Predictive Power of Extubation Failure Diagnosed by Cough Strength: A Systematic Review and Meta-Analysis

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Abstract

Background: The predictive power of extubation failure diagnosed by cough strength is various in different studies. We aimed to summarize the diagnostic power of extubation failure tested by cough strength.

Methods: A comprehensive on-line search was performed to select any potentially eligible studies that evaluated the predictive power of extubation failure tested by cough strength. A manual research was also performed to identify additional studies. Data were extracted to calculate the pooled sensitivity, specificity, positive likelihood ratio (LR), negative LR, diagnostic odds ratio (DOR), and area under the receiver operating characteristic curves (AUC) to evaluate predictive power of extubation failure. I^2 was used to test the heterogeneity and deek's funnel plot was used to detect the publication bias.

Results: A total of 35 studies involving 7515 patients were included. Of them, 1113 patients (14.8%) experienced extubation failure. Twenty studies involving 2787 patients assessed cough strength by measure of cough peak flow (CPF) to predict extubation failure. The pooled sensitivity, specificity, positive LR, negative LR, DOR, and AUC were 0.77 (95%CI: 0.72-0.80), 0.75 (0.69-0.80), 2.84 (2.36-3.42), 0.34 (0.29-0.39), 9.16 (6.14-13.67), and 0.81 (0.77-0.84), respectively. Twenty studies involving 5508 patients assessed cough strength by measurement of a semiquantitative cough strength scale (SCSS) to predict extubation failure. The pooled sensitivity, specificity, positive LR, negative LR, DOR, and AUC were 0.54 (95%CI: 0.43-0.65), 0.82 (0.73-0.88), 2.48 (1.92-3.21), 0.63 (0.54-0.74), 4.61 (3.03-7.01), and 0.74 (0.70-0.78), respectively.

Conclusions: Cough strength can be measured by CPF and SCSS. The CPF has good predictive power to diagnose extubation failure and SCSS has moderate predictive power.

Background

Mechanical ventilation (MV) is associated with many complications including ventilator-associated pneumonia, ventilator-associated lung injury, and ICU-acquired weakness [1–3]. Once the cause that lead to respiratory insufficiency is reversed, patient should be weaned from MV as it imposes a series of risks. The weaning process spends nearly 40% of time on MV [4]. To determine whether the patient can be weaned from MV, a spontaneous breathing trial (SBT) has been recommended by guidelines [5–7]. After a successful SBT, extubation has been recommended.

Not all patients can successfully wean from MV. Among the patients who successfully complete a SBT, 10–20% experience extubation failure [8]. Compared with patients experienced successful extubation, patients who experienced extubation failure are more likely to die in hospital [9, 10]. Evidences show that early identification of the patients at high risk for extubation failure and early application of preventive strategies (e.g., noninvasive ventilation or high-flow nasal cannula) can reduce hospital mortality [11, 12]. Therefore, the key is how to identify the patients at high risk for extubation failure.

Weak cough is a predictor of extubation failure. It can be measured by cough peak flow (CPF) [13, 14]. Patients with successful extubation had higher CPF than those who experienced extubation failure (74 vs. 42 L/min) [13]. In another study, however, the CPF did not differ between patients with extubation success and failure (61 vs. 58 L/min) [14]. In addition, cough strength also can be measured by a semiquantitative cough strength scale (SCSS) [15]. As the inconsistent results between different studies and multiple methods to measure cough strength, we aimed to review the literature systematically and perform a meta-analysis to assess the efficacy of diagnostic tests that use of cough strength for the early detection of extubation failure.

Methods

PICO statement

P-patient: Adult patients were under MV through endotracheal intubation. I-index test: Cough strength was measured in all included patients. C-complement: SBT was given to all included patients who were deemed ready to be liberated from MV. O-outcome: Efficacy of the cough strength to predict extubation failure was estimated.

Search techniques and selection criteria

This systematic review and meta-analysis has been disclosed in conformance with the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) statement [16]. We searched pertinent evaluations published before June 2021 in PubMed, Web of Science, Cochrane library, and some Chinese databases (CBM, Wanfang Data, and CNKI) without any language limitations. We also did a manual search for the reference lists of included articles to obtain additional relevant articles. The studies were searched by 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”).

Studies were enrolled based on the following inclusion criteria: 1) only adult patients with endotracheal tube were involved; 2) a SBT was completed before extubation; 3) cough strength was assessed before extubation; and 4) data were available to calculate the outcomes (true positive [TP], false positive [FP], false negative [FN], and true negative [TN]). The articles were excluded based on the following exclusion criteria: 1) reviews, case reports, editorials, letters, and conference abstracts; 2) inability to distinguish weak cough strength; and 3) without definition of extubation failure.

Data extraction and quality evaluation

All studies were independently selected by two investigators (JD and XFZ). Any discrepancies were resolved by consensus. If it failed to reach a consensus, a third investigator (JPS) reviewed the uncertain data. The first author's name, publication year, study region, sample size, the methods of cough strength assessment, cutoff value, definition of weak cough, and the number of patients with TP, FP, FN, and TN were collected. If the numbers of TP, FP, FN, and TN were unavailable, we communicated with the corresponding author to obtain these data. The Quality Assessment of Diagnostic Accuracy Studies 2 (QUADAS 2) was used to assess the quality of enrolled articles [17].

Statistical analyses

The data were analyzed by statistical software including Revman 5.3, Meta-Disc 1.4 and Stata SE 15.0. The pooled diagnostic odds ratio (DOR), sensitivity, specificity, positive likelihood ratio (LR), negative LR, area under the receiver operating characteristic curves (AUC), and corresponding 95% confidence interval (CI) were calculated by TP, FP, FN, TN. Deek's funnel plot was used to detect publication bias, with $P < 0.05$ indicating publication bias. If publication bias was present, sensitivity analysis was performed to explore the potential reasons.

