

**Consensus Document on Home  
Nebulization for Maintenance  
Treatment of Obstructive Airway  
Diseases**

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# Consensus Document on Home Nebulization for Maintenance Treatment of Obstructive Airway Diseases

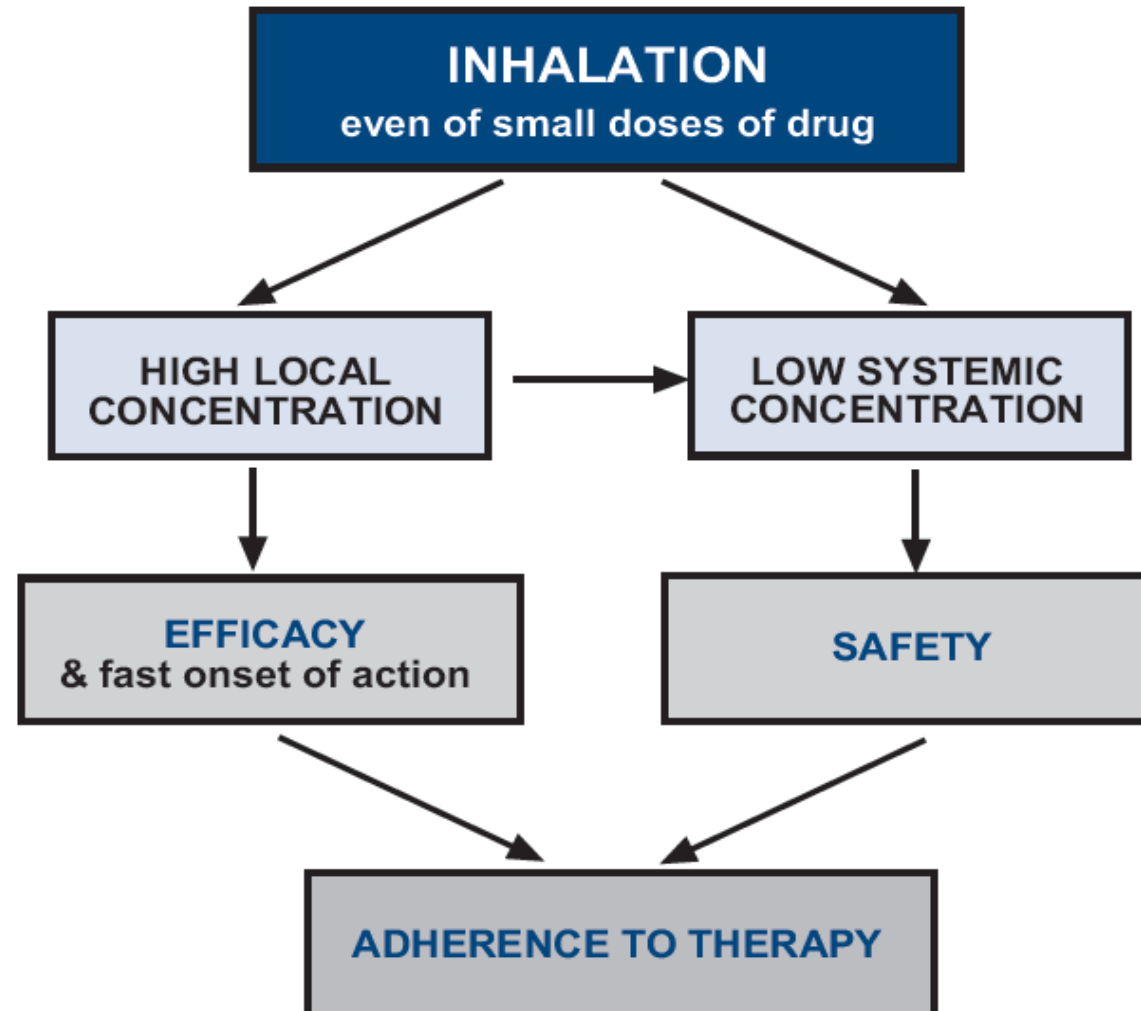
*A Joint Initiative by the National Allergy Asthma  
Bronchitis Institute (NAABI) and Chest Research  
Foundation (CRF)*

*Ghoshal A.G., Salvi S., Dhar R., Guleria R., Mahashur A., Mukhopadhyay A., Ramanathan RMPL.*

Global estimates for OADs.....

**334 million asthmatics and 384 million COPD**

# Inhalation therapy: cornerstone of OAD treatment



# TYPES OF INHALER DEVICES

## Metered Dose Inhalers



## Dry Powder Inhalers



## Small Volume Nebulizers



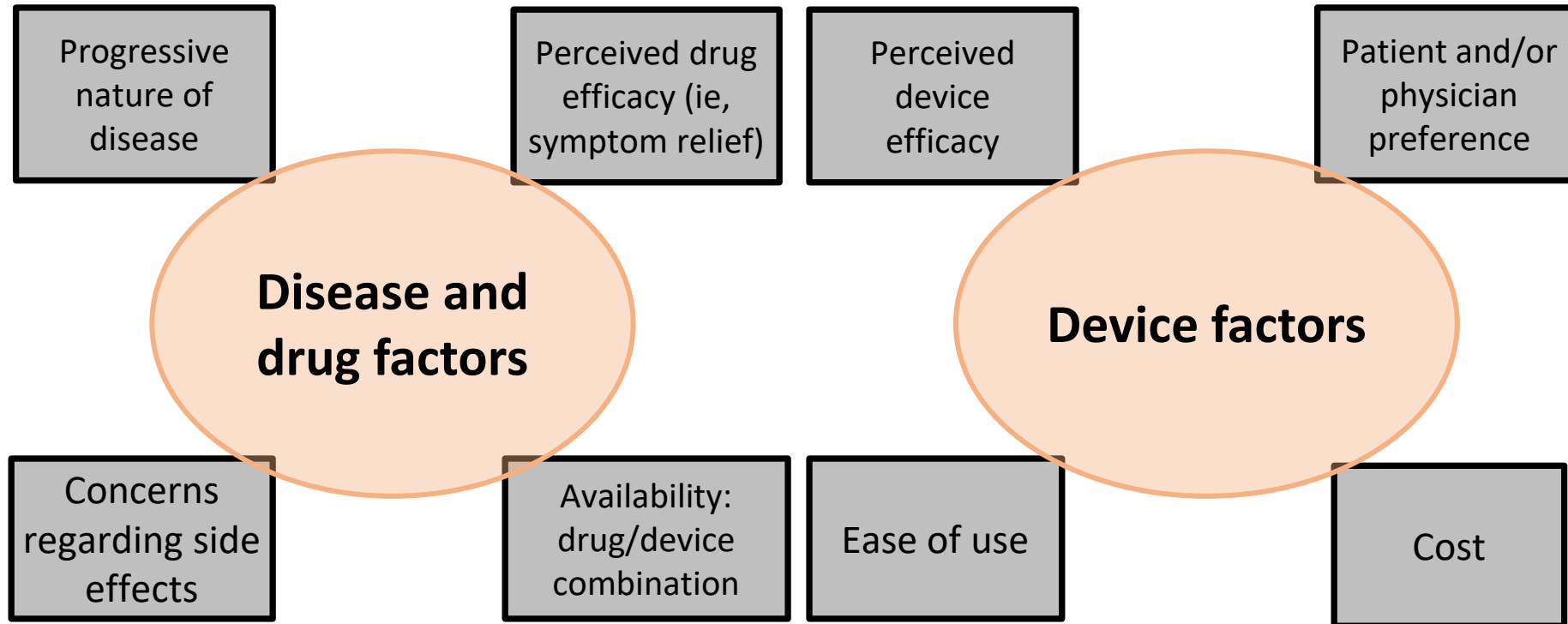
## Nebulizers



**Inhalers represent sophisticated applications of advanced technology developed over the last 50 years**

# Inhaler Device Selection Should Have an Individualized, Patient-Specific Approach

Selecting appropriate inhaled delivery device includes consideration of disease and device-related factors



**pMDIs and DPIs are the mostly widely  
prescribed devices in the world**



**pMDIs and DPIs are the mostly widely  
prescribed devices in the world**

**However can all OAD patients use them  
correctly?**

*Alarming, up to 43% of DPI users and 75% of pMDIs users displayed incorrect inhaler technique...*

*Up to one-third of older patients may lack the hand strength to generate the minimum force required to activate a pMDI device....*

*Also, patients with COPD have a higher incidence of errors in pMDI use (26%) than patients with asthma (13%)...*

