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# Uppdaterade riktlinjer för dynamisk spirometri

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# Dynamisk spirometri senaste riktlinjer



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## AMERICAN THORACIC SOCIETY DOCUMENTS

### **Standardization of Spirometry 2019 Update**

An Official American Thoracic Society and European Respiratory Society  
Technical Statement

8 Brian L. Graham, Irene Steenbruggen, Martin R. Miller, Igor Z. Barjaktarevic, Brendan G. Cooper, Graham L. Hall, Teal S. Hallstrand, David A. Kaminsky, Kevin McCarthy, Meredith C. McCormack, Cristine E. Oropez, Margaret Rosenfeld, Sanja Stanojevic, Maureen P. Swanney<sup>†</sup>, and Bruce R. Thompson; on behalf of the American Thoracic Society and the European Respiratory Society

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## Vad är nytt?

- Lyfter fram undersökarens roll
- Uppdaterat lista ang **relativa** kontraindikationer
- Uppdaterat avsnitt ang **förberedelser**
- Tydligare och mera pragmatiska riktlinjer kring en bra undersökning – **acceptabel** och reproducerbar mätning
- **Gradering av kvalitet** för spirometri
- Introducerar begreppet **svar på bronkdilaterande** och föreslår att den ska användas istället för reversibilitetstest
- Krav på spirometertillverkarna både ang tekniska egenskaper samt mjukvara



**Table 1.** Indications for Spirometry

---

**Diagnosis**

- To evaluate symptoms, signs, or abnormal laboratory test results
- To measure the physiologic effect of disease or disorder
- To screen individuals at risk of having pulmonary disease
- To assess preoperative risk
- To assess prognosis

**Diagnostik**

**Monitoring**

- To assess response to therapeutic intervention
- To monitor disease progression
- To monitor patients for exacerbations of disease and recovery from exacerbations
- To monitor people for adverse effects of exposure to injurious agents
- To watch for adverse reactions to drugs with known pulmonary toxicity

**Uppföljning**

**Disability/impairment evaluations**

- To assess patients as part of a rehabilitation program
- To assess risks as part of an insurance evaluation
- To assess individuals for legal reasons

**Prognos /  
Riskvärdering**

**Other**

- Research and clinical trials
  - Epidemiological surveys
  - Derivation of reference equations
  - Preemployment and lung health monitoring for at-risk occupations
  - To assess health status before beginning at-risk physical activities
- 

**Andra indikationer  
/ folkhälsa**



# Kontraindikationer



## Få absoluta kontraindikationer

- Akut hjärtinfarkt / instabil angina
- Akut lungemboli
- Aortadissektion

## Relativa kontraindikationer pga:

- kardiovaskulär påfrestning
- ökad intrakraniellt tryck
- ökad intratorakalt / intrabdominellt tryck
- infektionsrisk
- opålitlig (suboptimal) registrering

*(se nästa bild för mera detaljer)*



# Kontraindikationer



**Table 2.** Relative Contraindications for Spirometry

---

Due to increases in myocardial demand or changes in blood pressure

- Acute myocardial infarction within 1 wk
- Systemic hypotension or severe hypertension
- Significant atrial/ventricular arrhythmia
- Noncompensated heart failure
- Uncontrolled pulmonary hypertension
- Acute cor pulmonale
- Clinically unstable pulmonary embolism
- History of syncope related to forced expiration/cough

Due to increases in intracranial/intraocular pressure

- Cerebral aneurysm
- Brain surgery within 4 wk
- Recent concussion with continuing symptoms
- Eye surgery within 1 wk

Due to increases in sinus and middle ear pressures

- Sinus surgery or middle ear surgery or infection within 1 wk

Due to increases in intrathoracic and intraabdominal pressure

- Presence of pneumothorax
- Thoracic surgery within 4 wk
- Abdominal surgery within 4 wk
- Late-term pregnancy

Infection control issues

- Active or suspected transmissible respiratory or systemic infection, including tuberculosis
  - Physical conditions predisposing to transmission of infections, such as hemoptysis, significant secretions, or oral lesions or oral bleeding
-



# Aortaneurysm och spirometri



A 20-year review of 186,000 pulmonary function tests in a tertiary institution found that patient safety incidents occurred in 5 of every 10,000 routine pulmonary function tests (excluding exercise and provocation tests) with generally low risk of harm (21).

induced by spirometry (23). No adverse effects were reported in spirometry conducted in studies of 56 and 230 (24, 25) patients with abdominal aortic aneurysms from 5 to 13 cm in size and in 519 patients with thoracic aortic aneurysms from 5 to 8 cm in size (26).



**Table 3.** Equipment Quality Assurance (for Both Volume- and Flow-based Sensors)

---

## Spirometer

- Daily calibration verification at low, medium, and high flow: If the calibration verification fails, check for and remediate problems (Table 4) and repeat calibration verification
- If an in-line filter is used in spirometry testing, then it must also be used during recalibrations and verifications
- Recalibrate the spirometer both after failed calibration verification and at intervals specified by the manufacturer
- If the change in calibration factor is  $\geq 6\%$  or varies by more than  $\pm 2$  SD from the mean, inspect and, if necessary, clean the spirometer according to the manufacturer's instructions; check for errors (Table 4) and recalibrate the spirometer
- Perform routine checks and maintenance at intervals specified by the manufacturer

Daglig  
kalibrering

## 3-L calibration syringe

- Daily inspection for displacement of the piston stop
- Daily check for smooth operation of the syringe with no sticking or catching
- Accuracy of  $\pm 0.015$  L verified by manufacturer on delivery and at intervals recommended by the manufacturer
- Monthly syringe leak test

Kolla även  
kalibreringsprutan

## Documentation

- A log of all quality control findings, repairs and adjustments, and hardware and software updates
  - Verification of reference value calculations after software updates
- 

Dokumentera





**Table 6.** Procedures for FVC Maneuvers

---

**Wash hands\*** (or use an approved hand sanitizer)

**Prepare the patient**

Dispense hand sanitizer for the patient

Confirm patient identification, age, birth sex, ethnicity, etc.

Measure weight and height without shoes

Ask about activities listed in Table 5, medication use, and any relative contraindications flagged on the requisition; note respiratory symptoms

Mät längd  
och vikt

Instructions on withholding medications should be given to the patient at the time of making the appointment. The operator must record the type and dosage of any inspired, oral, or injected medication that may alter lung function and when the drugs were last administered. The operator should record observed signs or symptoms such as cough, wheeze, dyspnea, or cyanosis.

**Table 5.** Activities That Should Be Avoided before Lung Function Testing

---

- Smoking and/or vaping and/or water pipe use within 1 h before testing (to avoid acute bronchoconstriction due to smoke inhalation)
  - Consuming intoxicants within 8 h before testing (to avoid problems in coordination, comprehension, and physical ability)
  - Performing vigorous exercise within 1 h before testing (to avoid potential exercise-induced bronchoconstriction)
  - Wearing clothing that substantially restricts full chest and abdominal expansion (to avoid external restrictions on lung function)
- 

ATS/ERS 2019

Instruera om läkemedel  
Notera symtom, läkemedel



- Vid diagnostisk spirometri ska patienten avstå luftrörsvidgande behandling

**Table 8.** Bronchodilator Withholding Times

Bronchodilator Medication	Withholding Time
SABA (e.g., albuterol or salbutamol)	4–6 h
SAMA (e.g., ipratropium bromide)	12 h
LABA (e.g., formoterol or salmeterol)	24 h
Ultra-LABA (e.g., indacaterol, vilanterol, or olodaterol)	36 h
LAMA (e.g., tiotropium, umeclidinium, aclidinium, or glycopyrronium)	36–48 h

*Definition of abbreviations:* LABA = long-acting  $\beta_2$ -agonist; LAMA = long-acting muscarinic antagonist; SABA = short-acting  $\beta_2$ -agonist; SAMA = short-acting muscarinic antagonist.

*Note:* Withholding times for post-bronchodilator testing are shorter than those for methacholine challenge testing (147) because the bronchoprotection provided by these agents lasts longer than their bronchodilation effects. In the case of dual bronchodilators, the withholding time for the longer-acting bronchodilator is used.