Spearman correlation coefficient has been used to detect threshold effects and P value <0.05 indicates a significant threshold effect. The I^2 has been used to describe the heterogeneity in the meta-analysis. I^2 value ≥50% is considered as a significant heterogeneity. A fixed-effect model was adopted if no heterogeneity was observed. A random effect model was selected if significant heterogeneity was observed. And the possible sources of heterogeneity were explored by conducting a meta-regression analysis. The parameters in meta-regression included publication year, country, the methods used to measure cough strength, the device used to measure cough strength, number of cases in each study, and the time from ventilator weaning to extubation failure.

Results

Included studies and measurement of cough strength

A total of 575 studies were obtained using the search strategy and 14 studies from other sources (Figure 1). After screening title and abstracts, and review of the full paper, 35 studies were enrolled in this meta-analysis [13-15, 18-49]. A total of 7515 patients were included, and 1113 patients (14.8%) experienced extubation failure. The characteristic details of these articles are summarized in Table 1. Assessment of CPF before extubation was performed in 20 studies involving 2787 patients. The Spearman correlation coefficient was 0.103 ($p = 0.63$), indicating no threshold effect. Among the 20 studies, 17 researches involving 2454 patients measured the voluntary CPF, which was tested when the investigator coached the patient to cough as strong as possible. Five studies involving 529 patients measured the involuntary CPF, which was tested when the cough was stimulated by 2 ml of normal saline or suction catheter. Sixteen studies involving 2195 patients measured the CPF by a flowmeter. And 5 studies involving 718 patients measured the CPF by a ventilator.

Assessment of SCSS before extubation was performed in 20 studies involving 5508 patients. The Spearman correlation coefficient was 0.397 (p = 0.07), indicating no threshold effect. Among the 20 researches, 8 studies involving 1342 patients measured the SCSS ranged from 0 to 4/5 (weakest to strongest). Weak cough was defined if the SCSS ranged from 0 to 1/2. Four studies involving 406 patients measured the SCSS by white card test (WCT). WCT was performed before extubation. The investigator coached the patient to cough through the open-ended endotracheal tube while a white file card was placed 1–2 cm from its end. No moisture present on the card following 2–3 coughs was considered as negative WCT and it was defined as weak cough.

Quality assessment and publication bias

Quality assessment of the included studies was summarized in Figure 2. High risk of bias mainly came from flow and timing. Three studies collected extubation failure during hospitalization after extubation. And one studies collected the extubation failure during ICU stay after extubation. Supplementary Figure 1 shows no publication bias among studies assessed CPF to predict extubation failure (p = 0.34). Supplementary Figure 2 shows presence of publication bias among studies assessed SCSS to predict extubation failure (p = 0.02). Sensitivity analysis shows that the publication bias was avoided when the Frutos-Vivar's study [38] was excluded (p = 0.08). The sensitivity analysis also shows that the pooled DOR ranged from 4.08 to 5.02 and pooled AUC ranged from 0.70 to 0.75 when one study was omitted (Supplementary figure 3).

Accuracy of extubation failure diagnosed by CPF

The pooled sensitivity and specificity were 0.77 (95% CI: 0.72-0.80) and 0.75 (95% CI: 0.69-0.80), respectively (Figure 3). Meta-regression analyses indicate that the sensitivity and specificity did not influence by publication year, country, the voluntary or involuntary CPF, the assessment of CPF by a flowmeter or a ventilator, the different cutoff values, number of cases in each study, and the time to extubation failure from withdrawal of the endotracheal tube (Supplementary Figure 4). The pooled positive LR and negative LR were 2.84 (95%CI: 2.36-3.42) and 0.34 (0.29-0.39), respectively (Supplementary Figure 5). The pooled DOR was 9.16 (95%CI: 6.14-13.67) (Supplementary figure 6). The AUC was 0.81 (0.77-0.84) when the CPF was used to predict extubation failure (Figure 4).

In the subgroup analyses, the sensitivity, specificity, pooled DOR, and AUC were 0.74, 0.72, 7, and 0.77, respectively, among studies using voluntary CPF to predict extubation failure (Table 2). And these data were 0.82, 0.82, 21, 0.89, respectively, among studies using involuntary CPF to predict extubation failure. The AUC was 0.82 among the studies measured CPF by a flowmeter. However, it was 0.77 among those measured CPF by a ventilator.

Accuracy of extubation failure diagnosed by SCSS

The pooled sensitivity and specificity were 0.54 (95% CI: 0.43-0.65) and 0.82 (95% CI: 0.73-0.88), respectively (Figure 5). Meta-regression analyses indicate that the sensitivity and specificity did not

influence by publication year, country, study design, the ways used to assess the SCSS, number of cases in each study, and the time to extubation failure from withdrawal of the endotracheal tube (Supplementary Figure 7). The pooled positive LR and negative LR were 2.48 (95%CI: 1.92-3.21) and 0.63 (0.54-0.74), respectively (Supplementary Figure 8). The pooled DOR was 4.61 (95%CI: 3.03-7.01) (Supplementary figure 9). The AUC was 0.74 (0.70-0.78) when the SCSS was used to predict extubation failure (Figure 6).

In the subgroup analyses, the sensitivity, specificity, pooled DOR, and AUC were 0.36, 0.87, 4, 0.70, respectively, among studies using SCSS ranged from 0 to 4/5 to predict extubation failure (Table 2). And these data were 0.70, 0.74, 7, and 0.78, respectively, among studies using WCT to predict extubation failure.

Discussion

To the best of our knowledge, this is the first systematic review and meta-analysis to explore the prediction of extubation failure diagnosed by cough strength. CPF shows good diagnostic power to predict extubation failure, especially among those who measured involuntary CPF. SCSS shows moderate diagnostic power to predict extubation failure whether it was measured by a scale graded 0–4/5 or WCT.