# Inhalers are commonly misused by at least 10% patients in various ways

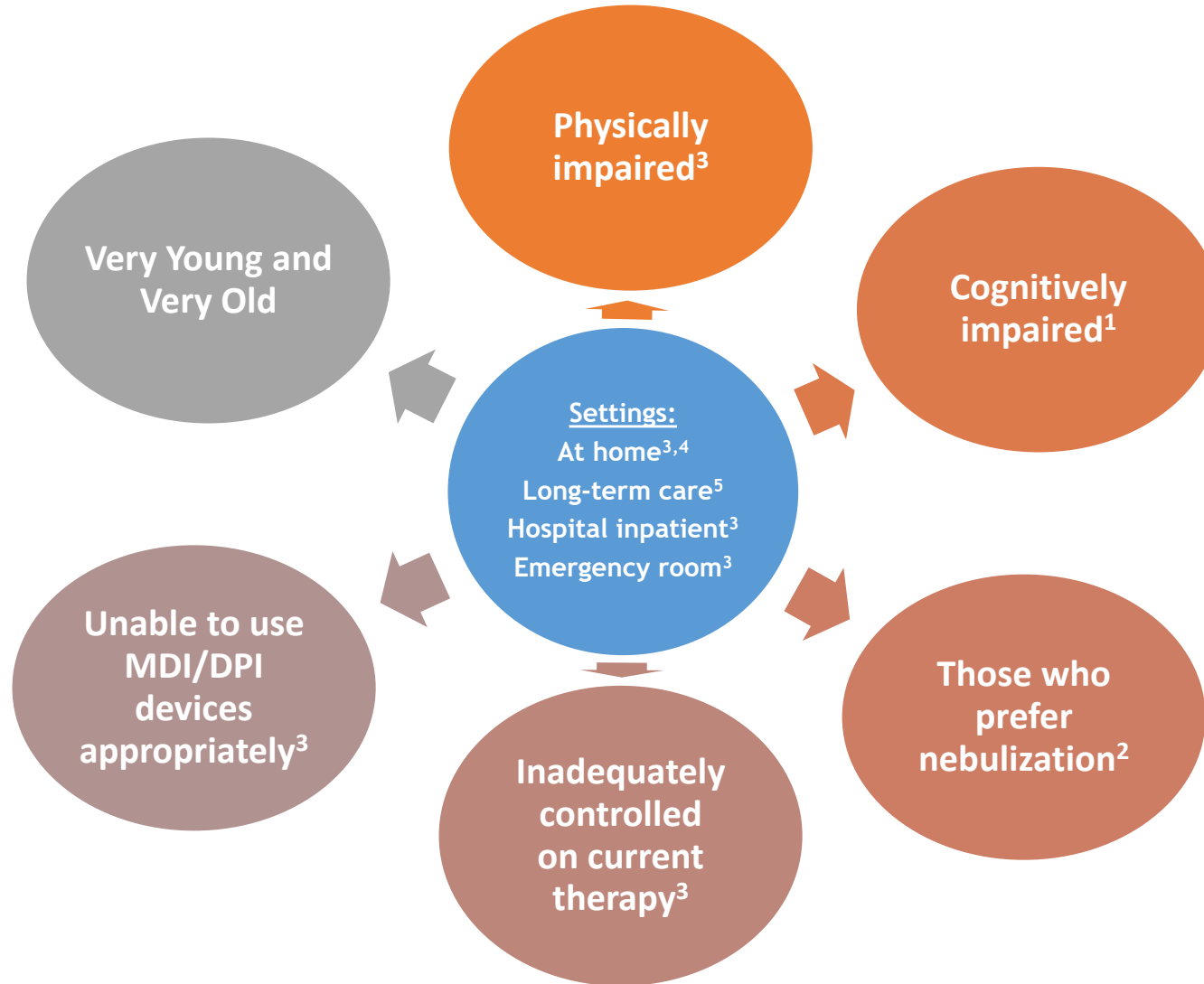
pMDIs	% patients performing the error	DPIs	% patients performing the error
Failure to coordinate MDI actuation with inhalation	27	Not holding device correctly	35
Too short a period of breathhold after inhalation	26	Exhaling through the mouthpiece	19
Too rapid an inspiratory flow	19	Not inhaling forcefully	17
Inadequate shaking/mixing before use	13	Inadequate or no breath-hold	23

# Although pMDIs/DPIs are the first choice of delivering aerosols, what do patients say...

- **46%** of patients using a pMDI and **17%** of those using a DPI rated their device difficult to use.
- **50%** of DPI users were 'unsure' as to whether they received any clinical benefit
- **85%** of older patients fail to use a spacer device when it is prescribed.

Nebulization Can Be Beneficial in These  
Patients

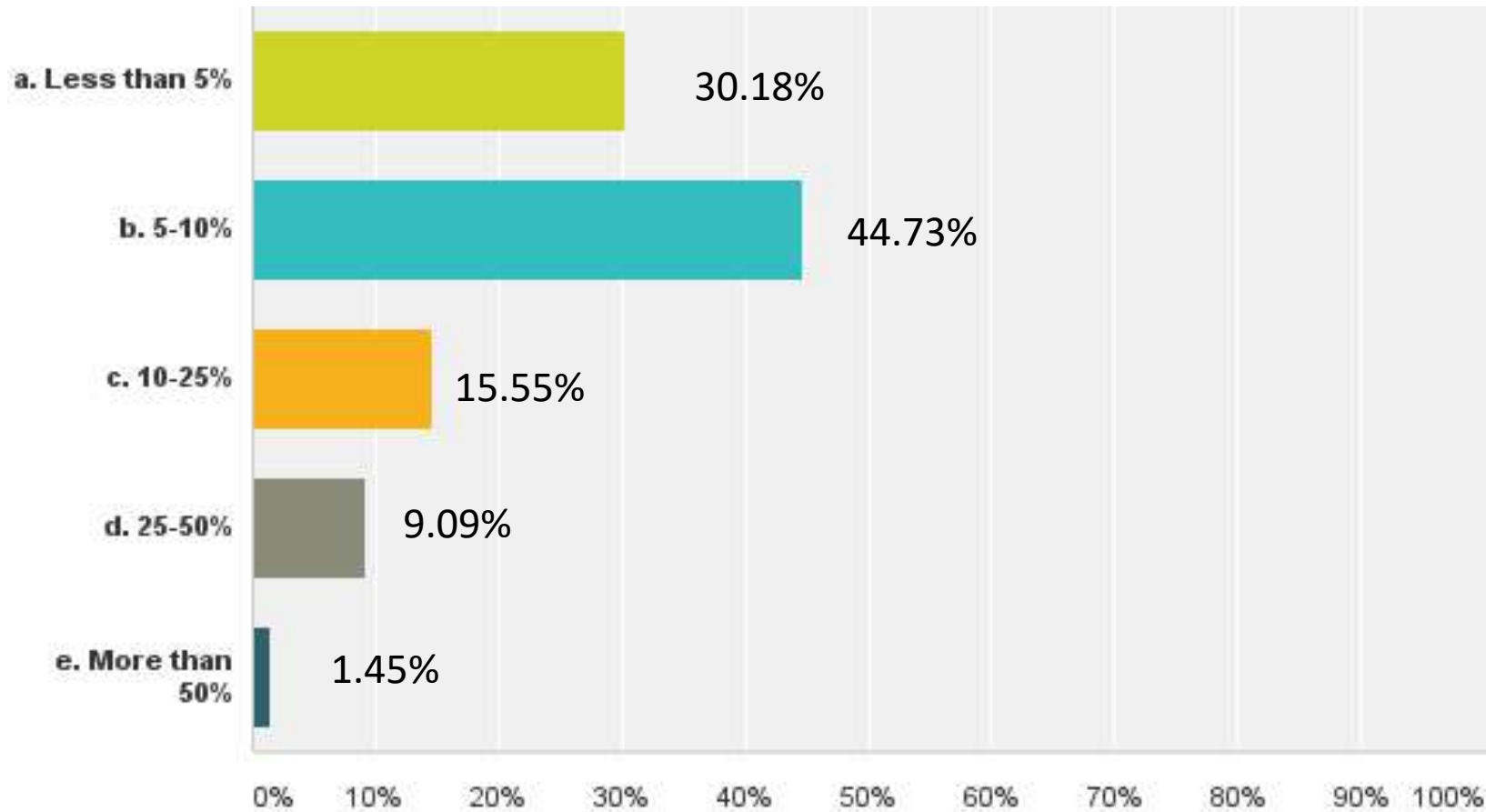
# Nebulization in Multiple Patients & Settings



1. Postgrad Med J. 2002;78:37-39; 2. Respir Med. 2002;96:375-381;  
3. Chest. 2005;127:335-371; 4. Am J Respir Crit Care Med. 2005;171:1443-1464; 5. American Medical Directors Association. COPD Management in the Long-Term Care Setting. Clinical Practice Guideline. Columbia, MD: AMDA; 2010.