## **Instruct and demonstrate the test**

- Position of the mouthpiece and noseclip
- Correct posture with head slightly elevated
- Inspire rapidly until completely full
- Expire with maximal effort until completely empty
- Inspire with maximal effort until completely full
- Confirm that patient understands the instructions and is willing to comply

## **Perform maneuver**

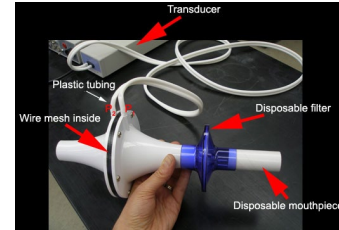
- Have patient assume the correct posture
- Attach noseclip, place mouthpiece in mouth, and close lips around the mouthpiece
- Breathe normally
- Inspire completely and rapidly with a pause of  $\leq 2$  s at TLC
- Expire with maximal effort until no more air can be expelled while maintaining an upright posture
- Inspire with maximal effort until completely full
- Repeat instructions as necessary, coaching vigorously
- Repeat for a minimum of three maneuvers, usually no more than eight for adults
- Check FEV<sub>1</sub> and FVC repeatability and perform more maneuvers as necessary



# Dynamisk Spirometri



$$\text{Flöde} = \frac{\text{Alveolartryck}}{\text{Luftvägsmotstånd}}$$



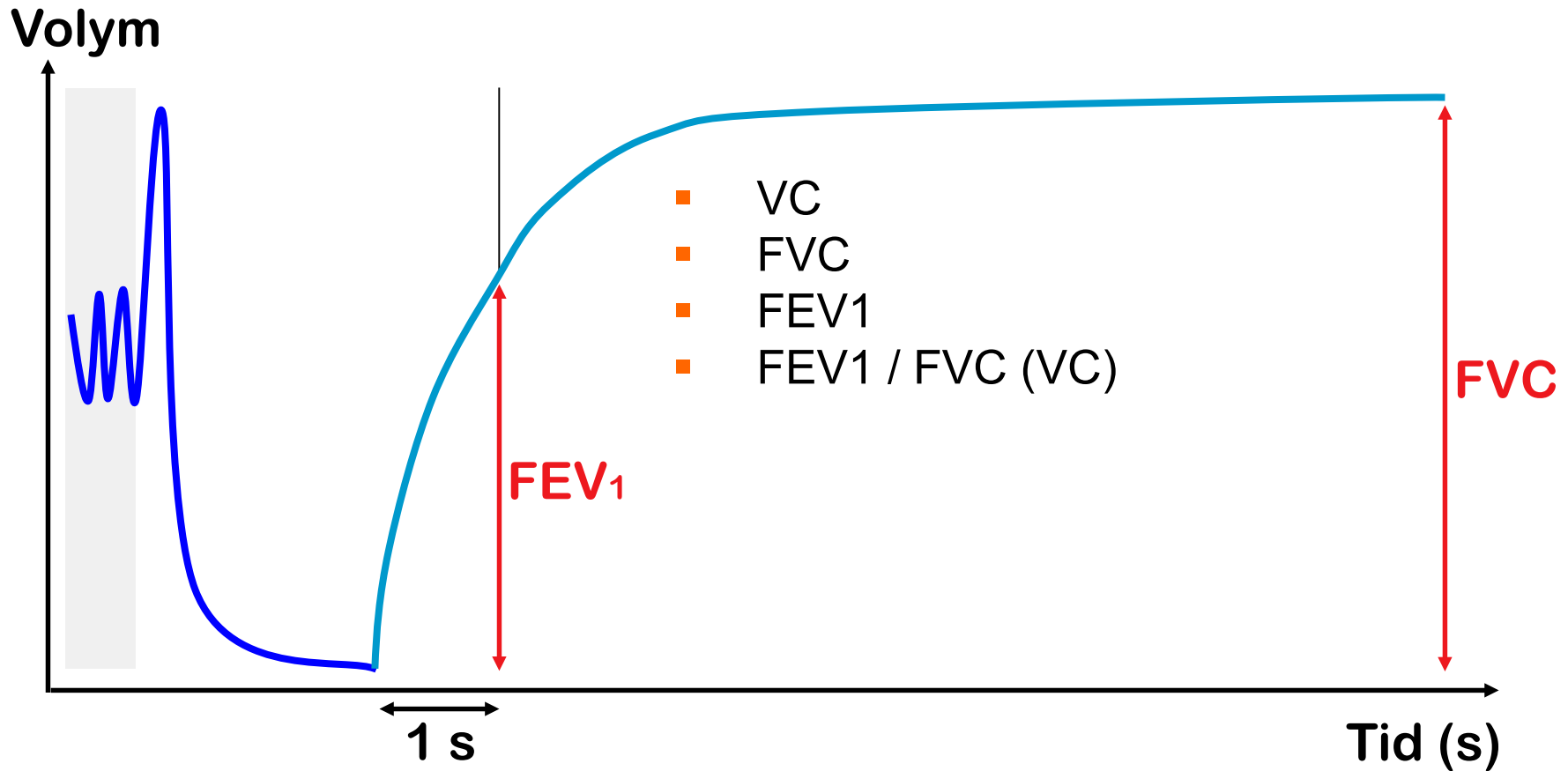
**Flödet minskar** om Alveolartrycket minskar eller Luftvägsmotståndet ökar

**Flödet ökar** om Alveolartrycket ökar eller Luftvägsmotståndet minskar





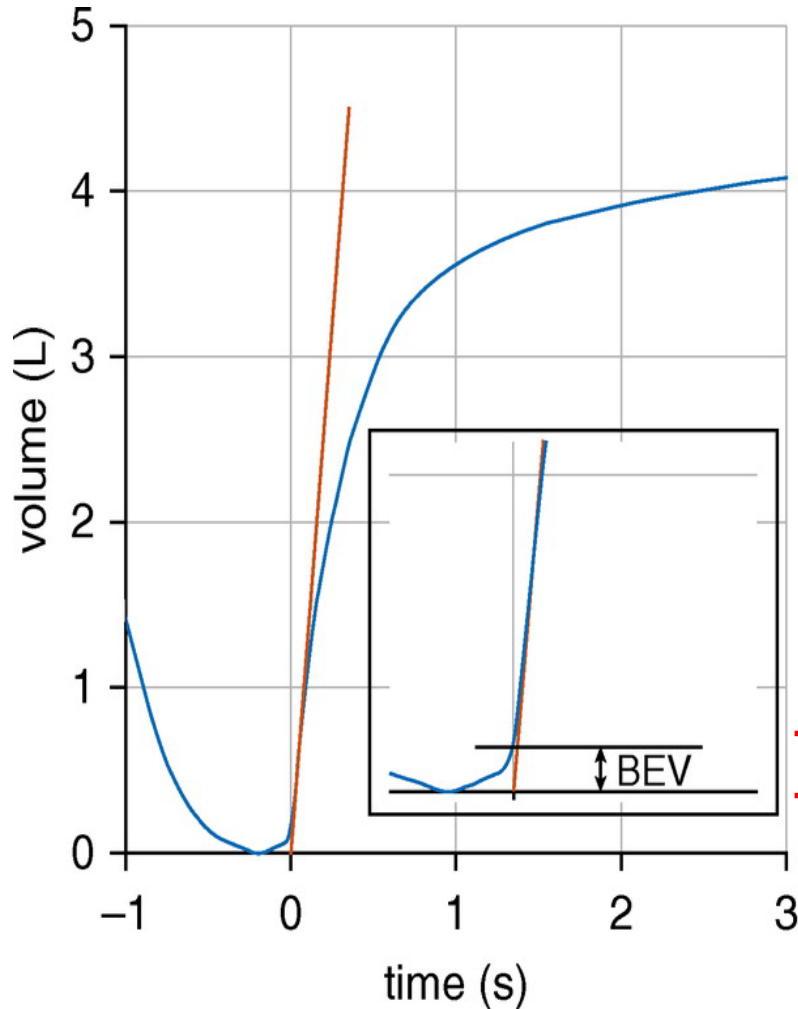
# Dynamisk Spirometri



- Oftra görs enbart FVC (pga rekommendationerna i SoS 2015)