Cough strength is strongly associated with maximal inspiratory and expiratory pressure [50]. And the maximal inspiratory and expiratory pressure can reflect the function of respiratory muscle. Better respiratory muscle function is associated with lower extubation failure [51]. Therefore, weaker cough strength is associated with higher extubation failure, which can be served as a predictor of extubation failure. However, the cough strength can be quantitatively measured by CPF or qualitatively measured by SCSS. The distinguishing power of extubation failure assessed by the two methods is unclear. This study with large sample size demonstrated that CPF reached good diagnostic power to predict extubation failure. But the SCSS only reached moderate diagnostic power. In the clinical practice, CPF as a method to assess cough strength can be firstly considered to predict extubation failure.

CPF includes voluntary and involuntary CPF. Voluntary CPF can be measured when the investigator coached the patient to cough. Involuntary CPF was stimulated by an injection of 2 ml of normal saline or by a suction catheter. Two studies simultaneously measured the voluntary and involuntary CPF. One study shown the voluntary CPF was better than involuntary CPF to predict extubation failure [19]. However, the other one shown no difference between the two methods to predict extubation failure [33]. Current study enrolled 17 researches measured voluntary CPF and 5 measured involuntary CPF to explore the predictive power of extubation failure, and found involuntary CPF had much higher predictive power than involuntary CPF. As known to all, measurement of voluntary CPF requires patients' cooperation. It means that the voluntary CPF only can be used in cooperative patients. However, the measurement of involuntary CPF can be used for all patients, especially unconscious ones. Thus, involuntary CPF may be more suitable to predict extubation failure for patients who are ready for extubation.

CPF can be measured by a flowmeter or a ventilator. Only one study with 126 cases simultaneously measured CPF using both methods, and shown similar predictive accuracy [28]. As the small sample size, the power is inadequate. Our study enrolled 16 researches measured CPF by a flowmeter and 5 by a ventilator, and demonstrated that the AUC was higher when the CPF measured by a flowmeter than a ventilator. It indicates that the predictive accuracy is better when the CPF was measured by a flowmeter. However, measurement of CPF by a flowmeter requires a dedicated device. This may limited the use of this method. As the AUC was 0.77 when the CPF was measured by a ventilator, indicating a moderate accuracy to predict extubation failure, it can be used to predict extubation failure if the dedicated flowmeter is unavailable.

SCSS ranged from 0–4/5 is the most common semiquantitative methods to measure cough strength in this meta-analysis. Zero indicates weakest cough and 4/5 indicates strongest cough [15, 31]. WCT was another semiquantitative method to measure cough strength [21]. However, no studies compared the two methods on predictive accuracy of extubation failure. This study demonstrated that WCT is more accurate than SCSS graded 0–4/5 to predict extubation failure. The SCSS graded 0–4/5 is subjectively rated by the investigators. However, the WCT is an objective method, which is less likely to be influenced by the investigator's experience. Thus, the WCT can be given priority when the SCSS was used to predict extubation failure.

This study has several limitations. First, high risk was reported in the time from withdrawal of endotracheal tube to extubation failure. However, we analyzed the studies who defined extubation failure within and beyond 72 h. The meta-regression shows this is not a factor to influence the sensitivity and specificity. Second, publication bias was observed among the studies measured SCSS. We performed sensitivity analysis and found that the pooled DOR ranged from 4.08 to 5.02 and pooled AUC ranged from 0.70 to 0.75. It indicates that the results were stable even presence of publication bias. Third, definition of weak cough was various between different studies. It is confused to judge weak cough for clinical practitioner. Therefore, the consensus on definition of weak cough requires further exploration.

Conclusions

Weak cough is a strong predictor of extubation failure. It can be assessed by CPF and SCSS. The predictive power of CPF may be better than SCSS to diagnose extubation failure.

Abbreviations

MV = mechanical ventilation

SBT = spontaneous breathing trial

PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-analysis

QUADAS = Quality Assessment of Diagnostic Accuracy Studies

CPF = cough peak flow

SCSS = semiquantitative cough strength scale

WCT = white card test

TP = true positive

FP = false positive

FN = false negative

TN = true negative

LR = likelihood ratio

DOR = diagnostic odds ratio

AUC = area under the receiver operating characteristic curves

CI = confidence interval

Declarations

Consent for publication

Not applicable.

Availability of data and material

All data generated and/or analyzed during the current study are included within the published article and its additional files.

Ethical approval and consent to participate

Not applicable.

Competing interests

We declare that we have no competing interests.

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None.

Authors’ contributions

JD conceived this study. JD and XFZ participated in study design, literature research, article selection and data extraction. JD and JPS participated in data analysis and interpretation. JPS also participated in article selection. All authors participated in manuscript preparation and revision, and approved the final version.