# Reality Check: Current Home Nebulization Prescription\*

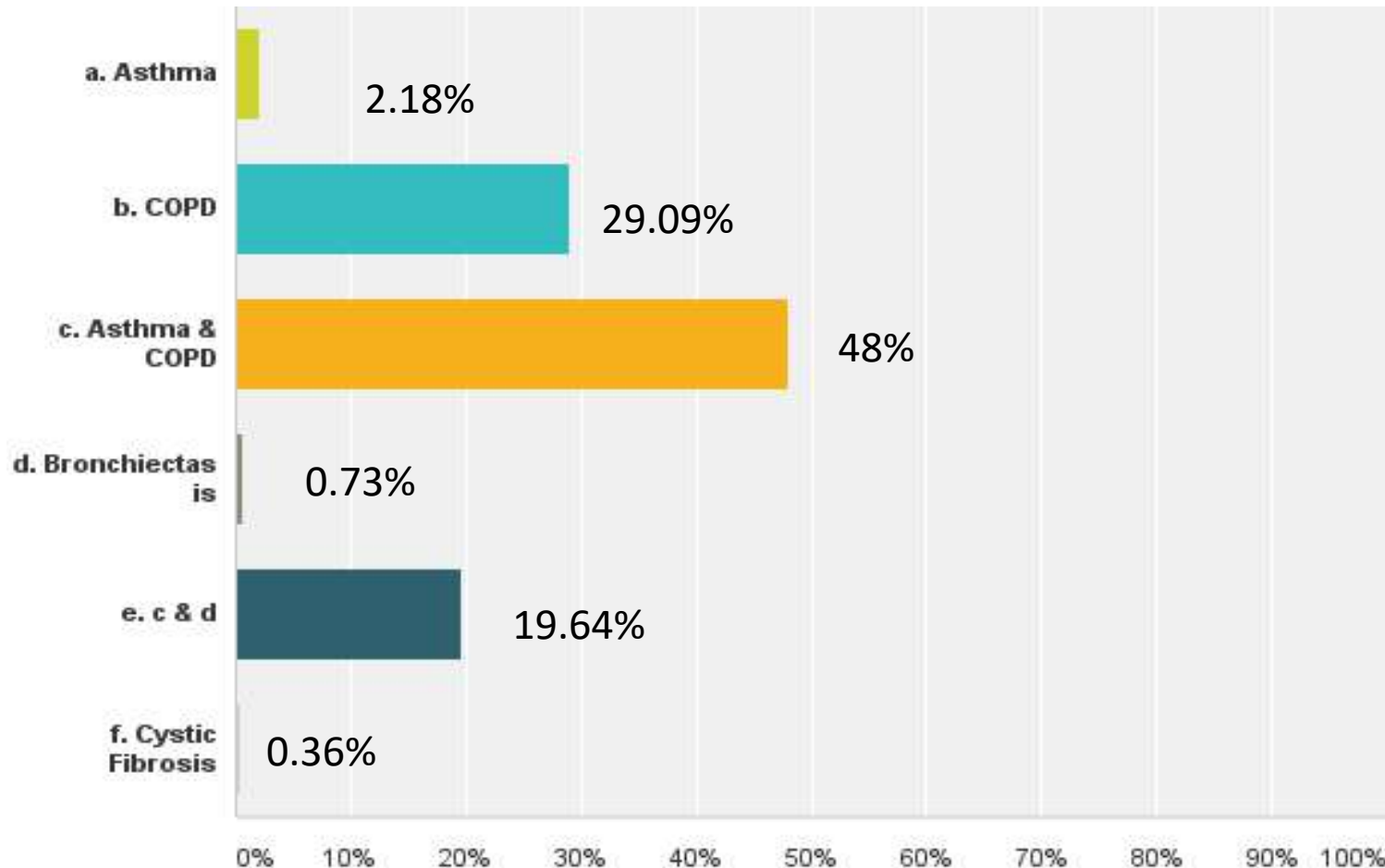
**In what % of your patients do you consider prescribing home nebulization?**



\* Results from a survey with 275 physicians practicing respiratory medicine, Mar 2015

# Reality Check: Where is Home Nebulization Currently Used?\*

Which of the following is the most common indication for which you prescribe home nebulization?



\* Results from a survey with 275 physicians practicing respiratory medicine, March 2015



Insufficient evidence to guide the correct and appropriate use of nebulizer especially at home...

**BTS and ERS guidelines were released in 1997 and 2001, respectively**

**Consensus document on home nebulizers by National Association for Medical Direction of Respiratory Care (NAMDRRC) was released 20 years ago...**

**No recommendations available from India!**

## CONSENSUS STATEMENT

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# Consensus Document on Home Nebulization for Maintenance Treatment of Obstructive Airway Diseases: A Joint Initiative by the National Allergy Asthma Bronchitis Institute (NAAABI) and Chest Research Foundation (CRF)

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**Aloke G Ghoshal<sup>1</sup>, Sundeep Salvi<sup>2</sup>, Raja Dhar<sup>1,6</sup>, Randeep Guleria<sup>3</sup>, Ashok Mahashur<sup>4</sup>, Anshuman Mukhopadhyay<sup>1</sup>, RMPL Ramanathan<sup>5</sup>**

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# Objective of the consensus

To formulate expert views, using available evidence, on the optimal use of maintenance treatment with nebulization at home

# Workflow of consensus meeting and preparation of the document

Conveners (Aloke G. Ghoshal and Sundeep Salvi) identified 5 experts and questions to be addressed during the meeting



Conveners assigned questions for discussion amongst the working group (conveners and experts)



Presentation of the findings by the individual participants



Discussion on the questions and arrival at consensus on the day of the meeting



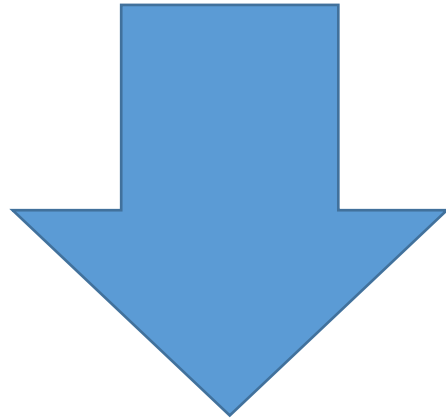
Preparation of the consensus document post the meeting

What should be appropriate terminology and definition to describe maintenance treatment with nebulization at home?

# Terminologies used

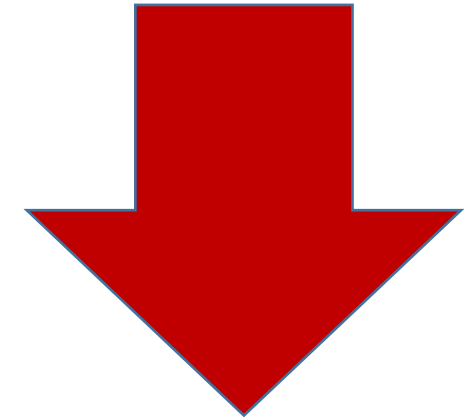
Home Nebulization

Domiciliary use



However, unclear about chronic or intermittent use of nebulizers at home

Maintenance Nebulization



Appropriate terminology for chronic use of nebulizers

# Maintenance Nebulization & Home Nebulization?

## **Maintenance Nebulization**

- Appropriate terminology for chronic use of nebulizers (including rescue use for maintenance)
- Can be defined as physician-prescribed therapy to deliver long-term maintenance drugs ( $\geq 3$  weeks duration) in carefully selected patients

## **Home Nebulization**

- Umbrella term that can include acute use and short term use (<3 weeks) of nebulizers at home

What should be appropriate terminology and definition to describe maintenance treatment with nebulization at home?

## RECOMMENDATION

Maintenance treatment of OADs with nebulization at home can be referred to as 'maintenance nebulization' rather than 'home nebulization' to specifically imply long-term chronic use ( $\geq 3$  weeks)

**Maintenance nebulization can be defined as physician–prescribed therapy to deliver long-term maintenance drugs ( $\geq 3$  weeks) in appropriately selected patients with OADs**