# Snabb tömning



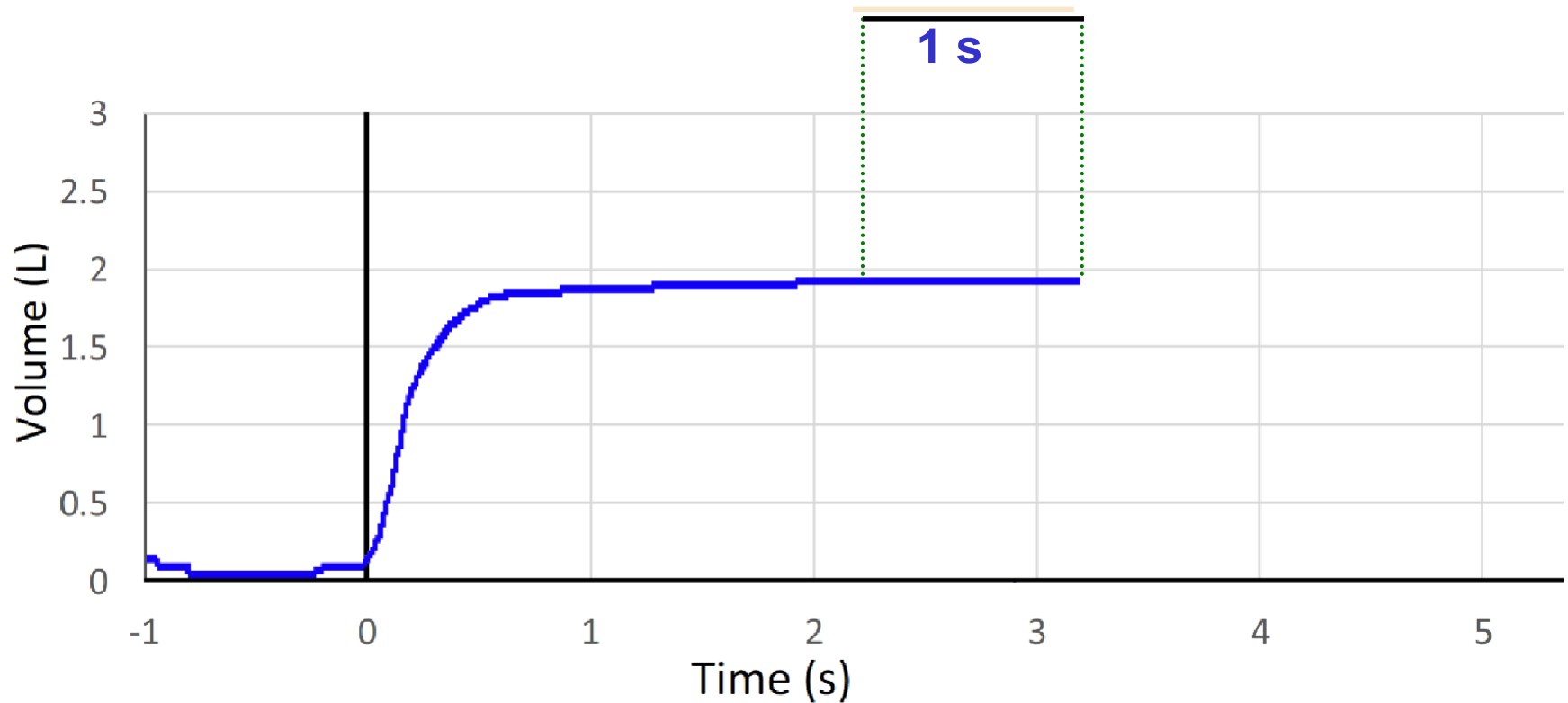
Utandad volym (BEV)  
innan den forcerade  
utandningen är påbörjad  
får ej överstiga 5% av  
FVC och/eller 0,10 L



# Platå under sista utandningssekunden

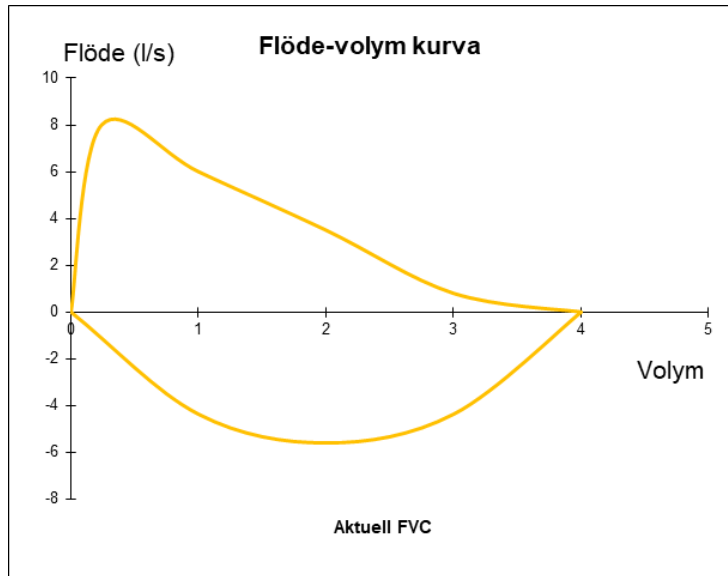


Volymsändring högst  
0,025 L under sista  
utandningssekunden





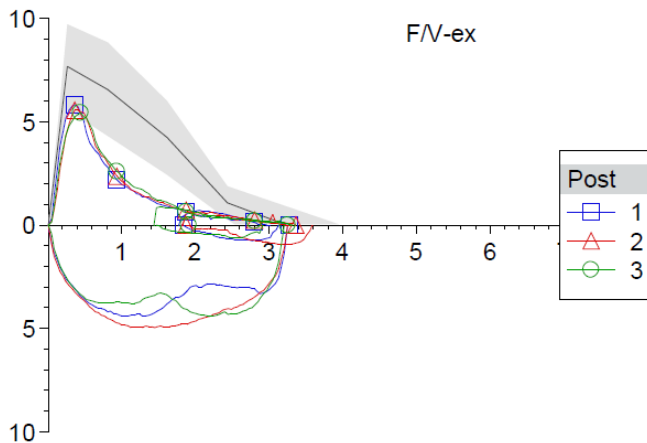
# Även informationen från flöde-volymkurva



Tydlig och tidig peak

Inga artefakta  
(kommande slides)

Överlappande kurvor  
(flera försök)



Inspiration och  
expirationsvolymen  
ska vara samma

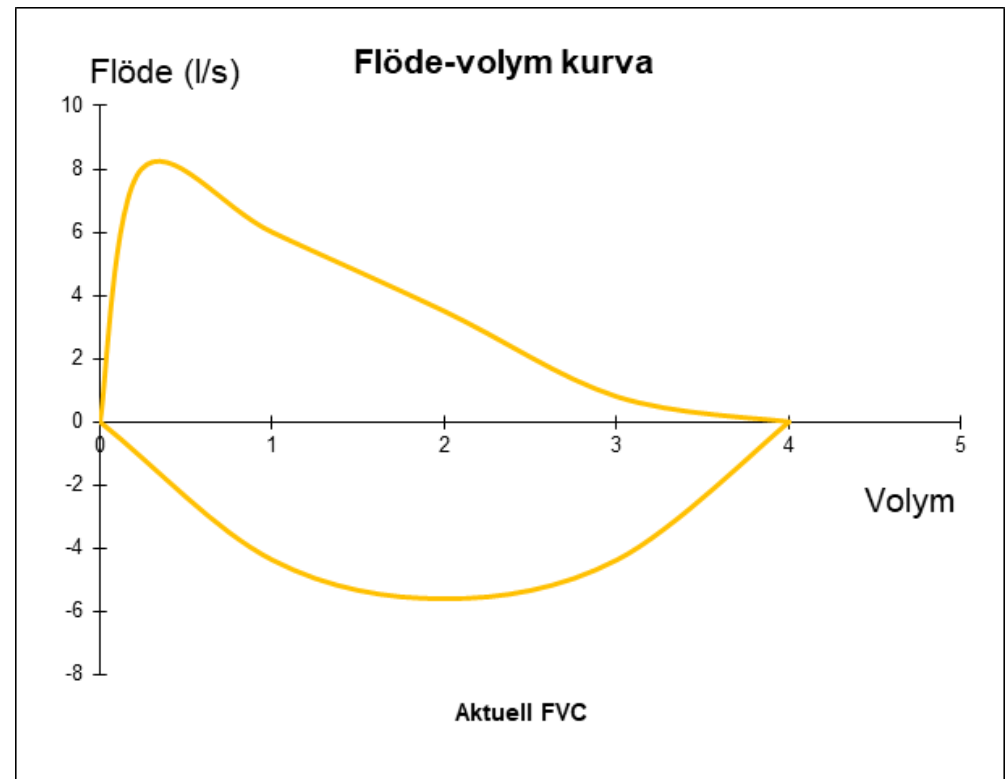
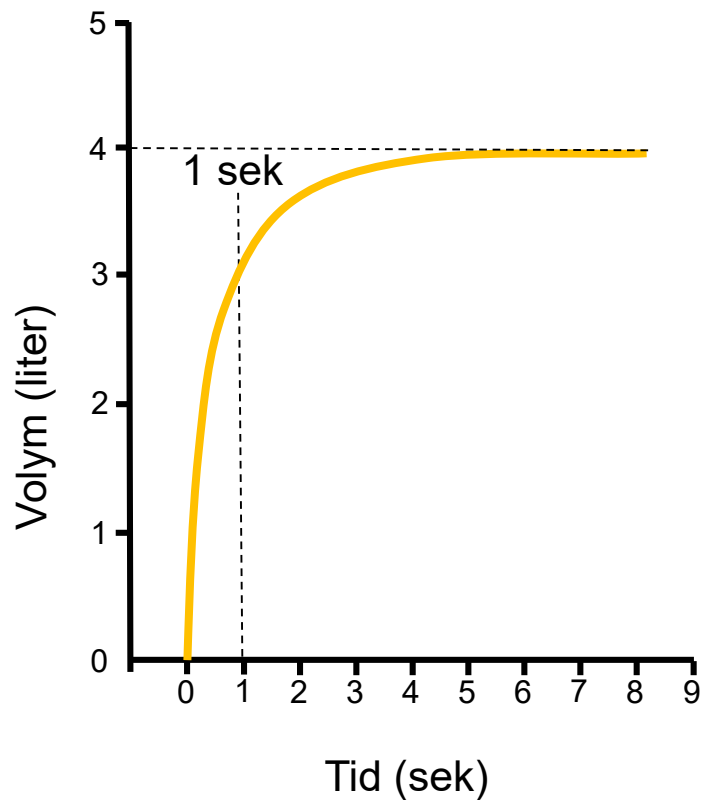