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Tables

Table 1. Characteristics of included studies

Author	Year	Country	Design	Measurement of cough strength	Definition of weak cough	Total Cases	TP	FP	FN	TN	Time to extubation failure
Beuret	2009	France	Prospective	Voluntary CPF tested by a flowmeter	CPF ≤35 L/min	130	11	34	3	82	48 h
Duan	2014	China	Prospective	Voluntary CPF tested by a flowmeter	CPF ≤62.4 L/min	115	17	34	3	61	72 h
Duan	2014	China	Prospective	#Involuntary CPF tested by a flowmeter	CPF ≤ 49.8 L/min	115	14	32	6	63	72 h
Gao	2009	China	Prospective	Voluntary CPF tested by a ventilator	CPF ≤58.5 L/min	200	20	55	8	117	72 h
Gao	2009	China	Prospective	SCSS (strong, moderate, weak)	Weak	200	13	15	3	169	72 h
Salam	2004	USA	Prospective	Voluntary CPF tested by a flowmeter	CPF ≤60 L/min	88	11	25	3	49	72 h
Salam	2004	USA	Prospective	WCT	Negative	88	10	36	4	38	72 h
Smailes	2013	UK	Prospective	Voluntary CPF tested by a flowmeter	CPF ≤60 L/min	125	10	7	7	101	48 h
Smina	2003	USA	Prospective	Voluntary CPF tested by a flowmeter	CPF ≤60 L/min	115	9	25	4	73	72 h
Su	2010	China	Prospective	#Involuntary CPF tested by a flowmeter	CPF ≤58.5 L/min	150	25	7	25	93	Hospital stay
Su	2010	China	Prospective	SCSS (strong, weak, no cough)	Weak and no cough	150	25	47	7	71	Hospital stay
Khamiees	2001	China	Prospective	SCSS (grade 0 to 5)	Grade 0 to 2	100	10	8	14	68	72 h
Khamiees	2001	China	Prospective	WCT	Negative	100	9	9	16	66	72 h
Huang	2013	China	Retrospective	SCSS (effective and ineffective)	Ineffective	119	23	4	27	65	7 d
Gobert	2017	France	Prospective	Voluntary CPF tested by a ventilator	CPF ≤60 L/min	92	7	24	4	57	48 h
Liu	2014	China	Prospective	Voluntary CPF tested by a ventilator	CPF ≤60 L/min	102	8	7	36	51	48 h
Duan	2015	China	Prospective	SCSS (grade 0 to 5)	Grade 0 to 2	186	16	52	12	106	72 h
Duan	2015	China	Prospective	Voluntary CPF tested by a flowmeter	CPF ≤60 L/min	186	23	71	5	87	72 h
Bai	2017	China	Prospective	Voluntary CPF tested by a flowmeter	CPF ≤56.4 L/min	126	11	14	4	97	72 h
Bai	2017	China	Prospective	Voluntary CPF tested by a ventilator	CPF ≤56 L/min	126	11	16	4	95	72 h
Xiao	2018	China	Prospective	Voluntary CPF tested by a flowmeter	CPF ≤60 L/min	139	15	36	7	81	72 h
Duan	2017	China	Prospective	Voluntary CPF tested by a flowmeter	CPF ≤70 L/min	356	61	119	15	161	7 d
Thille	2015	France	Prospective	SCSS (grade 0 to 4)	Grade 0 to 2	223	10	15	20	178	7 d
Kutchak	2015	Brazil	Prospective	$Involuntary CPF tested by a flowmeter	CPF ≤80 L/min	135	35	20	10	70	24 h
Almeida	2020	Brazil	Prospective	Voluntary CPF tested by a flowmeter	CPF ≤45 L/min	81	23	3	10	45	48 h
Almeida	2020	Brazil	Prospective	#Involuntary CPF tested by a flowmeter	CPF ≤60 L/min	81	29	4	4	44	48 h
Almeida	2020	Brazil	Prospective	$Involuntary CPF tested by a flowmeter	CPF ≤55 L/min	81	30	7	3	41	48 h
Aziz	2018	Egypt	Prospective	SCSS (grade 0 to 5)	Grade 0 to 2	80	18	19	3	40	72h
Vivier	2019	France	Prospective	SCSS (ineffective, moderate, and effective)	Ineffective	191	6	27	7	141	7 d
Vivier	2019	France	Prospective	Voluntary CPF tested by a flowmeter	CPF ≤60L/min	160	18	10	74	58	7 d
Wang	2019	China	Retrospective	SCSS (with or without spontaneous cough)	Without spontaneous cough	86	19	0	6	61	Hospital stay
Ma	2018	China	Retrospective	SCSS (strong, weak, no cough)	Weak and no cough	108	11	6	8	83	48h
Bach	2010	USA	Prospective	Voluntary CPF tested by a flowmeter	CPF ≤160 L/min	172	15	0	59	98	Hospital stay
Frutos-Vivar	2006	Canada	Prospective	SCSS (poor, moderate, or excellent)	Poor	900	33	178	88	601	72 h
Jaber	2018	France	Prospective	SCSS (weak and strong)	Weak	1505	116	811	32	546	48 h
Dos	2017	Brazil	Prospective	SCSS (grade 0 to 5)	Grade 0 to 2	311	8	21	35	247	48 h
Michetti	2018	USA	Prospective	SCSS (not strong and	Not strong	464	11	142	24	287	96 h

				strong)							
Abbas	2018	Egypt	Prospective	SCSS (grade 0 to 5)	Grade 0 to 2	90	7	11	19	53	48 h
Norisue	2020	Japan	Prospective	Voluntary CPF tested by a ventilator	CPF ≤50 L/min	252	8	62	4	178	72 h
Sanson	2018	Italy	Prospective	SCSS (strong, weak, no cough)	Weak and no cough	205	21	5	121	58	ICU stay
Wang	2009	China	Prospective	SCSS (grade 0 to 5)	Grade 0 to 2	68	9	11	9	39	72 h
Wang	2009	China	Prospective	WCT	Negative	68	10	10	11	37	72 h
Elkholy	2021	Egypt	Prospective	WCT	Negative	150	21	1	24	104	72 h
Lu	2010	China	Prospective	Voluntary CPF tested by a flowmeter	CPF ≤29.35 L/min	19	7	0	4	8	72 h
Liang	2019	China	Prospective	#Involuntary CPF tested by a ventilator	CPF ≤71.15 L/min	48	8	4	2	34	48 h
Thille	2020	France	Prospective	SCSS (grade 0 to 4)	Grade 0 to 1	284	11	45	16	212	7 d

#The cough was stimulated by 2 ml of normal saline.

$The cough was stimulated by suction catheter.

CPF = cough peak flow, SCSS = semiquantitative cough strength scale, WCT = white card test, TP = true positive, FP = false positive, FN = false negative, TN = true negative

