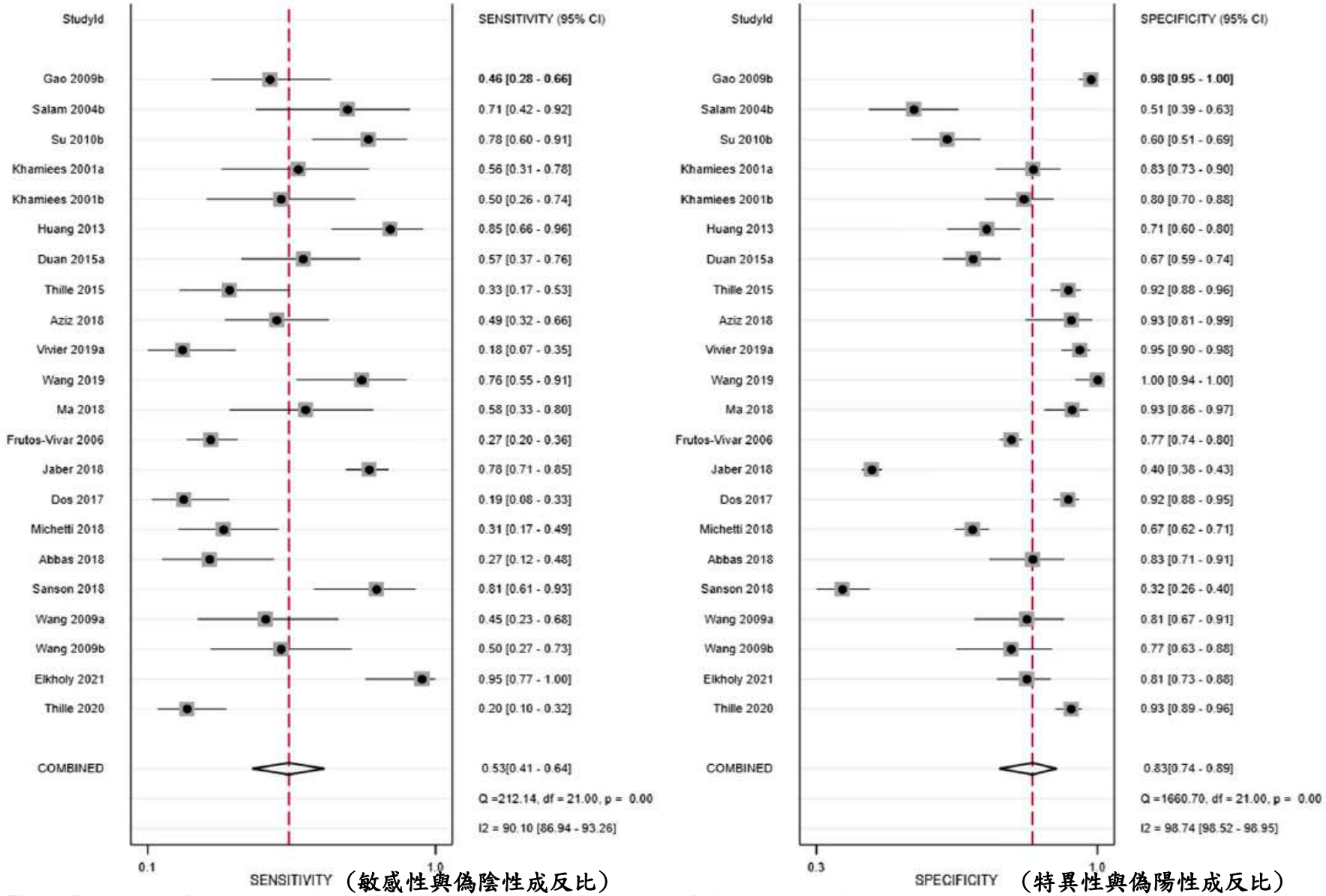



**Fig. 5** Forest plot of sensitivity and specificity in the diagnosis of extubation failure tested by the semiquantitative cough strength score. CI = confidence interval

| | CPF | SCSS | WCT |
|---|---|---|---|
| 敏感性<br>（偽陰性成反比） | 0.76<br>(0.72 - 0.8) | 0.53<br>(0.41 - 0.64) | 0.7<br>(0.44 - 0.88) |
| 敏感性P值 | 0.18 | 0 | |
| 敏感性異質性 | 0.2129 | 0.901 | |
| 特異性<br>（偽陽性成反比） | 0.75<br>(0.69 - 0.81) | 0.83<br>(0.74 - 0.89) | 0.74<br>(0.61 - 0.84) |
| 特異性P值 | 0 | 0 | |
| 特異性異質性 | 0.9022 | 0.9874 | |