# Spirometriundersökningen - bedömning av underlag

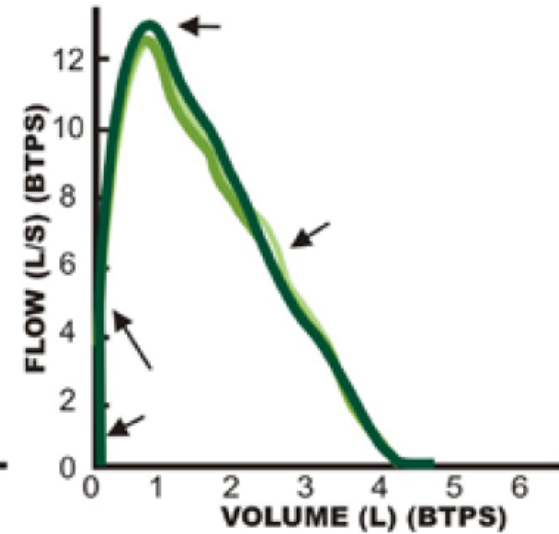
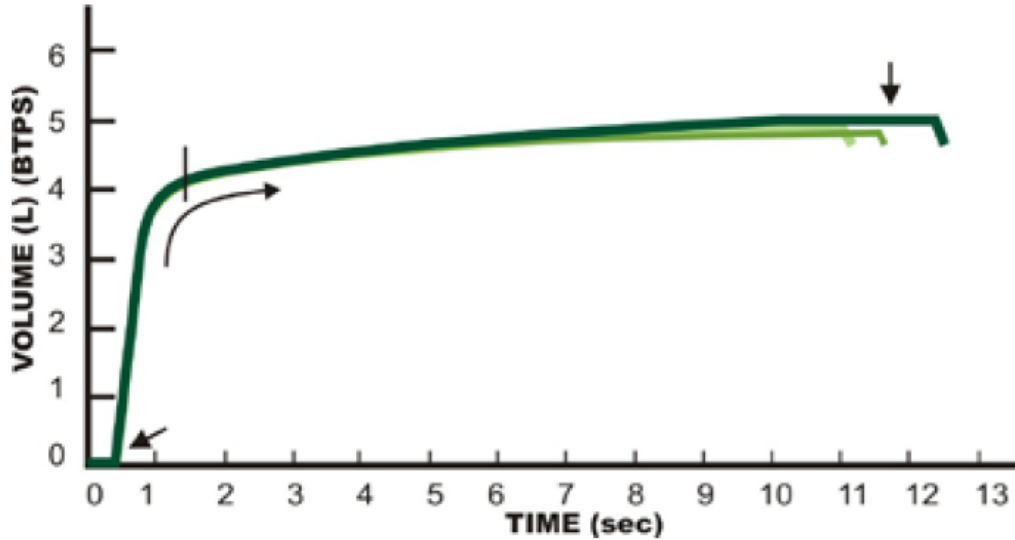


Både volym-tidskurva samt flöde-volymkurva





# Bra mätning



2012 NIOSH Spirometry Quality Assurance: Common Errors and Their Impact on Test Results 8

## Valid Normal Test

Trial	FVC (L)	FEV <sub>1</sub> (L)	PEF (L/sec)
1	4.81	4.09	12.1
2	4.74	4.07	12.0
3	<b>4.87</b>	<b>4.14</b>	<b>12.5</b>
Repeatability	0.06	0.05	

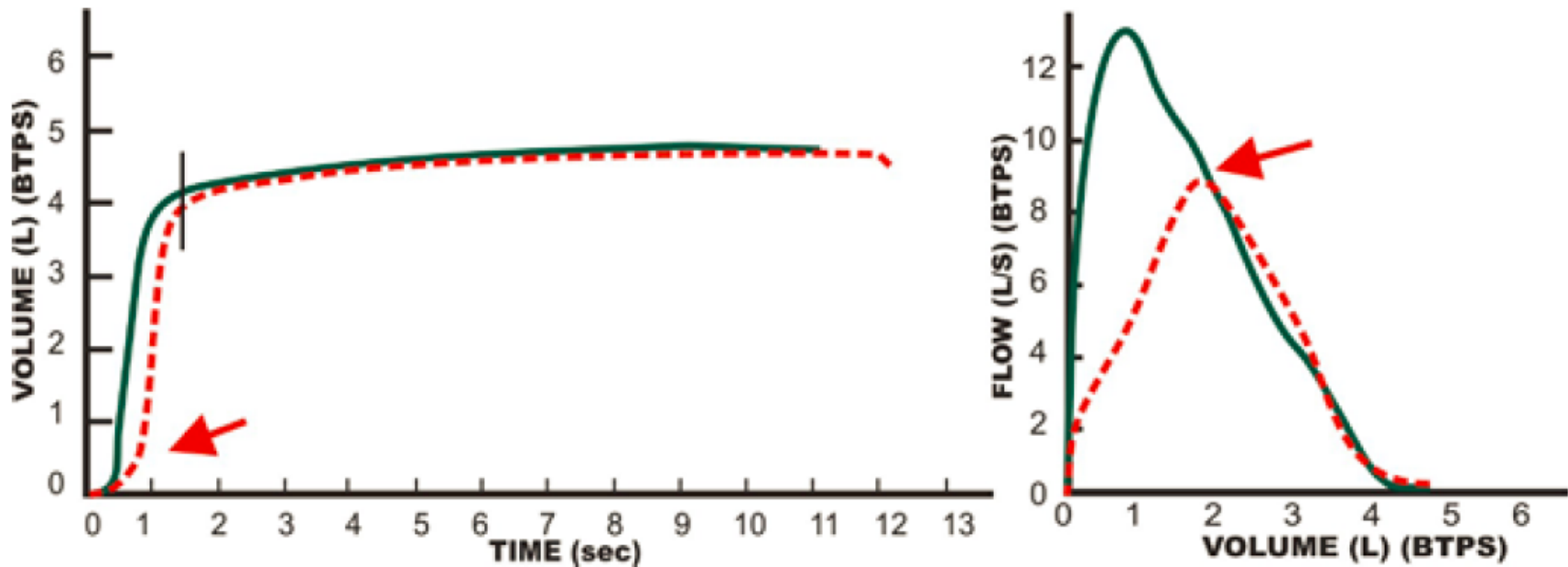
$4.87 - 4.81 = 0.06$     $4.14 - 4.09 = 0.05$



# Vanliga felkällor



## Tveksam start

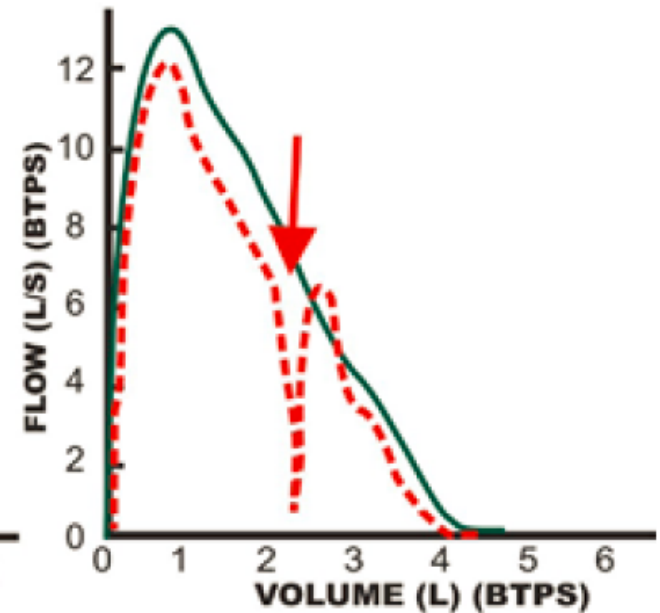
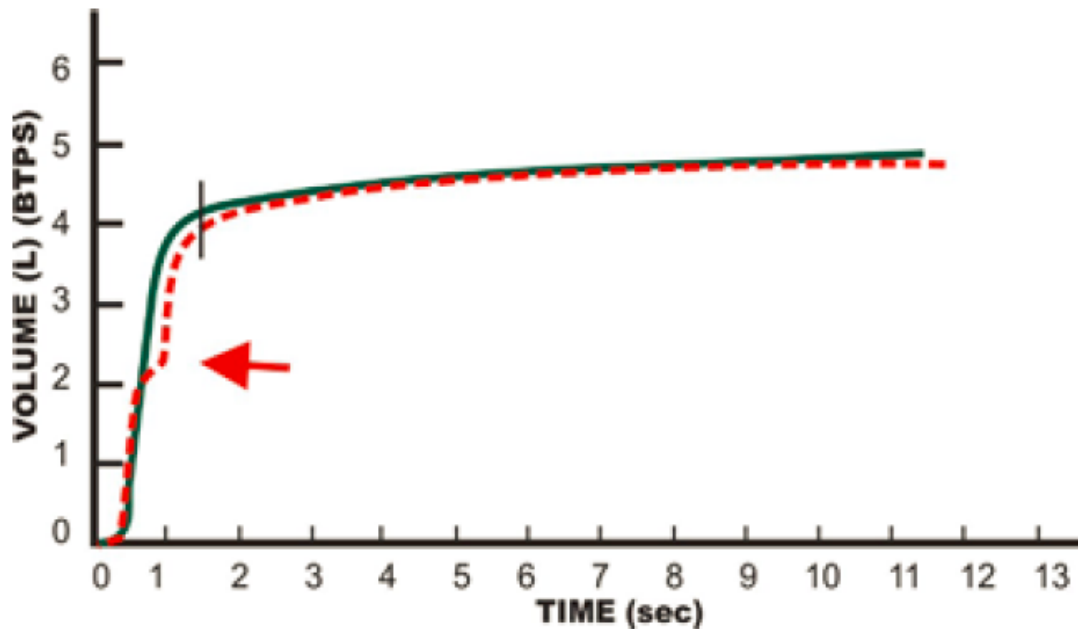