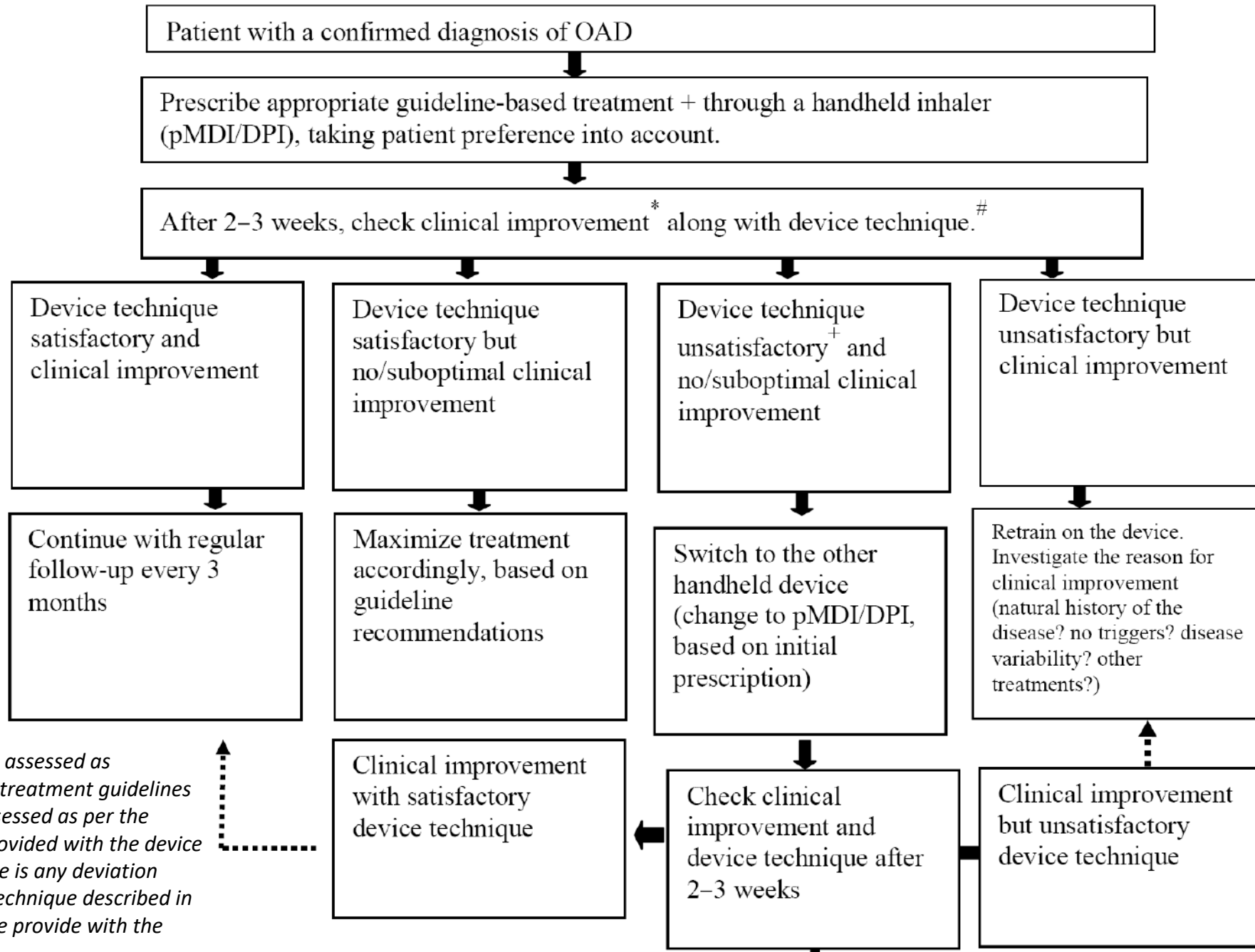


How should one identify/select patients suitable for maintenance treatment with nebulizers?

# Identifying/Selecting patients for maintenance nebulization

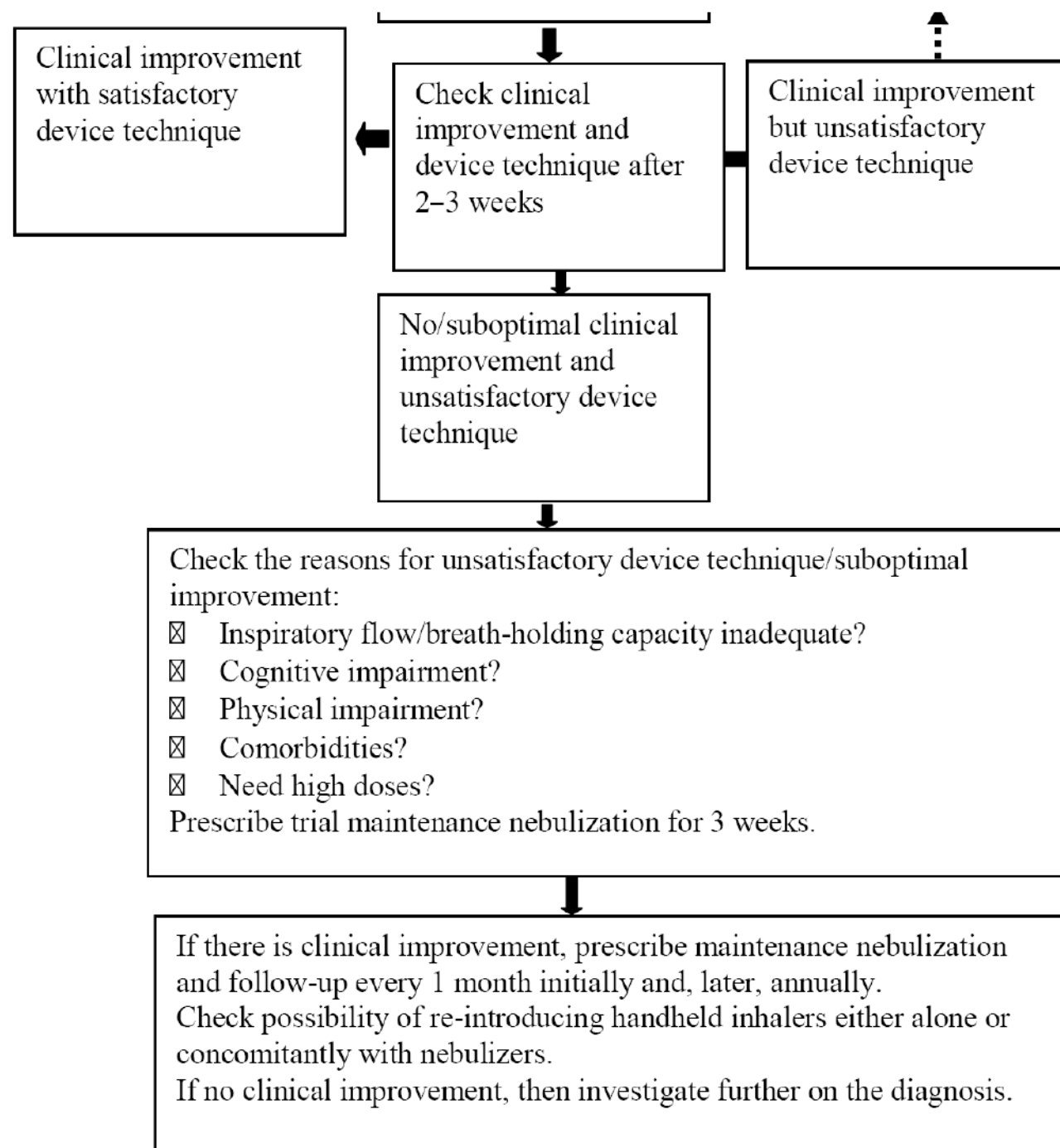
Careful screening of the patients for maintenance nebulization needed

Algorithmic approach for patient selection practically relevant



*\*Clinical improvement should be assessed as recommended by the respective treatment guidelines  
# Device technique should be assessed as per the patient information literature provided with the device  
+ Unsatisfactory device technique is any deviation from the recommended device technique described in the patient information literature provide with the device*

*Continued...*



How should one identify/select patients suitable for maintenance treatment with nebulizers?

**RECOMMENDATION**

Patients should be carefully screened before prescription of maintenance nebulization.

More importantly, the screening should focus on the ability to use handheld inhaler devices... and every effort should be made to introduce/re-introduce drug administration through handheld inhalers.

**Patient satisfaction and choice should also be taken into account when considering handheld inhalers versus nebulizers for long-term use.**

**Additionally, the advantages and drawbacks of all inhaler devices including nebulizers should be explained to the patients so as to facilitate an informed decision.**

What should be the duration of maintenance treatment with nebulization?

# Duration of maintenance treatment with nebulization

Minimum duration of the maintenance treatment for nebulization can be 2-3 weeks, however, maximum duration of the treatment cannot be defined in the realm of the chronic treatment.

# Long Term Nebulization Use...

*Respiratory Medicine* (1996) **90**, 561–566

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## **A long-term study of symptoms, spirometry and survival amongst home nebulizer users**