**Table 2** Summary of the outcomes of different subgroups

| | Measurement of cough peak flow | | | | Measurement of semiquantitative cough strength score | | |
|---|---|---|---|---|---|---|---|
| | Voluntary CPF | Involuntary CPF | CPF measured with an external flowmeter | CPF measured with a ventilator | SCSS (grade 0 to 4/5) | WCT | Other# |
| No. of study arms | 17 | 6 | 18 | 5 | 8 | 4 | 10 |
| Total cases | 2282 | 529 | 2023 | 718 | 1342 | 406 | 3918 |
| Total tests | 2408 | 610 | 2300 | 718 | 1342 | 406 | 3918 |
| Pooled sensitivity | 0.73 (0.68–0.78) | 0.82 (0.73–0.88) | 0.77 (0.72–0.81) | 0.72 (0.60–0.81) | 0.36 (0.26–0.48) | 0.70 (0.44–0.88) | 0.59 (0.41–0.47) |
| Pooled specificity | 0.72 (0.65–0.79) | 0.82 (0.74–0.88) | 0.74 (0.67–0.81) | 0.77 (0.69–0.84) | 0.87 (0.80–0.91) | 0.74 (0.61–0.84) | 0.83 (0.62–0.64) |
| Pooled positive LR | 2.7 (2.1–3.4) | 4.5 (2.9–7.0) | 3.0 (2.3–4.0) | 3.1 (2.1–4.6) | 2.7 (2.1–3.6) | 2.7 (1.5–4.8) | 3.5 (1.5–8.2) |
| Pooled negative LR | 0.37 (0.31–0.45) | 0.22 (0.14–0.35) | 0.31 (0.25–0.39) | 0.37 (0.25–0.55) | 0.73 (0.64–0.84) | 0.40 (0.18–0.90) | 0.49 (0.33–0.73) |
| Pooled DOR | 7 (5–10) | 21 (9–48) | 10 (6–15) | 9 (4–18) | 4 (3–5) | 7 (2–25) | 7 (2–21) |
| Pooled AUC | 0.76 (0.72–0.79) | 0.89 (0.86–0.91) | 0.80 (0.77–0.84) | 0.77 (0.73–0.81) | 0.70 (0.65–0.73) | 0.78 (0.74–0.82) | 0.75 (0.71–0.79) |

CPF = cough peak flow, SCSS = semiquantitative cough strength score, WCT = white card test, LR = likelihood ratio, DOR = diagnostic odds ratio, AUC = area under the receiver operating characteristic curve（良好：大於0.8，中等：0.7-0.8）（代表判別效果）

# Includes strong, moderate, and weak; strong, weak, and no cough; effective and ineffective; with or without spontaneous cough; excellent, moderate, and poor; strong and weak; strong and not strong; and effective, moderate, and ineffective

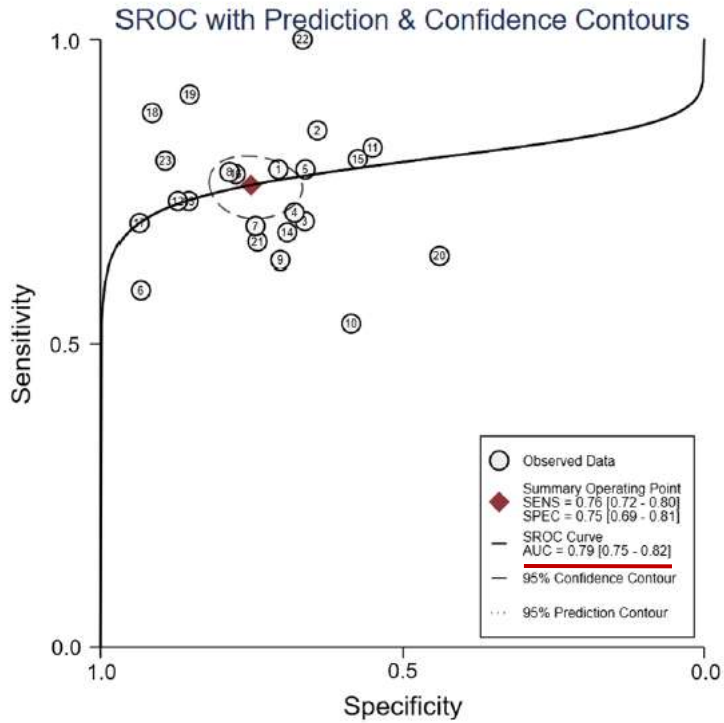



**Fig. 4** Summary receiver operator characteristic (SROC) curve in the prediction of extubation failure tested by cough peak flow. SENS = sensitivity, SPEC = specificity, AUC = area under the receiver operating characteristic curve. Numbers 1 to 23 represent the study arms (Beuret 2009, Duan 2014a, Duan 2014b, Gao 2009a, Salam 2004a, Smailes 2013, Smina 2003, Su 2010a, Gobert 2017, Liu 2014, Duan 2015b, Bai 2017a, Bai 2017b, Xiao 2018, Duan 2017, Kutchak 2015, Almeida 2020a, Almeida 2020b, Almeida 2020c, Vivier 2019b, Norisue 2020, Lu 2010, and Liang 2019)