# Vanliga felkällor



## Hosta

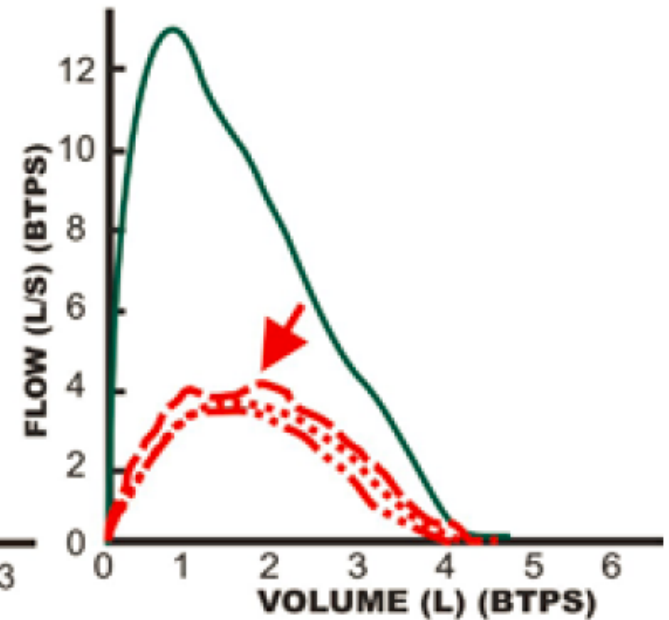
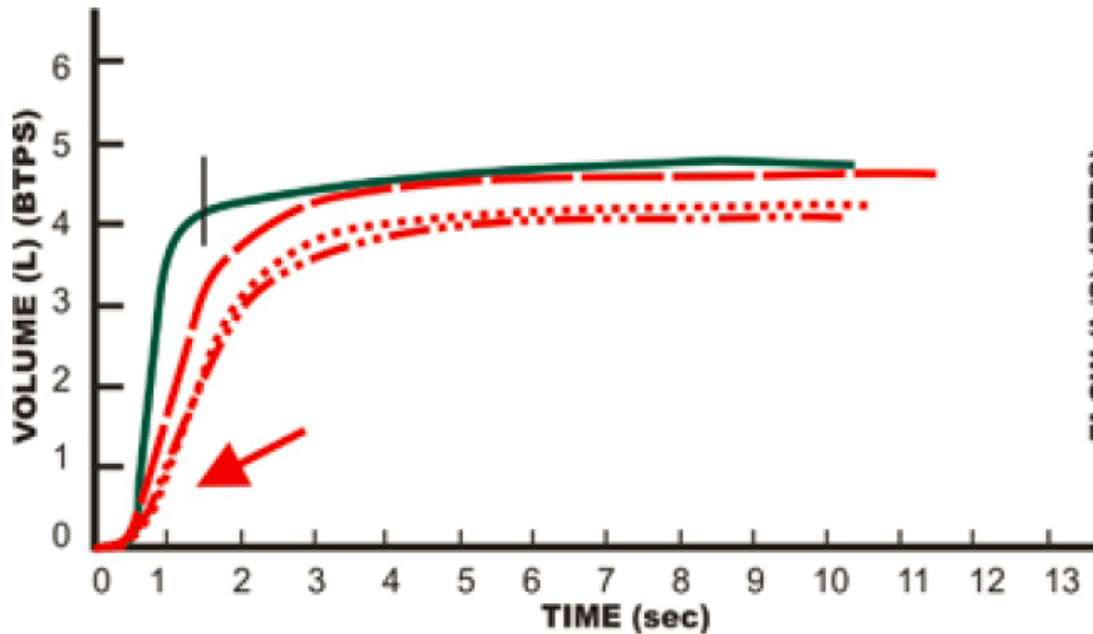




# Vanliga felkällor

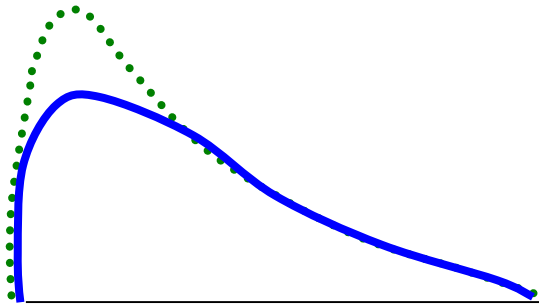


## Dålig ansträngning

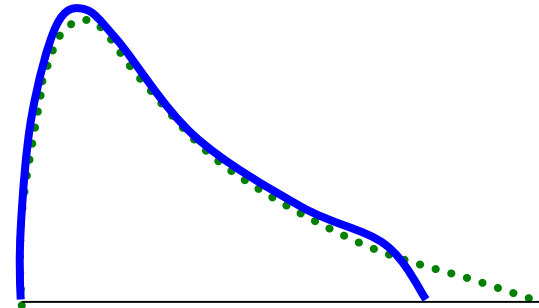




## Möjliga fel och effekten av dessa



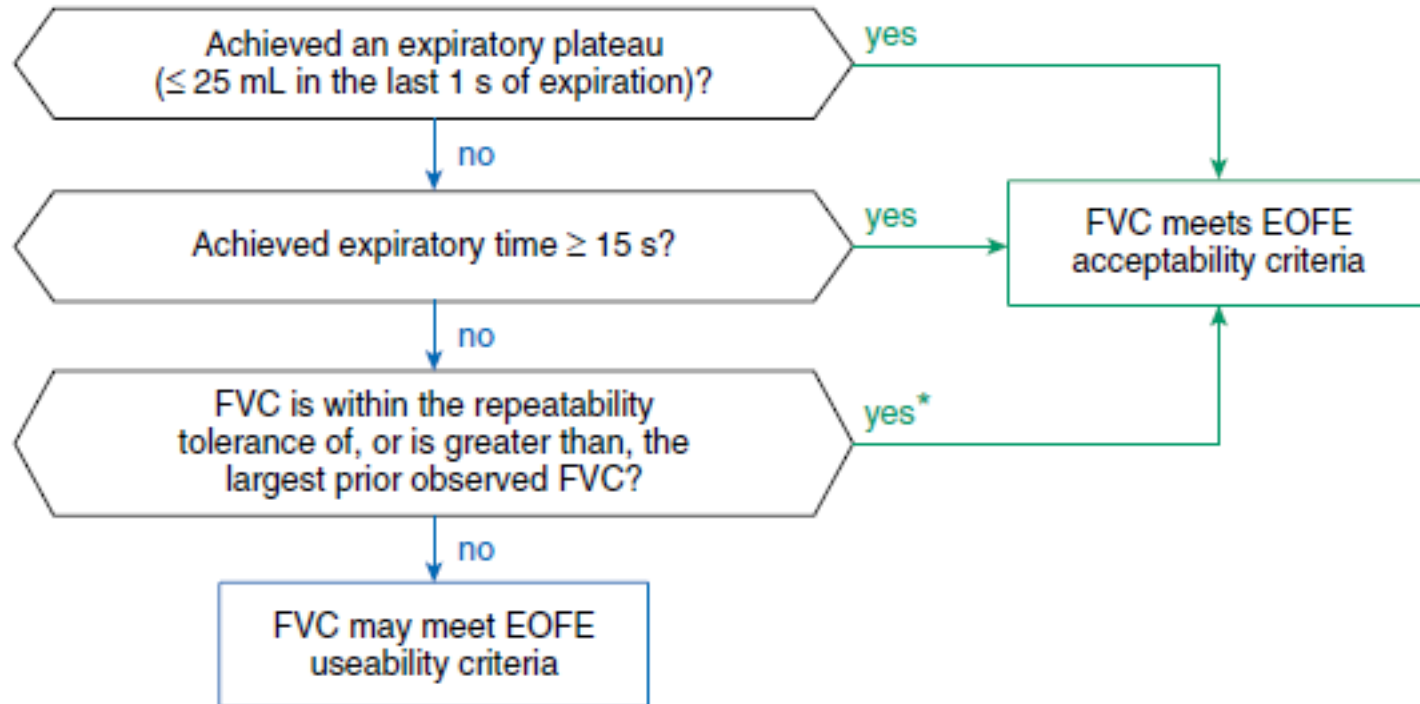
**Dålig Peak**  
**Falskt Låg PEF**  
**Falskt Låg FEV<sub>1</sub>**  
**Falskt Låg FEV<sub>1</sub>/VC**  
**Korrekt FVC**