B. R. O'DRISCOLL\* AND A. BERNSTEIN

*Salford Royal Hospitals NHS Trust, Hope Hospital, Salford, U.K.*

*Salford Royal Hospitals NHS Trust, Hope Hospital, Salford, U.K.*

*B. R. O'DRISCOLL\* AND A. BERNSTEIN*

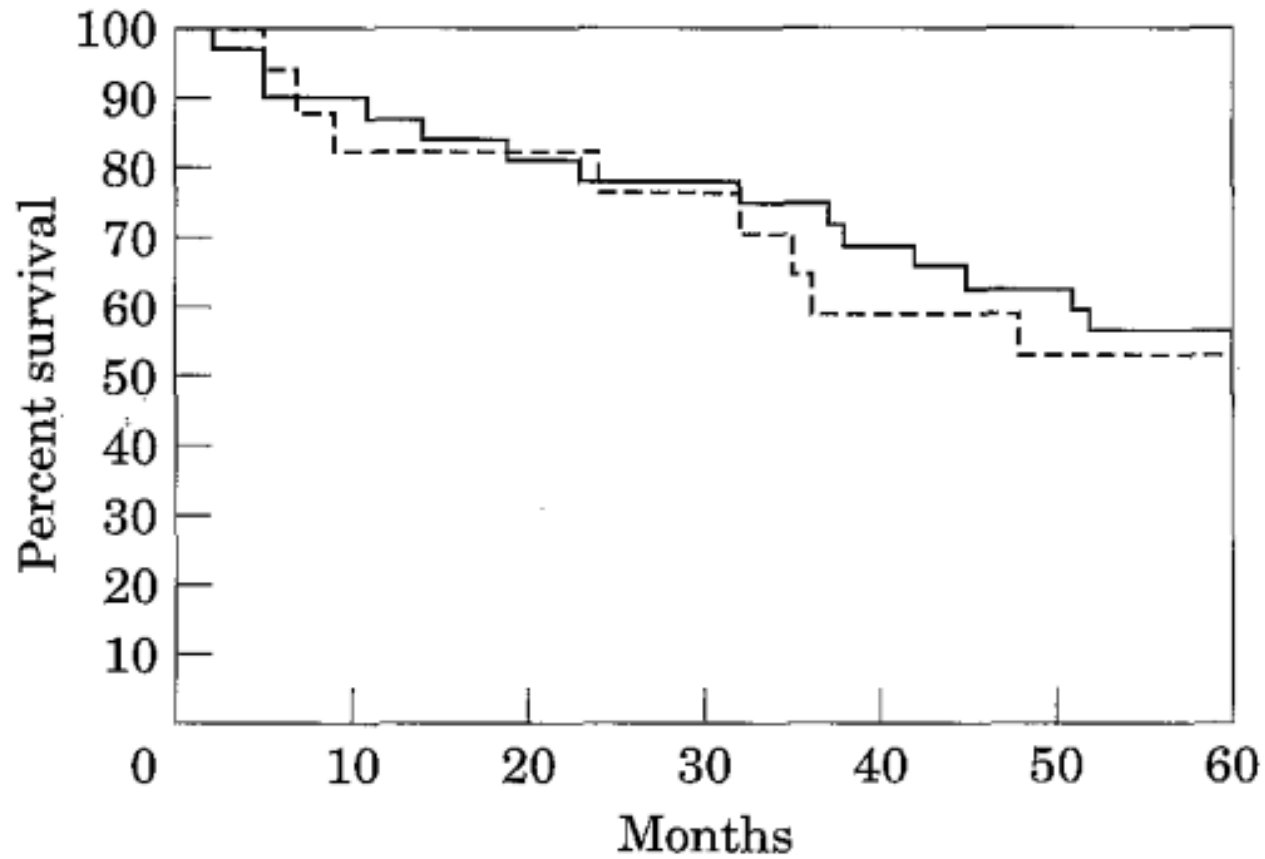
n= 32 severe asthma/COPD patients

Nebulization treatment at home for 5 years



# Baseline Characteristics

	Asthma	COPD
Number of patients	15 (6M, 9F)	34 (21M, 13F)
Number of smokers	1 current, 10 ex	11 current, 22 ex
Mean age, years (range)	54 (43–74)	61 (35–75)
Mean PEF, l min <sup>-1</sup> (SD)	194 (118)	157 (66)
Mean PEF post salbutamol	231 (20% rise)	171 (11% rise)
Mean FEV <sub>1</sub> l (SD)	1.31 (0.8)	0.71 (0.3)
Mean FVC, (SD)	2.11 (1.1)	1.81 (0.8)
Mean KCO as percent of predicted value (range)	105% (83–128)	62% (22–110)
Inhaled steroid		
Number of users	15	23
Mean daily dose	1681 µg	1565 µg
Oral prednisolone		
Number of users	8	11
Mean daily dose	8 mg	8 mg
Oral theophylline		
Number of users	9	21
Mean daily dose	594 mg	702 mg
Oral β-agonist		
Number of users	1	5
Mean daily dose	12 mg	10.6 mg



*Fig. 1* Survival of nebulizer users (—,  $n=32$ ) and metered dose inhaler users (---,  $n=17$ ) over a 5-yr period. Survival curve analysis  $P=0.77$ , n.s.

**The five year survival was similar in the nebulizer users (56%) and pMDI users (53%)**

What should be the duration of maintenance treatment with nebulization?

**RECOMMENDATION**

The minimum duration of maintenance therapy that can be prescribed in a patient with OADs is 3 weeks  
No recommendation can be made on the maximum duration of the therapy.

**The decision to end/continue maintenance nebulization lies with the prescribing physician, after taking into account the subjective and objective improvement along with ensuring that there are no concerns regarding AEs with the prescribed nebulized formulations.**

Which are the drugs that can be prescribed for maintenance treatment with nebulizers and with which type of nebulizer?

**Table 1: Approved or recommended nebulized drugs in India for use in home nebulization**

Drug class	Molecule	Recommended use (in adults)*
Short-acting beta <sub>2</sub> -agonist (SABA)	Salbutamol	As-needed use in OADs
	Levosalbutamol	
Long-acting beta <sub>2</sub> -agonist (LABA)	Formoterol	Long-term maintenance in COPD
	Arformoterol	
Short-acting muscarinic antagonist (SAMA)	Ipratropium bromide	Long-term maintenance in COPD
Inhaled Corticosteroids (ICS)	Fluticasone	Long-term maintenance in asthma
	Budesonide	
SABA + SAMA	Salbutamol + ipratropium	Long-term maintenance in COPD/ as-needed use in maintenance regimen in COPD
	Levosalbutamol + ipratropium	
ICS + SABA	Budesonide + levosalbutamol	Long-term maintenance in asthma
	Budesonide + salbutamol	
ICS + LABA	Budesonide + formoterol	Long-term maintenance in OAD
Mucolytics	N-acetylcysteine	Short-term adjuvant use in OAD in case of mucus hypersecretion
	Ambroxol	

\*For exact indications, posology and administration, please refer to the prescribing information available from the manufacturer of the respective products.

Compatibility of the nebulizer and the drug formulation is important or optimum drug deposition!



**Jet**



**Ultrasonic**



**Mesh**

**Table 2: Characteristics of different types of nebulizers**

	Jet	Ultrasonic	Vibrating mesh
<b>Features</b>			
Power source	Compressed gas or electrical mains	Electrical mains	Batteries or electrical mains
Portability	Restricted	Restricted	Portable
Treatment time	Long	Intermediate	Short
Output rate	Low	Higher	Highest
Residual volume	0.8-2.0 mL	Variable but low	≤0.2 mL
<b>Environmental contamination</b>			
Continuous use	High	High	High
Breath-activated	Low	Low	Low
Performance variability	High	Intermediate	Low
<b>Formulation characteristics</b>			
Temperature	Decreases*	Increases†	Minimum change
Concentration	Increases	Variable	Minimum change
Suspensions	Low efficiency	Poor efficiency	Variable efficiency
Denaturation	Possible‡	Probable‡	Possible‡
Cleaning	Required, after single use	Required, after multiple use	Required, after single use
Cost	Very low	High	High

\*For jet nebulizers, the temperature of the reservoir fluid decreases about 15°C during nebulisation because of evaporation; †For ultrasonic nebulizers, vibration of the reservoir fluid causes a temperature increase during aerosol generation, which can be as high as 10–15°C.; ‡Denaturation of DNA occurs with all the nebulisers; (With permission from Dolovich M, Dhand, R; The Lancet 2011)

Which are the drugs that can be prescribed for maintenance treatment with nebulizers and with which type of nebulizer?

## RECOMMENDATION

Selecting the right drug and the right nebulizer is important for the success of maintenance nebulization in OADs

**Prescribers are advised to refer to the exact indications, posology and administration available in the prescribing information of the available drugs.**



What is the long-term safety of  
maintenance treatment with  
nebulization at home?