Table 2. Summary of the outcomes in different subgroups

	Voluntary CPF	Involuntary CPF	CPF measured by a flowmeter	CPF measured by a ventilator	SCSS (grade 0 to 4/5)	WCT
No. of studies	17	5	16	5	8	4
Total cases	2454	529	2195	718	1342	406
Pooled sensitivity	0.74 (0.69-0.78)	0.82 (0.73-0.88)	0.78 (0.73-0.82)	0.72 (0.60-0.81)	0.36 (0.26-0.48)	0.70 (0.44-0.88)
Pooled specificity	0.72 (0.65-0.78)	0.82 (0.74-0.88)	0.74 (0.66-0.80)	0.77 (0.69-0.84)	0.87 (0.80-0.91)	0.74 (0.61-0.84)
Pooled positive LR	2.6 (2.1-3.3)	4.5 (2.9-7.0)	3.0 (2.3-3.9)	3.1 (2.1-4.6)	2.7 (2.1-3.6)	2.7 (1.5-4.8)
Pooled negative LR	0.36 (0.3-0.43)	0.22 (0.14-0.35)	0.30 (0.24-0.38)	0.37 (0.25-0.55)	0.73 (0.64-0.84)	0.40 (0.18-0.90)
Pooled DOR	7 (5-10)	21 (9-48)	10 (6-15)	9 (4-18)	4 (3-5)	7 (2-25)
Pooled AUC	0.77 (0.73-0.80)	0.89 (0.86-0.91)	0.82 (0.78-0.85)	0.77 (0.73-0.81)	0.70 (0.65-0.73)	0.78 (0.74-0.82)

CPF = cough peak flow, SCSS = semiquantitative cough strength scale, WCT = white card test, LR = likelihood ratio, DOR = diagnostic odds ratio, AUC = area under the receiver operating characteristic curves