**Tidigt avslut**  
**Falskt Låg FVC**  
**Falskt Hög FEV<sub>1</sub>/FVC**  
**Korrekt PEF**  
**Korrekt FEV<sub>1</sub>**



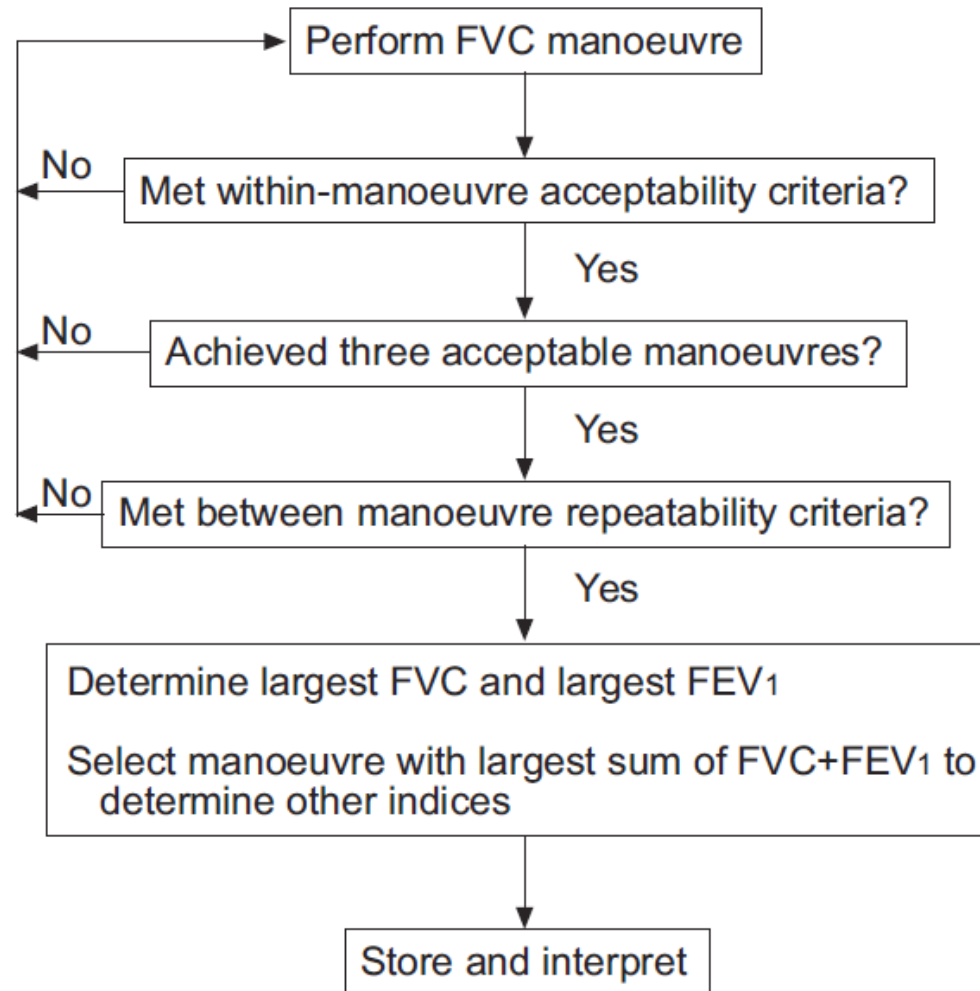
# Spirometriundersökningen



**Figure 2.** Flowchart outlining the end of forced expiration (EOFE) acceptability criteria for FVC. \*If there are no prior observed FVC values in the current pre- or post-bronchodilator testing set, then the FVC provisionally meets EOFE acceptability criteria.



# Spirometriundersökningen







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# Spirometriundersökningen



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**Alltid utföra (minst) 3 tekniskt  
godkända spirometrimanövrar  
(*max 8*)**

**Värdena från de två bästa  
manövrarna för FEV<sub>1</sub> och FVC får ej  
sprida mer än 150 mL**

**Högsta FEV<sub>1</sub> och FVC (från alla  
försök) rapporteras och används för  
att beräkna kvoten.**



# Spirometriundersökningen - föreslagen kvalitetsgradering



**Table 10.** Grading System for FEV<sub>1</sub> and FVC (Graded Separately)

Grade	Number of Measurements	Repeatability: Age >6 yr
A	≥3 acceptable	Within 0.150 L
B	2 acceptable	Within 0.150 L
C	≥2 acceptable	Within 0.200 L
D	≥2 acceptable	Within 0.250 L
E	≥2 acceptable OR 1 acceptable	>0.250 L N/A
U	0 acceptable AND ≥1 usable	N/A
F	0 acceptable and 0 usable	N/A



# Bronkdilatationstest\*



$$\frac{100 \times (\text{FEV}_1 \text{ (efter)} - \text{FEV}_1 \text{ (före)})}{\text{FEV}_1 \text{ (före)}}$$

**Signifikant (relevant) effekt om  
FEV<sub>1</sub> ökar  $\geq 12\%$  och 200 ml**

**\* I de nyaste riktlinjerna ATS 2019 har man  
ersatt termen reversibilitetstest**



Beta-2 agonister i första hand – inget konsensus om dos och hur det ska administreras, men 400 mikrogram salbutamol i spacer är ett exempel i riktlinjerna.

Andra beta-2 agonister / antikolinerga kan användas.

Se <https://vardgivare.skane.se/siteassets/3.-kompetens-och-utveckling/sakkunniggrupper/kc-astma-allergi/kunskapsblad/kunskapsblad-revtestvuxen.pdf>

Man tittar också på svaret i FVC och VC och bedömer dem på samma sätt – dvs ökning med minst 12% och 200 mL som betydelsefullt svar.



# Svar på bronkdilaterande vid astma och KOL

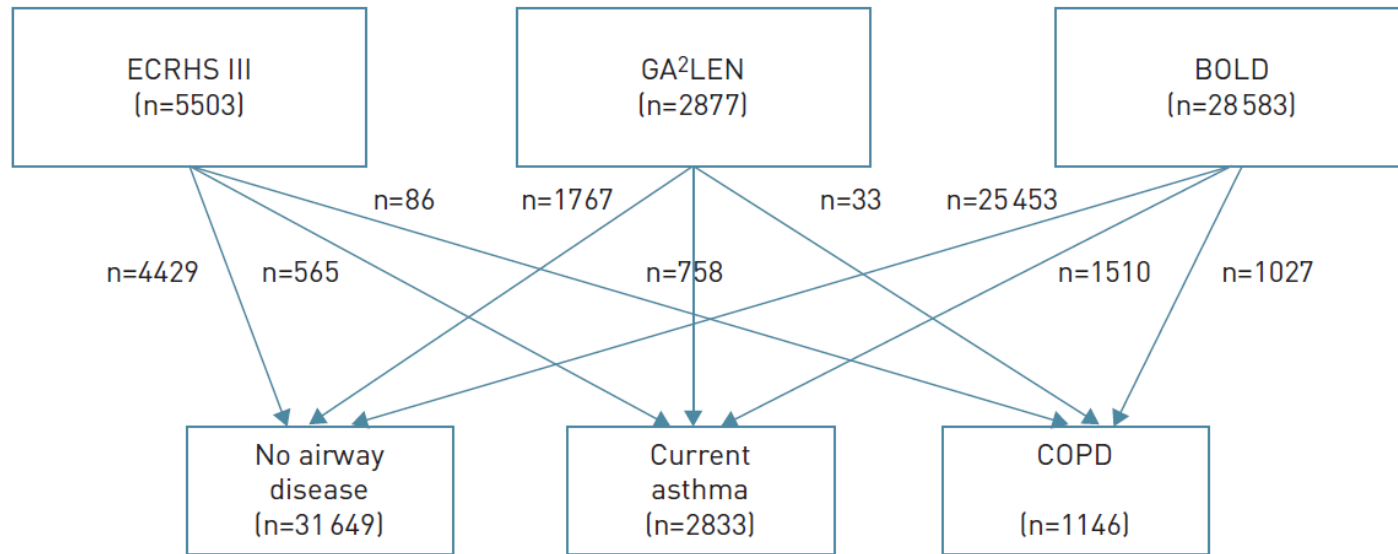


FIGURE 1 Study design. ECRHS: European Community Respiratory Health Survey; GA<sup>2</sup>LEN: Global Asthma and Allergy European Network; BOLD: Burden of Obstructive Lung Disease study; COPD: chronic obstructive pulmonary disease.