# Drugs that can be delivered for home use in OADs

**Bronchodilators** ( $\beta_2$ -agonists and anticholinergics): salbutamol, levosalbutamol, ipratropium bromide, arformoterol

**Corticosteroids:** budesonide, fluticasone

**Mucolytics:** N-acetylcystiene, ambroxol

**Combination** of budesonide-formoterol, levosalbutamol-ipratropium, Levosalbutamol-budesonide

The five year survival with nebulizer users (56%) and pMDI users (53%) was similar

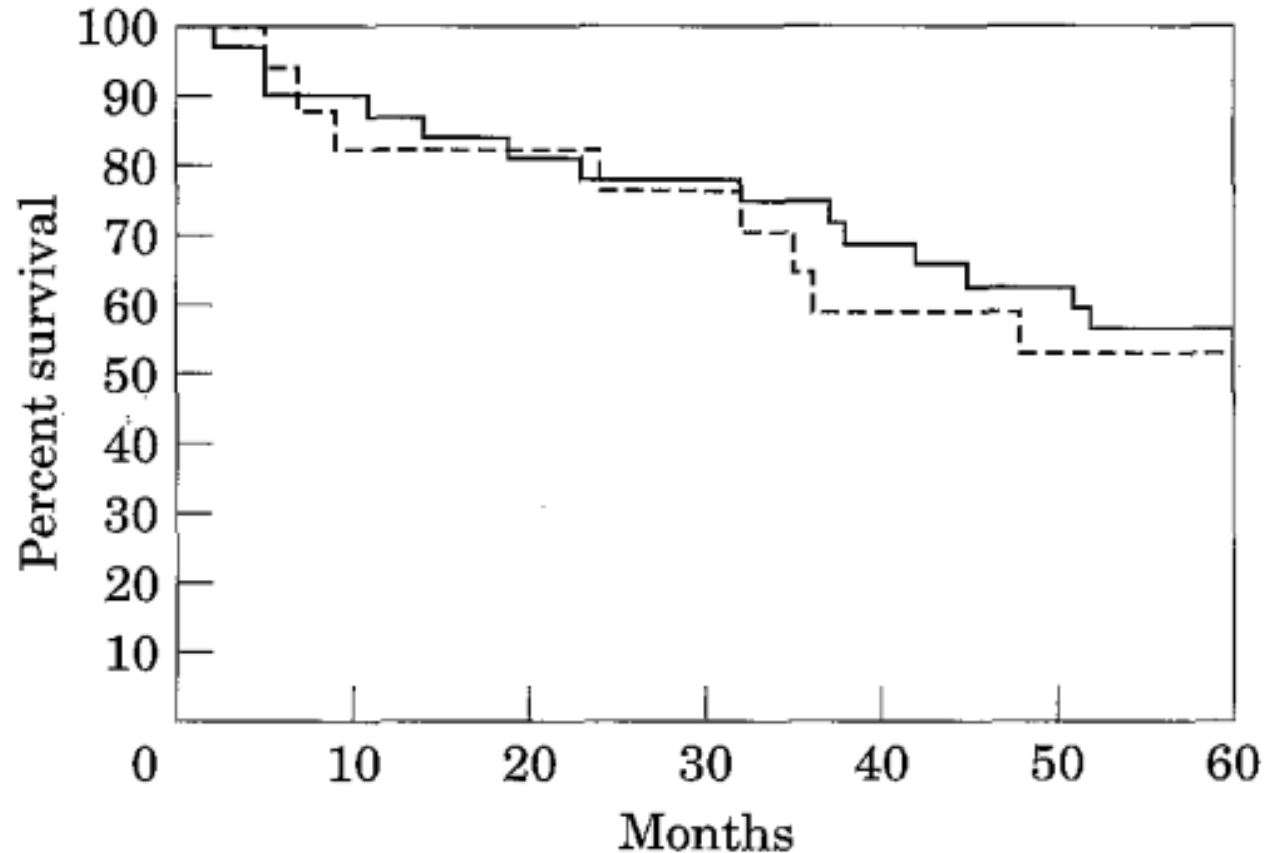


Fig. 1 Survival of nebulizer users (—,  $n=32$ ) and metered dose inhaler users (---,  $n=17$ ) over a 5-yr period. Survival curve analysis  $P=0.77$ , n.s.

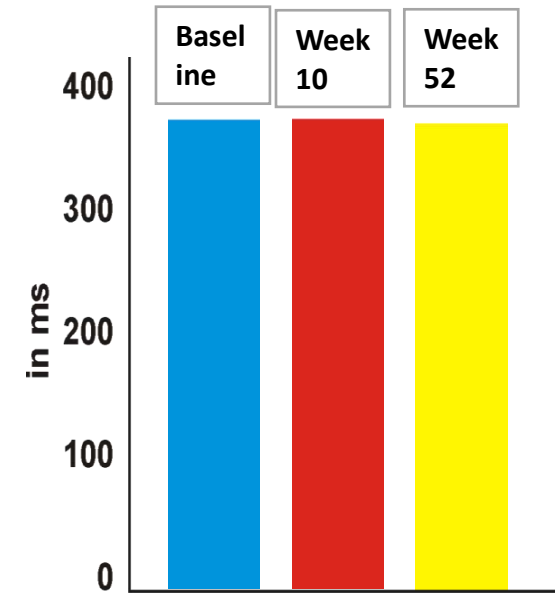
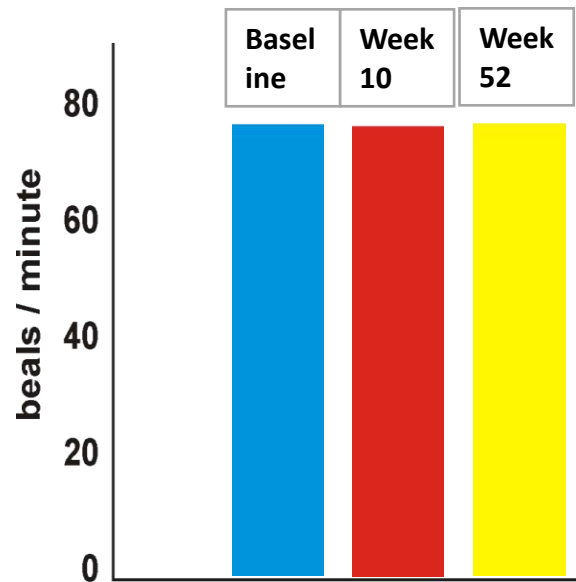
# Long-term safety of nebulized formoterol: Results of a twelve-month open-label clinical trial

Therapeutic Advances in  
Respiratory Disease  
(2008) 2(4) 199–208  
DOI: 10.1177/  
1753465808093934  
©SAGE Publications 2008  
Los Angeles, London,  
New Delhi and Singapore

James F. Donohue, Nicola A. Hanania, Charles Fogarty, Sammy C. Campbell, Mike Rinehart  
and Kimberly Denis-Mize

No clinical meaningful  
effects on heart rate\* ,  
serum potassium and  
glucose, or vital signs

No increase in cardiac  
arrhythmias, or QTc  
prolongation



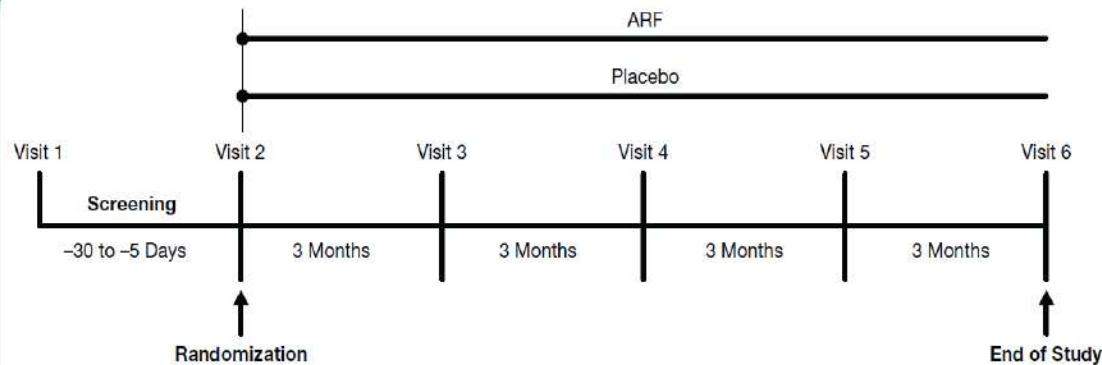
N=569 moderate to  
severe COPD patients

# One-Year Safety and Efficacy Study of Arformoterol Tartrate in Patients With Moderate to Severe COPD

OPEN ACCESS

James F. Donohue, MD; Nicola A. Hanania, MD; Barry Make, MD; Matthew C. Miles, MD; Donald A. Mahler, MD; Lisa Curry, BS; Robert Tosiello, MS; Alistair Wheeler, MD; Donald P. Tashkin, MD

Figure 1. Study Design.

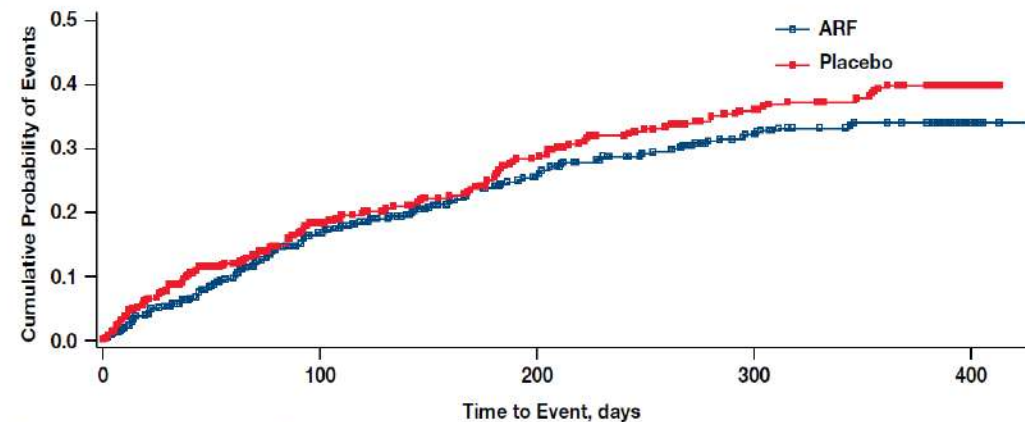


Abbreviation: ARF, arformoterol 15 µg twice daily.