Figures

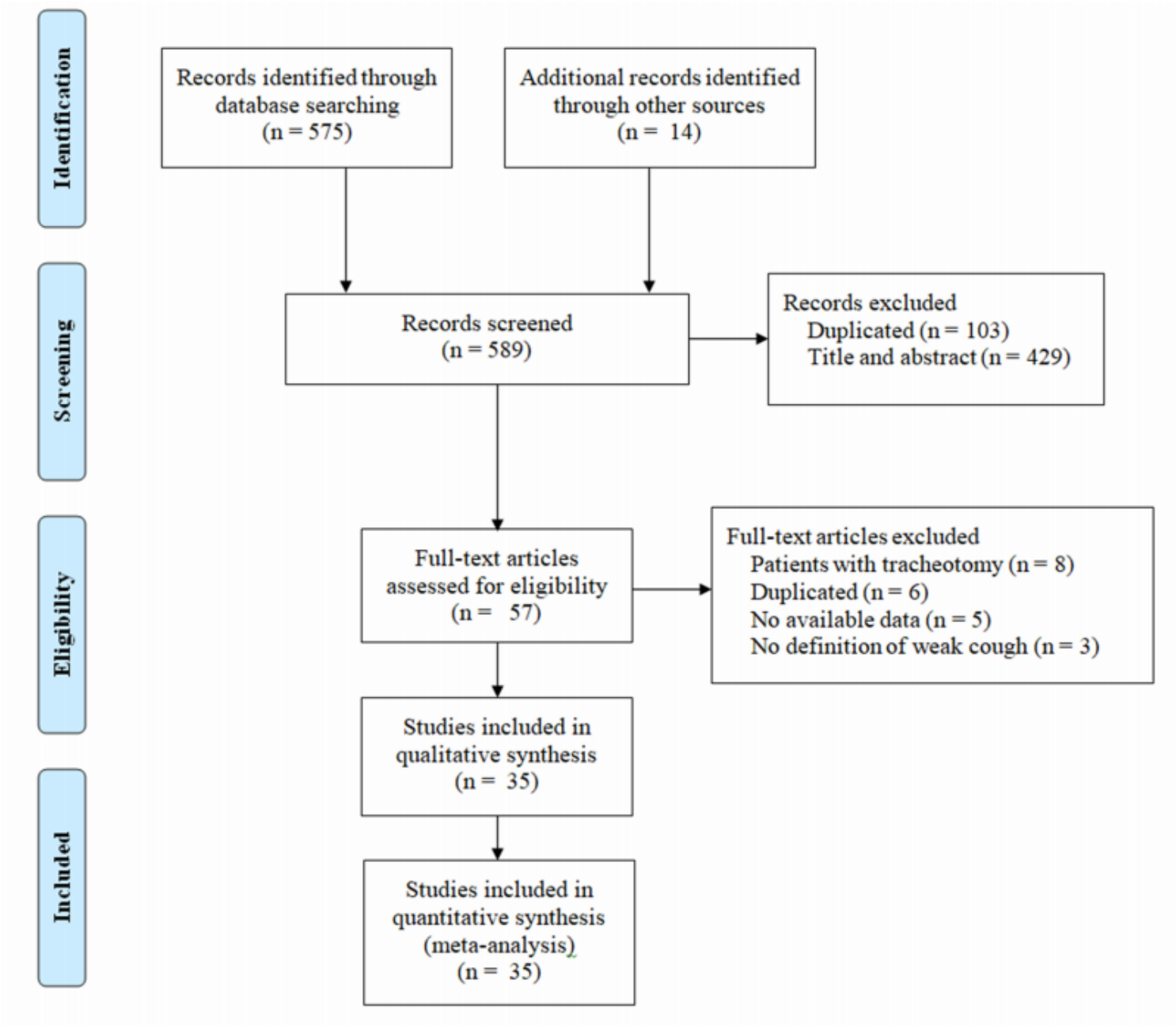

Figure 1

Flowchart of study selection

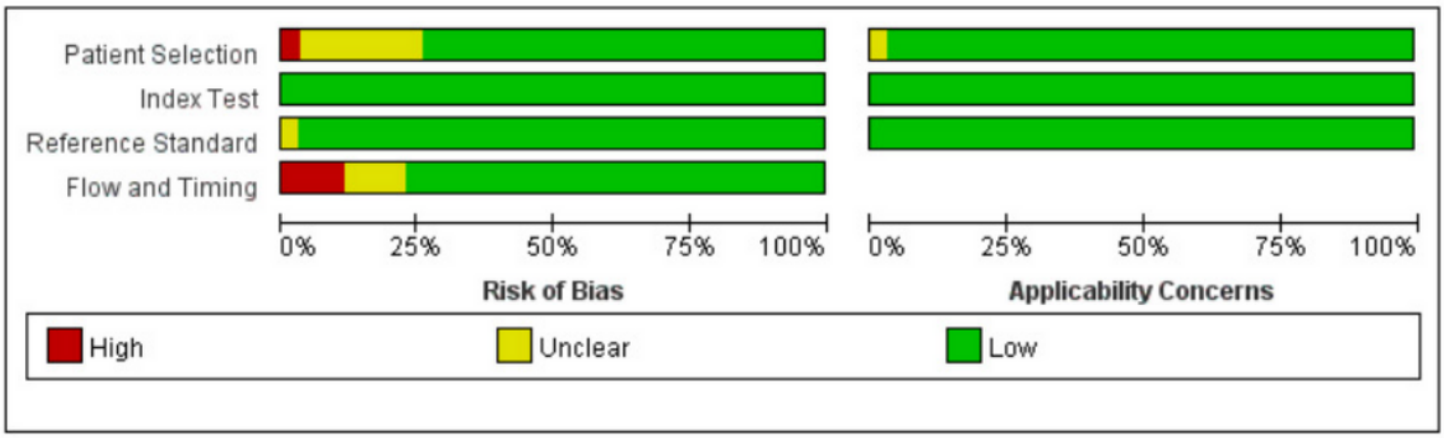

Figure 2

Quality Assessment of Diagnostic Accuracy Studies criteria for the included studies

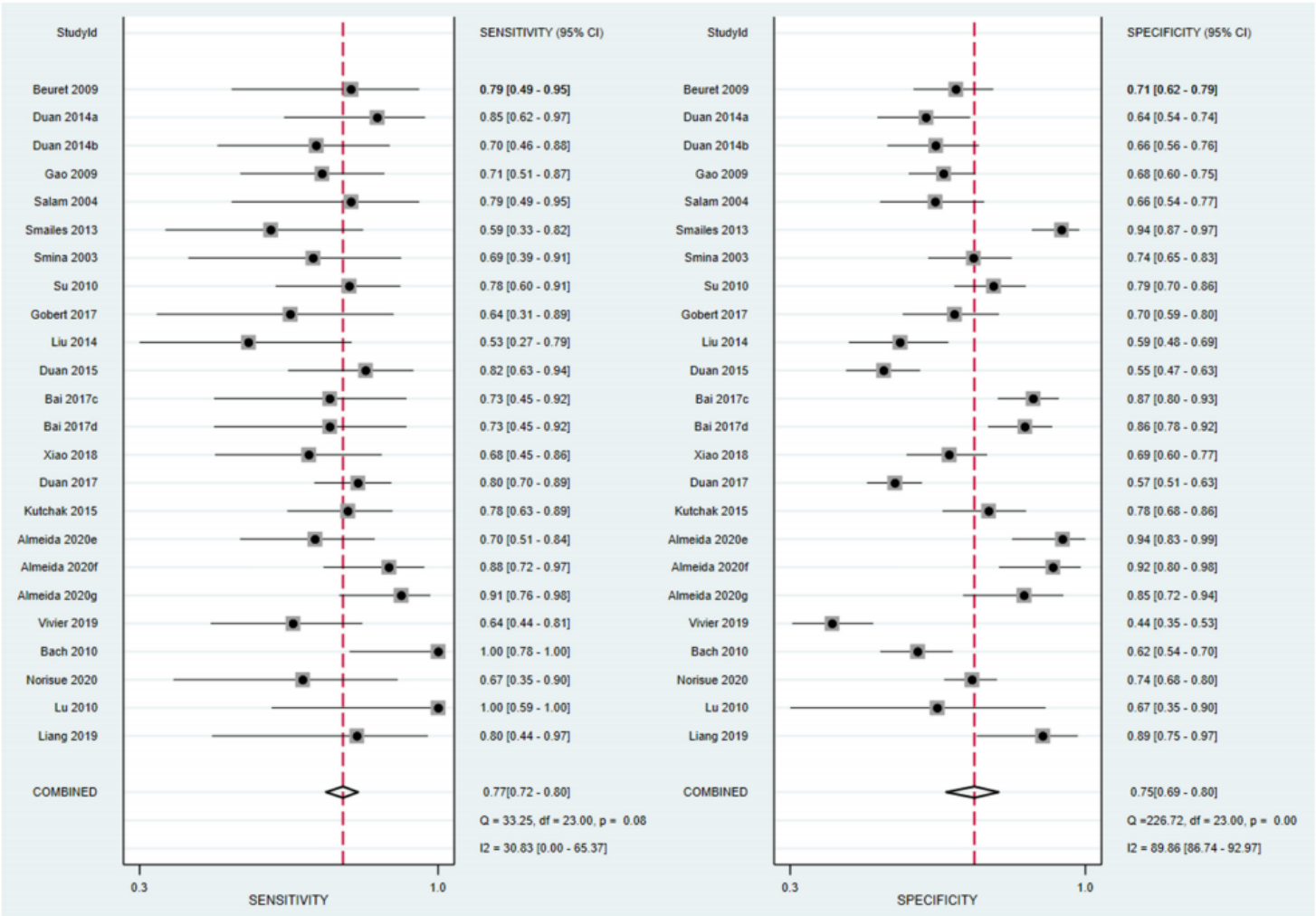

Figure 3

Forest plot of the sensitivity and specificity among studies assessed CPF to predict extubation failure Duan 2014a measured voluntary CPF by a flowmeter. Duan 2014b measured involuntary CPF by a

flowmeter. Bai 2017c measured voluntary CPF by a flowmeter. Bai 2017d measured voluntary CPF by a ventilator. Almeida 2020e measured voluntary CPF by a flowmeter. Almeida 2020f measured involuntary CPF stimulated by 2 ml of normal saline. And Almeida 2020g measured involuntary CPF stimulated by suction catheter.