# Svar på bronkdilaterande vid astma och KOL



TABLE 1 Characteristics and prevalence of bronchodilator reversibility

	No airway disease (controls)	Current asthma	p-value versus controls	COPD	p-value versus controls	p-value asthma versus COPD
<b>Subjects n</b>	31 649	2833		1146		
<b>Characteristics</b>						
Female	53.0	63.1	<0.0001	26.4	<0.0001	<0.0001
Age years	54±11	53±12	<0.0001	60±11	<0.0001	<0.0001
Smoking history			<0.0001		<0.0001	<0.0001
Never-smoker	61.2	54.6		0		
Ex-smoker	21.8	30.4		40.9		
Current smoker	17.0	15.1		59.1		
BMI kg·m <sup>-2</sup>			<0.0001		<0.0001	<0.0001
<20	8.3	5.3		14.8		
20–25	33.6	29.6		37.4		
>25–30	35.3	32.2		32.8		
>30	22.8	32.9		15.0		
Pre-bronchodilator FEV <sub>1</sub> % pred	87±18	78±21	<0.0001	65±20	<0.0001	<0.0001
Pre-bronchodilator FVC % pred	90±18	88±18	<0.0001	87±20	<0.0001	0.58
Pre-bronchodilator FEV <sub>1</sub> /FVC %	77±7	69±13	<0.0001	57±10	<0.0001	<0.0001
Post-bronchodilator FEV <sub>1</sub> % pred	89±18	82±21	<0.0001	69±20	<0.0001	<0.0001
Post-bronchodilator FVC % pred	90±18	90±18	>0.99	92±20	0.001	0.001
Post-bronchodilator FEV <sub>1</sub> /FVC %	79±7	73±12	<0.0001	58±9	<0.0001	<0.0001
<b>Flow response</b>						
ΔFEV <sub>1</sub> ≥12% from baseline	5.9	20.2	<0.0001	24.5	<0.0001	<0.0001
ΔFEV <sub>1</sub> ≥10% pred	8.9	25.8	<0.0001	29.8	<0.0001	0.10
ΔFEV <sub>1</sub> ≥12% and 200 mL from baseline	5.1	17.3	<0.0001	18.4	<0.0001	0.39
<b>Volume response</b>						
ΔFVC ≥10.5% from baseline	5.3	15.8	<0.0001	25.2	<0.0001	<0.0001
ΔFVC ≥9.2% pred	10.7	22.8	<0.0001	31.6	<0.0001	<0.0001
ΔFVC ≥10.5% and 320 mL from baseline	3.6	11.8	<0.0001	21.6	<0.0001	<0.0001



# Presentation av spirometriresultat



## SPIROMETRY

	Pre-Bronchodilator				Post-Bronchodilator				
	Best	LLN	z-score	%Pred	Best	z-score	%Pred	Change	%Chng
FVC (L)	3.90	3.70	-1.34	82%	4.70	-0.09	99%	600 mL	20%
FEV1 (L)	2.02	2.91	-3.78	54%	2.61	-2.21	70%	590 mL	29%
FEV1/FVC	0.52	0.68	-3.54		0.55	-3.35			
FET (s)	10.3				11.2				

Reference values: GLI 2012 Test quality: Pre: FEV1 - A, FVC - A; Post: FEV1 - A, FVC - B

Både V/t samt F/V-kurva

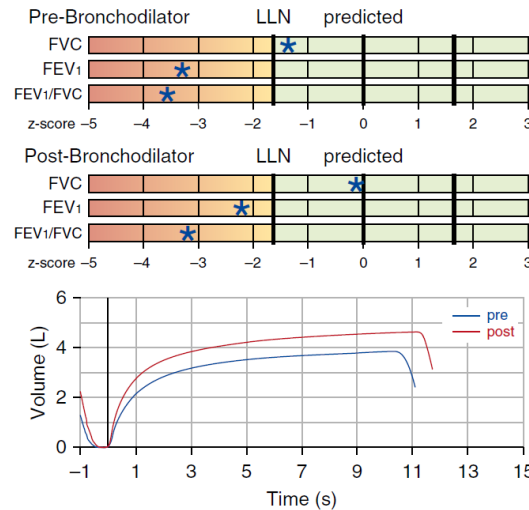
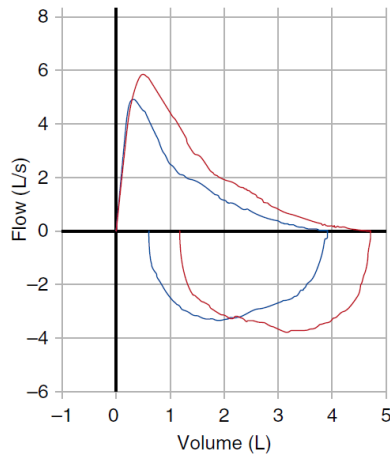
Ange referensvärden

Kvalitetsgradering

Redovisa LLN

Resultat uttryckta både  
som % förväntat och  
z-score

Även visuell redovisning



## AMERICAN THORACIC SOCIETY DOCUMENTS

### Recommendations for a Standardized Pulmonary Function Report

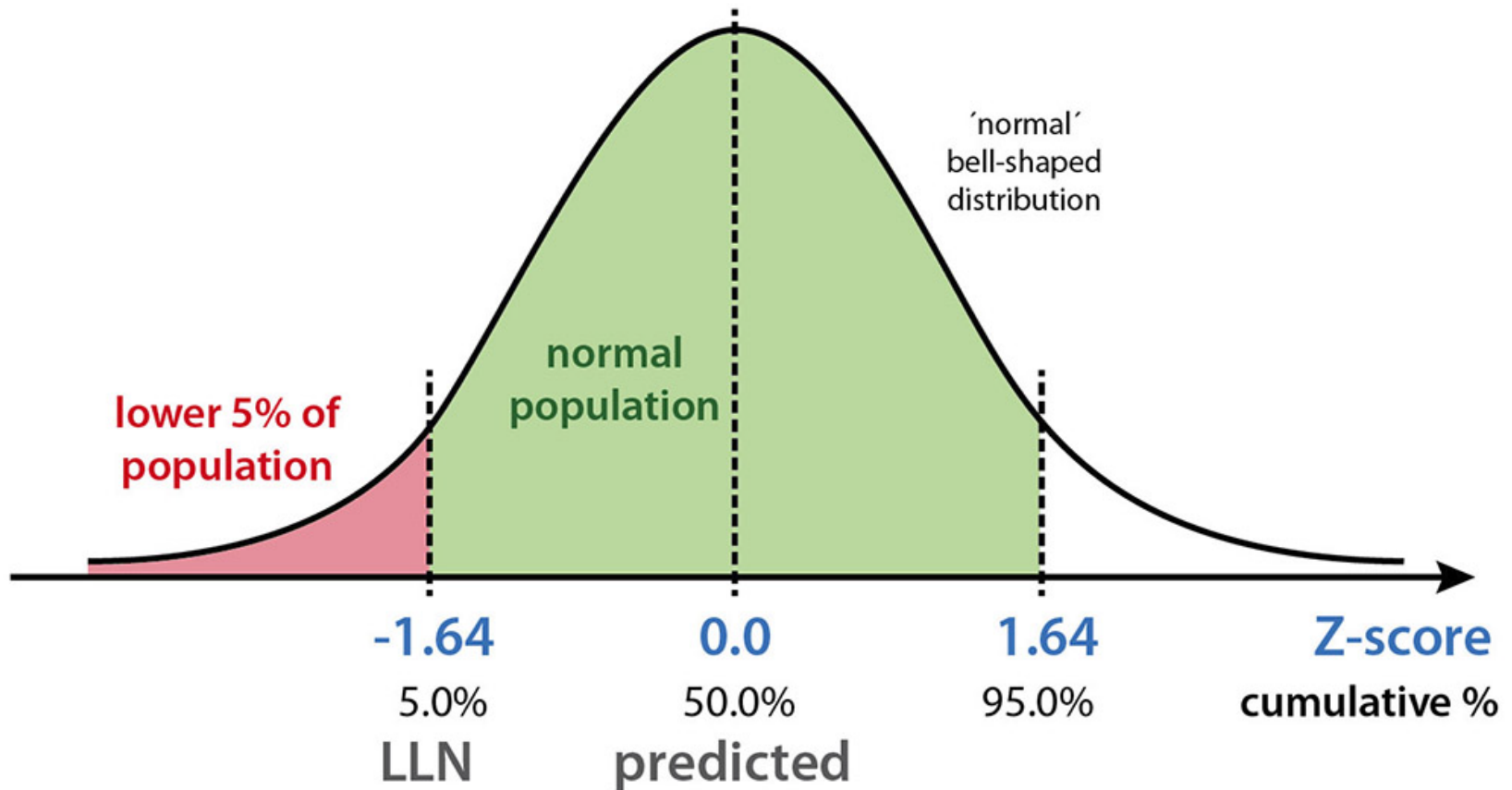
An Official American Thoracic Society Technical Statement