841 patients (aged  $\geq 40$  years, with baseline  $FEV_1 \leq 65\%$ ), which were randomized to receive either arformoterol (N=420 receiving, 15 mcg twice daily) or placebo (N=421) for 1 year.

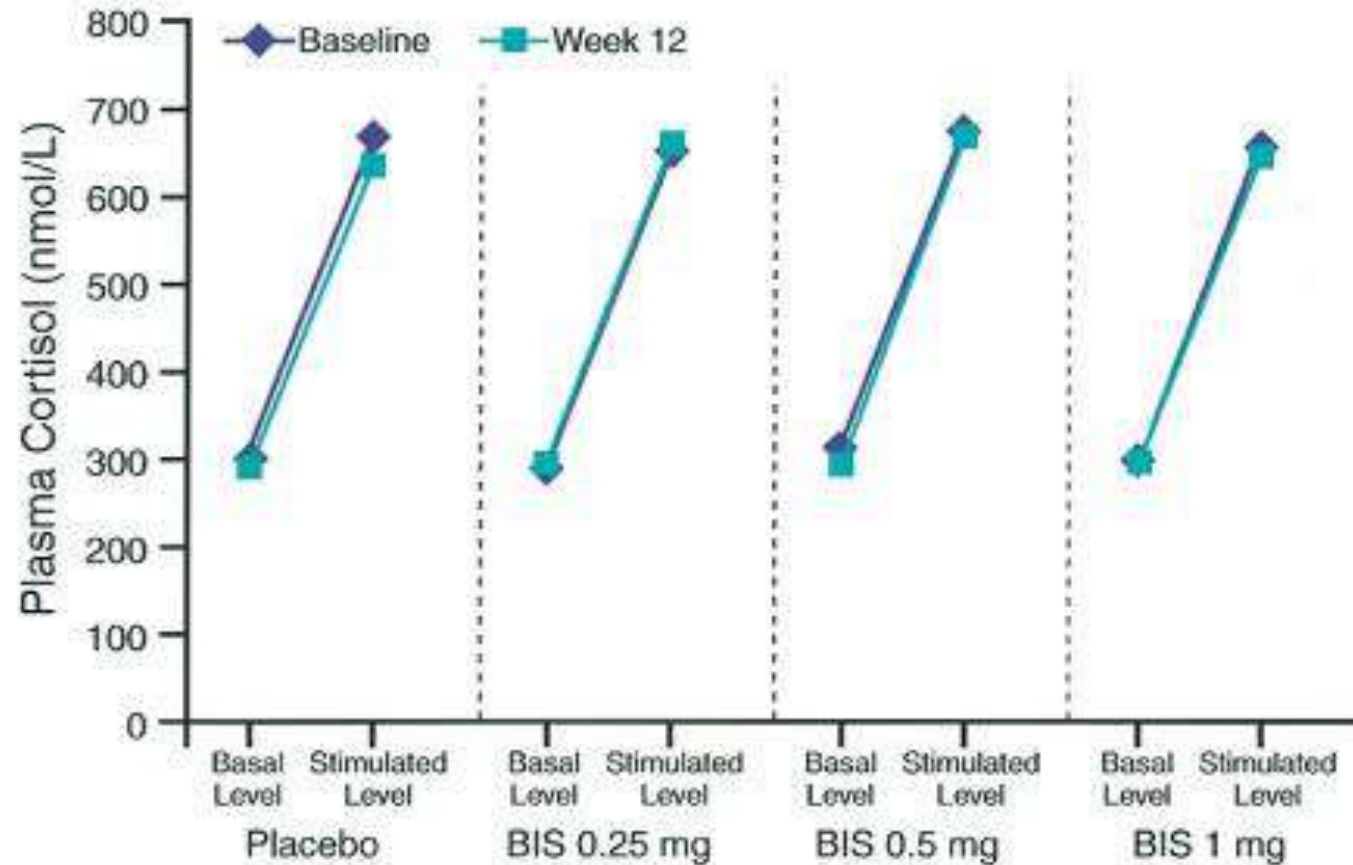
*Chest*. 2014. doi:10.1378/chest.14-0117

Figure 2. Kaplan-Meier Plot of the Cumulative Probability of Events for Time to First Protocol-Defined COPD Exacerbation (ITT Population).



Abbreviation: ARF, arformoterol tartrate 15 µg twice daily.

# Safety of nebulized budesonide in children



**No significant differences between placebo and budesonide groups**

Basal and ACTH-stimulated cortisol levels at baseline and at week 12 from the double-blind studies. Basal level represents morning plasma cortisol. The 30- to 60-minute short ACTH-stimulation test was used. *BIS*, Budesonide inhalation suspension.

What is the long-term safety of maintenance treatment with nebulization at home?

**RECOMMENDATION**

To ascertain long-term safety in patients with OADs, it is recommended to perform a regular review (at least every 6 months)

**Regular review is recommended for local and systemic AEs and for patients with known heart disease**

Are there any special precautions for OAD patients with co-morbid conditions such as cardiovascular diseases (CVDs) and diabetes?



# Safety in co-morbid conditions: Cardiac safety

- Safety of LABAs have been established in one year trials. No significant differences observed in terms of time to first serious cardiac AEs.
- BTS guidelines recommend ECG monitoring in patients with cardiac condition as a precaution after the first dose of nebulized bronchodilator.

# Safety in co-morbid conditions: Diabetes

- A trial on high dose fluticasone in patients with asthma/COPD and co-morbid diabetes showed no significant effect on glycosylated hemoglobin.
- However, blood glucose levels should be monitored in patients taking high dose ICS with concomitant diabetes.

## **Safety of common drugs used in home nebulization**

Safety precautions for Long Acting  $\beta_2$  Agonist (LABA), Short Acting  $\beta_2$  Agonist (SABA), Short Acting Anti-muscarinic (SAMA)

- A baseline Echocardiogram (ECG) should be recorded for all patients initiating Home Nebulization.
  - Any baseline ECG abnormality should be investigated further. Ideally with a cardiology consultation.
  - Any prolongation of QT interval should preclude the use of LABA & SABA.
  - A baseline K<sup>+</sup> (Potassium) level should be checked in patients receiving Salbutamol or Levosalbutamol.
  - K<sup>+</sup> level should be rechecked at the end of one month and again at 3 months in patient on long term Home Nebulization.
  - Patients complaining of intermittent palpitation should be advised to undergo ECG and if normal a 24 hours Holter monitoring should be performed.
  - Inspection of the oral cavity and oropharynx should be done regularly in patients on nebulized steroids to check for fungal (Candida) infection.
  - Regular stringent mouth washing and cleaning of nebulizer & accessories daily should be advocated at each contact by a trained health personnel.
-

Are there any special precautions for OAD patients with co-morbid conditions such as CVD and diabetes?

**RECOMMENDATION**

OAD patients with complicating co-morbidities such as CVD and diabetes should be reviewed regularly (every 6 months) for blood glucose and cardiac parameters.

What are the cleaning and maintenance recommendations that need to be communicated to patients using long-term nebulization?

# Cleaning and Maintaining Nebulizers at Home

- Bacterial isolates obtained from home nebulizers of 50 patients

Gram negative	Frequency*	Gram positive	Frequency*
<i>Pseudomonas sp</i>	4	<i>Staphylococcus albus</i>	23
<i>Acinetobacter sp</i>	2	Diphtheroids	11
<i>Serrania marcescens</i>	2	<i>Micrococcus sp</i>	8
<i>Flavobacterium sp</i>	2	Beta Haemolytic <i>streptococcus</i>	2
		<i>Streptococcus viridans</i>	1
		<i>Streptococcus aureus</i>	1

*\*Number of positive isolates out of 50 units tested*

*Patients were using jet nebulizers at home for asthma, chronic obstructive bronchitis and cystic fibrosis*

*Samples were obtained from facemasks or mouthpieces*



## How do patients use their nebuliser in the community?

Anne C. Boyter<sup>a,\*</sup>, Roger Carter<sup>b</sup>

ANNE C. BOYTER<sup>a,\*</sup>, ROGER CARTER<sup>b</sup>

COMMUNITY

HOW DO PATIENTS USE THEIR NEBULISER IN THE

n= 117 patients using nebulizers at home for asthma or COPD

**Table 2** Replacement of disposables.

Frequency	Number of patients (%)			
	Filters	Tubing	Chambers	Frequency of servicing
1–3 months	17 (14.5)	18 (15.3)	21 (17.9)	
4–6 months	22 (18.8)	24 (20.5)	18 (15.4)	14 (12.0)
7–11 months	5 (4.3)	5 (4.3)	3 (2.6)	
Annually	28 (23.9)	26 (22.2)	25 (21.4)	53 (45.3)
More than 12 months				6 (5.1)
When damaged	6 (5.1)	8 (6.8)	7 (6.0)	
Never	15 (12.8)	13 (11.1)	21 (17.9)	6 (5.1)
Not answered	24 (20.5)	23 (19.6)	22 (18.8)	38 (37.5)



**Table 3** Cleaning of the nebuliser chamber.

Frequency	Number of patients (%)
After each use	55 (47.0)
Daily	25 (21.4)
Weekly	18 (15.4)
Monthly	4 (3.4)
Never cleaned	2 (1.7)
Not answered	10 (8.5)

**Table 4** Methods of cleaning.

Method of cleaning	Number of patients (%)
Warm soapy water, then rinse	80 (68.4)
Water only	18 (15.4)
Sterilise	14 (12.0)
Dry with a cloth	64 (54.7)
Dry naturally	41 (35.0)

# Cleaning the nebulizer

To prevent the possible risk of infection, cleaning of the nebulizer is recommended after each treatment.