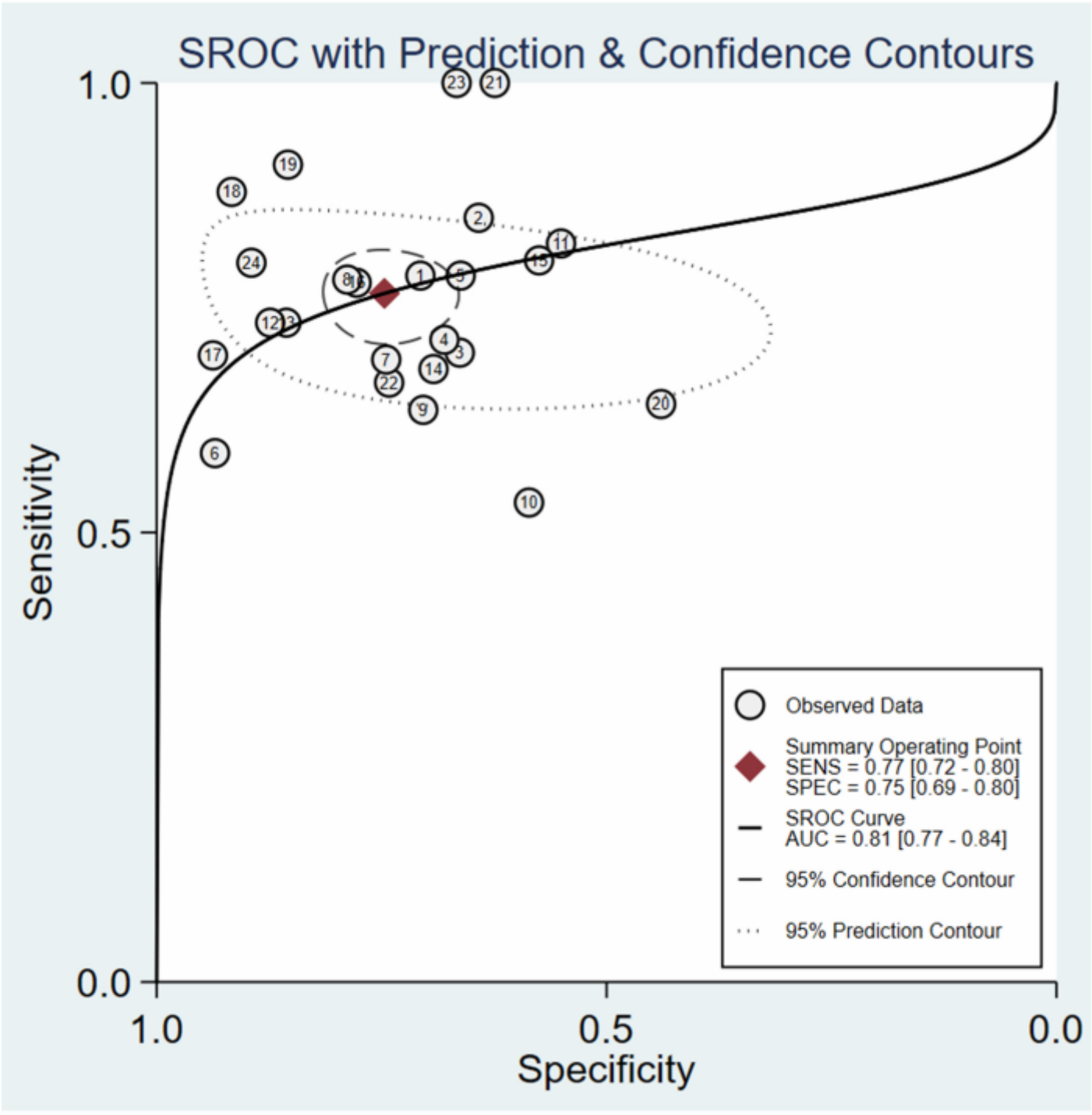

Figure 4

SROC curve for the diagnostic accuracy of CPF in the prediction of extubation failure