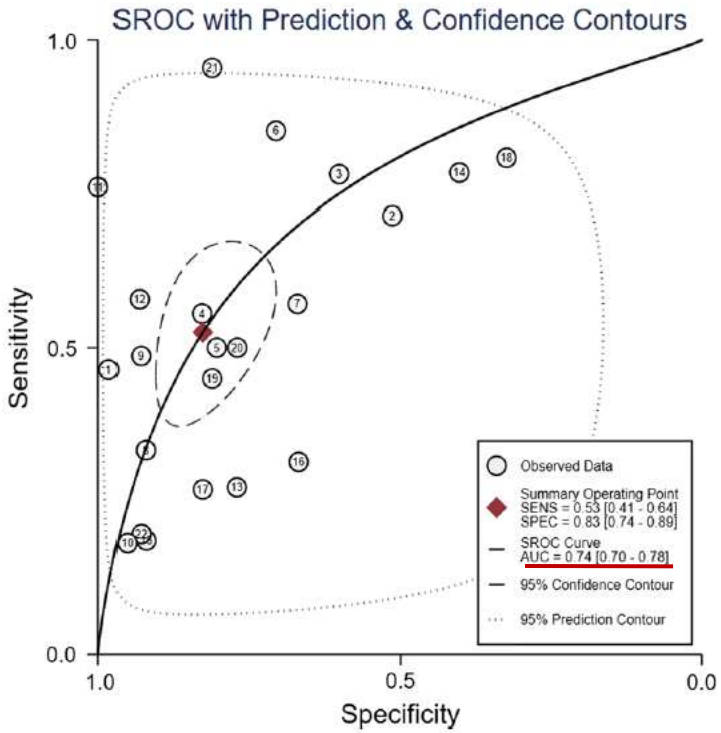



**Fig. 6** Summary receiver operator characteristic (SROC) curve in the prediction of extubation failure tested by the semiquantitative cough strength score. SENS = sensitivity, SPEC = specificity, AUC = area under the receiver operating characteristic curve. Numbers 1 to 22 represent the study arms (Gao 2009b, Salam 2004b, Su 2010b, Khamiees 2001a, Khamiees 2001b, Huang 2013, Duan 2015a, Thille 2015, Aziz 2018, Vivier 2019a, Wang 2019, Ma 2018, Frutos-Vivar 2006, Jaber 2018, Dos 2017, Michetti 2018, Abbas 2018, Sanson 2018, Wang 2009a, Wang 2009b, Elkholy 2021, and Thille 2020)

# 步驟2：系統性文獻回顧的品質如何？(FAITH)
# H－試驗的結果是否相近-異質性(Heterogeneity)？

各個試驗的結果應相近或具同質性，若具有異質性，作者應評估差異是否顯著(卡方檢定)。根據每篇個別研究中不同的PICO及研究方法探討造成異質性的原因。

1. Cough peak flow使用外接肺活量計或使用呼吸器測量咳嗽尖峰流量，僅一項126位病例的研究同時使用這兩種方法測量咳嗽峰值流量。兩種方法都顯示出相似的預測準確性，但該研究的樣本量小。
2. 其中18個研究組使用外接肺活量計，5個研究組使用呼吸器測量，結果發現使用外接肺活量計測量的流量較大。但外接流量計需專用設備，可能會限制使用。
3. WCT根據卡片上的潮濕狀況進行評分，可能會受到調查人員經驗的影響。

評讀結果：■是 □否 □不清楚

# 限制

- 拔管後發生拔管失敗的時間定義不同，但這因子經過分析並不影響敏感性和特異性。
- 研究中觀察到SCSS有出版性偏差。作者進行了敏感性分析，發現DOR範圍從4.08到5.02、AUC範圍為0.71至0.75。表示儘管存在偏差，但結果是穩定的。
- 對於微弱咳嗽的定義因研究而異。
- 研究中使用不同的SBT方法，而SBT的成功率在PSV下比T-piece或CPAP高。但拔管失敗不因SBT方法而異。因此，SBT的方法不太可能影響咳嗽強度與拔管之間的關係。

# 結論

- 較弱的咳嗽強度與較高的拔管失敗率相關。
- 咳嗽強度可用cough peak flow及SCSS來評估。
- Cough peak flow預測拔管失敗的能力可能優於SCSS 。

# 能依系統性文獻回顧之結論回答問題嗎?

- 同不同意在成功SBT後的成人插管病人，利用咳嗽能力評估來預測拔管失敗?