Bruce H. Culver, Brian L. Graham, Allan L. Coates, Jack Wanger, Cristine E. Berry, Patricia K. Clarke, Teal S. Hallstrand, John L. Hankinson, David A. Kaminsky, Neil R. MacIntyre, Meredith C. McCormack, Margaret Rosenfeld, Sanja Stanojevic, and Daniel J. Weiner; on behalf of the ATS Committee on Proficiency Standards for Pulmonary Function Laboratories

THIS OFFICIAL TECHNICAL STATEMENT OF THE AMERICAN THORACIC SOCIETY WAS APPROVED OCTOBER 2017



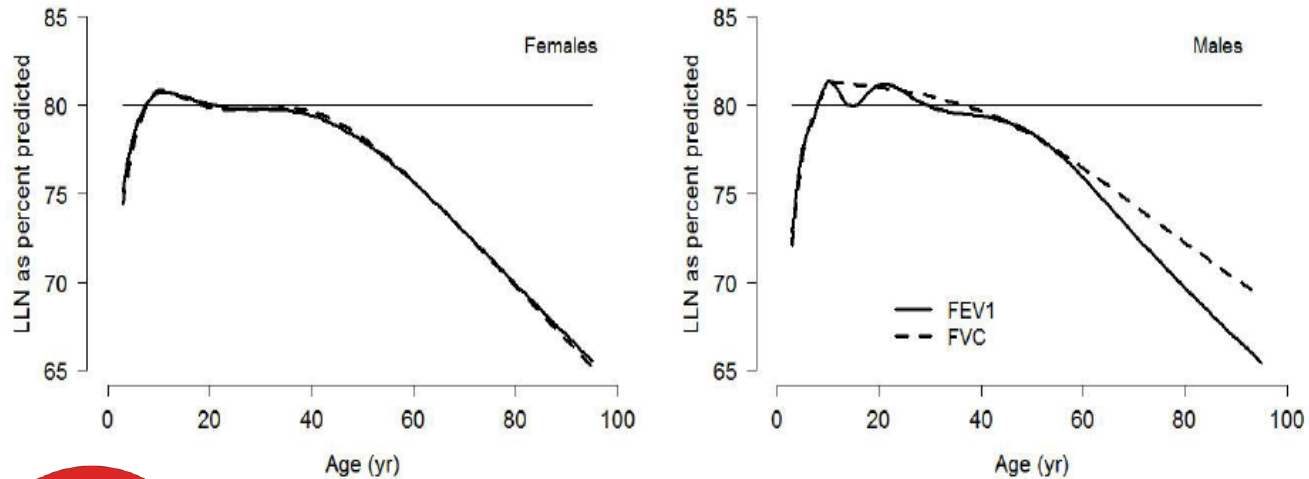
# Koncepten av nedre normalgräns







# Procent förväntat vs 5e percentil för FEV<sub>1</sub> och FVC



LLN = 5<sup>th</sup> centile; using 80% introduces age-related bias



# 5e percentil vs 80% av förväntat värde



Table 2. The 5th percentile values (Lower Limit of Normal) for various lung function indices expressed as percent predicted for four individuals. GLI reference equations were used for all indices (10-12). The table demonstrates that the equivalent % predicted value at the lower limit of normal varies considerably for individuals of different ages and for each pulmonary function index and highlights the potential bias introduced when using percent of predicted thresholds for defining normal limits.

	<b>A:</b> <b>Male</b> <b>Age 10</b> <b>Height 137</b> <b>cm</b>	<b>B:</b> <b>Female</b> <b>Age 15</b> <b>Height 162</b> <b>cm</b>	<b>C:</b> <b>Male</b> <b>Age 25</b> <b>Height 175</b> <b>cm</b>	<b>D:</b> <b>Female</b> <b>Age 25</b> <b>Height 165</b> <b>cm</b>	<b>E:</b> <b>Male</b> <b>Age 80</b> <b>Height 175</b> <b>cm</b>	<b>F:</b> <b>Female</b> <b>Age 80</b> <b>Height 165</b> <b>cm</b>
<b>FEV<sub>1</sub></b>	81.3	80.5	80.5	80.2	69.4	70.0
<b>FVC</b>	81.2	80.4	80.9	79.9	72.0	70.0



**FVC normal**

**FVC sänkt**

**Kvoten  
förhöjd**

**Normal**

**Restriktiv**

**Kvoten  
normal**

**Normal**

**Restriktiv?**

**Kvoten  
sänkt**

**Obstruktiv**

**Både och?**



**Bronkdilatation**



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# Nya riktlinjer ang tolkning



AKADEMISKA  
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EUROPEAN RESPIRATORY *journal*

FLAGSHIP SCIENTIFIC JOURNAL OF ERS

Early View

Task force report

## **ERS/ATS technical standard on interpretive strategies for routine lung function tests**

Sanja Stanojevic, David A. Kaminsky, Martin Miller, Bruce Thompson, Andrea Aliverti, Igor Barjaktarevic, Brendan G. Cooper, Bruce Culver, Eric Derom, Graham L. Hall, Teal S. Hallstrand, Joerg D. Leuppi, Neil MacIntyre, Meredith McCormack, Margaret Rosenfeld, Erik R. Swenson

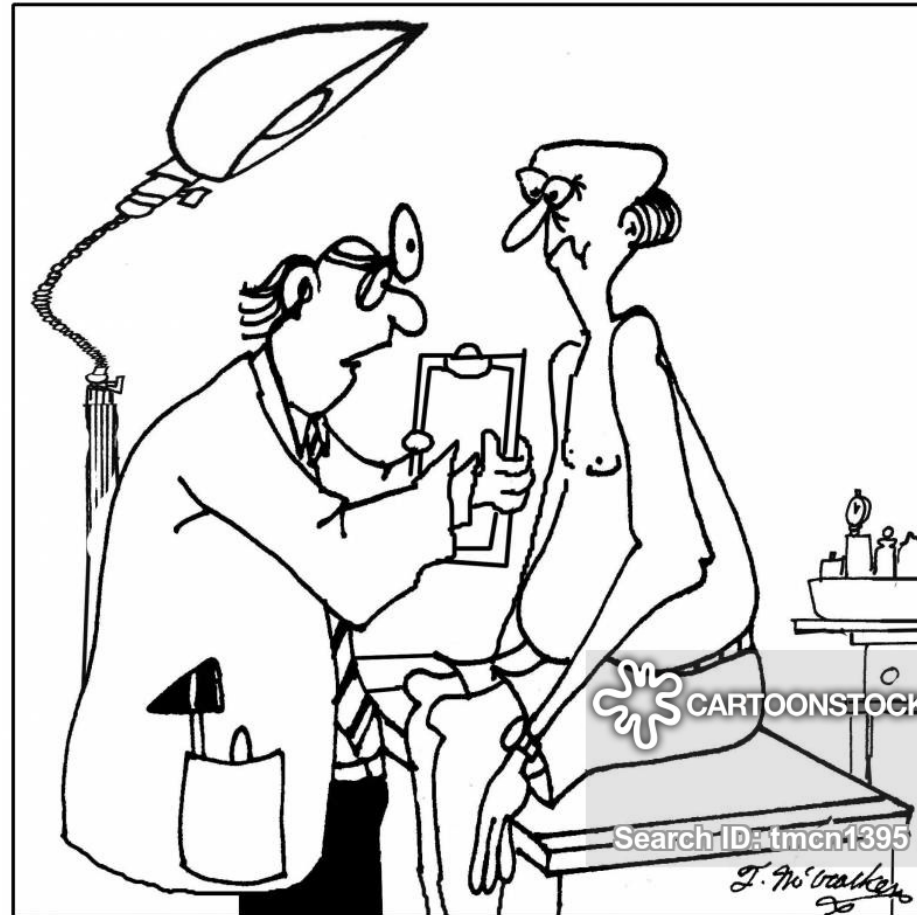


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# Tack för uppmärksamheten!



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“Your breathing test results would be normal ...  
if you were 3'8" and 150 years old.”