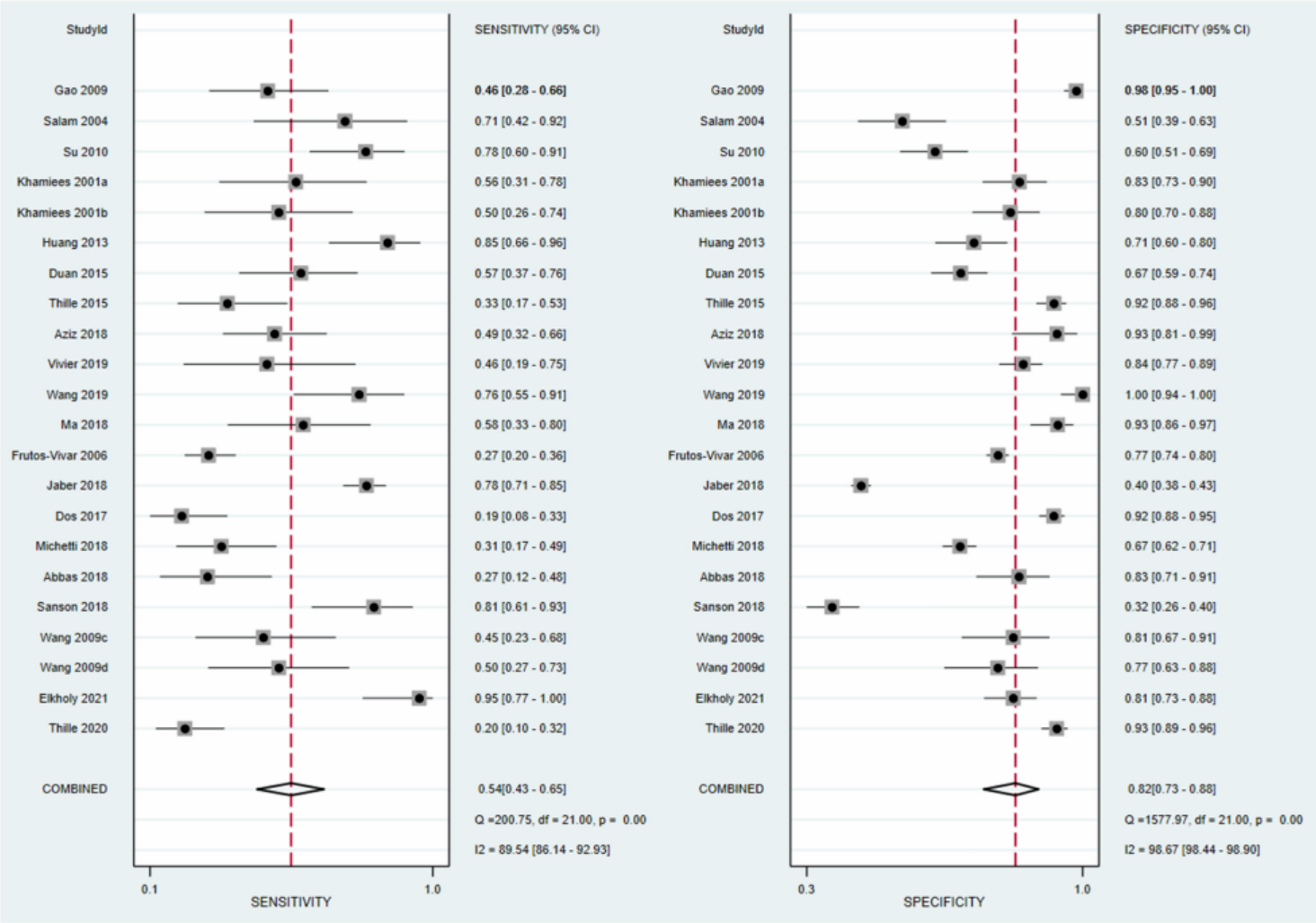

Figure 5

Forest plot of the sensitivity and specificity among studies assessed SCSS to predict extubation failure Khamiees 2001a measured SCSS ranged from 0 to 5. Khamiees 2001b measured SCSS by WCT. Wang 2009c measured SCSS ranged from 0 to 5. And Wang 2009d measured SCSS by WCT.

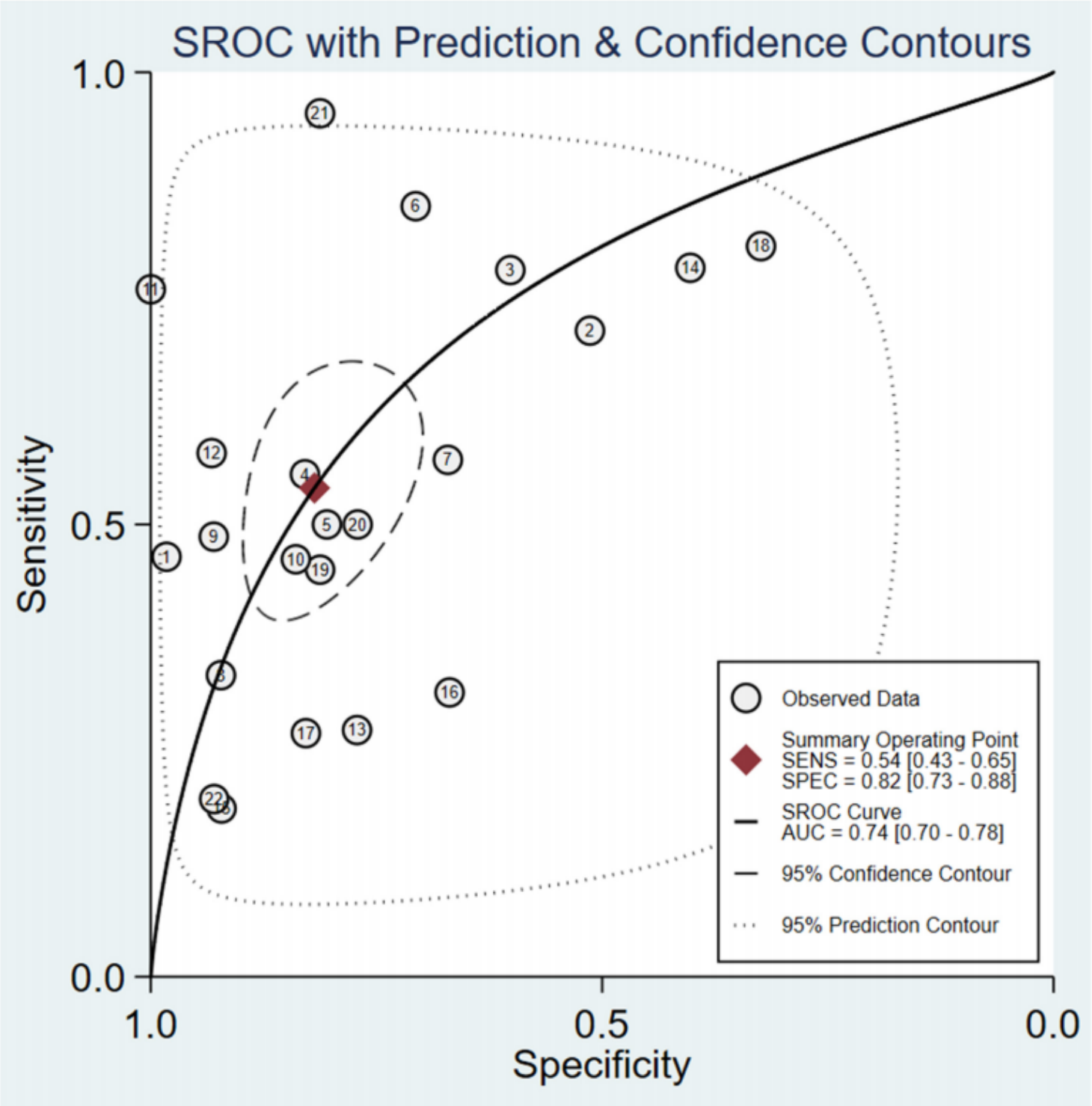

Figure 6

SROC curve for the diagnostic accuracy of SCSS in the prediction of extubation failure

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Supplementaryfigure1.pdf
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- Supplementaryfigure3.pdf
- Supplementaryfigure4.pdf
- Supplementaryfigure5.pdf
- Supplementaryfigure6.pdf
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- Supplementaryfigure9.pdf