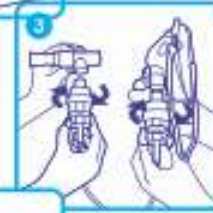
- 1 With the power switch off, unplug the power cord.



- 2 Disconnect the tubing from the air outlet.



- 3 Disassemble the mouthpiece or face mask from the cap. Open the medication cap and remove the baffle.



- 4 Wash all the accessories (except the tubing), in warm water/mild detergent solution. Rinse with warm water to remove detergent residue. Allow to air-dry.



- 5 Wipe the outer surface of the tubing regularly. If you notice some liquid droplets in the tubing, connect it to the compressor air outlet, switch on the compressor and blow air through the tubing for a few seconds.



# Care and maintenance

## Disinfect daily

### Step 1

Using a clean container, soak all the accessories (except the tubing) for 30 minutes in

- commercially available medical disinfectant *or*
- mild detergent *or*
- vinegar solution (1 part white vinegar and 3 parts warm water)



### Step 2

With clean hands, rinse all the accessories with warm water, and air-dry.



## Maintenance

- \* Do not open the compressor cabinet. All disassembly and maintenance must be done by the manufacturer.
- \* **Filter**-The filter should be changed when it discolours totally. Do not reuse or wash the filter or substitute it with any other material.
- \* **Compressor** - Wipe the outside of the compressor with a clean cloth regularly.



# Cleaning and maintenance of nebulizers

- Ideally, nebulizers should be cleaned after every use, however it is practically not possible, hence, cleaning and disinfecting the nebulizer should be done at least once a day.
- Cleaning and maintenance of nebulizers should be done before using the nebulizer for the first time or if the nebulizer has not been used for long time.
- Cleaning and maintenance also depends on the frequency of use.

**Table 5: General instructions for cleaning and maintenance of different nebulizers**

**Jet nebulizers**

Wash all accessories except the tubing in warm water/mild detergent solution. Rinse with warm water to remove detergent residue and leave to air-dry.

Wipe the outer surface of the tubing and the compressor with a clean cloth. If there is some water in the tubing, connect it to the compressor and blow air through the tubing for a few seconds.

Change the air filter as soon as it changes colour.

**Ultrasonic nebulizers**

Wash all the accessories such as mouthpiece/mask, extension tube, medication cap and air filter with a mild detergent or a commercially available disinfectant.

Wipe the main body with a damp, soft cloth.

**Mesh nebulizers**

Medication container, mesh cap, mask adapter and mouthpiece/mask should be washed in warm soapy solution and later left to air-dry.

Do not touch/remove the mesh cap. The remaining medication in the mesh holes can be removed by nebulizing clean water after re-assembling the unit.

Wipe the main unit with a clean cloth.

## **Table 4: The safety check list**

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### **Safety measures for equipment used**

1. Checking the filter: Filter should be checked every month as a routine. Blackening of the filter should be reported to the manufacturer and blackened filter should be changed immediately
2. Every 6-12 months filter should be changed routinely [or as suggested by the information brochure provided by the manufacturer].
3. No liquids, even for cleaning purposes should be applied to compressor.

### **Safety of Accessories**

- Safety in regard to nebulizer accessories is for microbiological perspective (Infection/ Contamination).
- The tubing and the nebulizer chamber should be replaced every 4-6 weeks. They should be cleaned on a daily basis (see cleaning section).
- If a patient develops an LRTI and has a sputum test which shows a positive culture, it would be prudent to do swabs for culture from the nebulizer and the accessories.

Any positive swab culture would mean an immediate change of the accessories or a cleaning of the equipment.

[If this is not possible from a logistic stand point, tubing and nebulization chamber should be replaced compulsorily every 4 weeks. Positive culture from accessories should mandate a sputum culture/sensitivity from the patient to check whether same microorganism is growing in the bronchial secretions/airways.]

What are the cleaning and maintenance recommendations that need to be communicated to patients using long-term nebulization?

## RECOMMENDATION

Patients should be educated on cleaning and maintenance of their nebulizers, and a periodic review of the nebulizer should be performed by the prescribing physician.

Patients should be advised to clean the nebulizer accessories at least once a day.

Should oxygen-driven nebulization be used in COPD patients on maintenance treatment with nebulization at home?



# Long term oxygen therapy in patients with COPD

- Long term oxygen therapy (LTOT) for more than 15 hours is recommended by the GOLD guidelines as a treatment to improve survival in patients with COPD treated with maintenance nebulization.
- Drugs to be delivered with oxygen should not be recommended for home use because of the risk of carbon dioxide retention, especially with bronchodilators.

In individuals with chronic obstructive pulmonary disease who receive supplemental oxygen, carbon dioxide accumulation may occur through three main mechanisms:<sup>[5]</sup>

- Ventilation/perfusion matching: under-ventilated lung usually has a low oxygen content which leads to localised **vasoconstriction** limiting blood flow to that lung tissue. Supplemental oxygen abolishes this constriction, leading to poor **ventilation/perfusion** matching. This redistribution of blood to areas of the lung with poor ventilation reduces the amount of carbon dioxide eliminated from the system.
- The **Haldane effect**: most carbon dioxide is carried by the blood as bicarbonate, and deoxygenated **hemoglobin** promotes the production of bicarbonate. Increasing the amount of oxygen in the blood by administering supplemental oxygen reduces the amount of deoxygenated hemoglobin, and thus reduces the capacity of blood to carry carbon dioxide.
- Respiratory homeostasis: in healthy individuals, a rise in carbon dioxide causes an increase in the drive to breathe. However, in some patients with chronic obstructive pulmonary disease, this response has been blunted, leaving low oxygen levels as the main stimulus of respiration (**hypoxic drive**). Hence, giving supplemental oxygen reduces their stimulus to breathe, causing respiration to slow (**hypoventilation**), and allowing carbon dioxide to accumulate in the body.

## Abstract

Changes in blood gas tensions occurring when 100% oxygen or air was used as the driving gas for nebulised salbutamol were studied in 23 patients with severe airways obstruction. The patients fell into three groups: nine had chronic bronchitis and emphysema with carbon dioxide retention, seven had emphysema and chronic bronchitis without carbon dioxide retention, and seven had severe asthma (no carbon dioxide retention). When oxygen was used as the driving gas patients who retained carbon dioxide showed a mean rise of 1.03 kPa (7.7 mm Hg) in their pressure of carbon dioxide ( $P_{CO_2}$ ) after 15 minutes ( $p < 0.001$ ) but the  $P_{CO_2}$  returned to baseline values within 20 minutes of stopping the nebuliser. The other two groups showed no rise in  $P_{CO_2}$  with oxygen. When air was used as the driving gas none of the groups became significantly more hypoxic. Although it is safe to use oxygen as the driving gas for nebulisers in patients with obstructive airways disease with normal  $P_{CO_2}$ , caution should be exercised in those who already have carbon dioxide retention.

Should oxygen-driven nebulization be used in COPD patients on maintenance treatment with nebulization at home?

**RECOMMENDATION**

Patients (especially those with COPD) should not be prescribed maintenance nebulization with oxygen driven jet nebulizers because of the risk of carbon dioxide retention, especially with bronchodilators.

At what time intervals should patients using nebulization at home be assessed?

**ERS TASK FORCE**

**European Respiratory Society Guidelines on the use of nebulizers**

It is suggested that long-term nebulizer users should have the support of a local service, as described earlier. Patients should be re-assessed soon after treatment starts (at ~ 1 month) and then re-assessed regularly (at least annually) to determine whether their treatment is still necessary and effective and to ensure that the patient continues to use the nebulized treatment safely and effectively (Grade C). This evaluation should include lung function testing, assessment of symptom control and breathlessness and sense of well-being. The clinician should also ask about side-effects of treatment and check that the treatment is still judged by the patient to be working (Grade C).

**ERS TASK FORCE**

**European Respiratory Society Guidelines on the use of nebulizers**

Follow up assessment should include:

- Lung function testing
- Symptom control, breathlessness and well being
- Treatment side effects
- Subjective assessment of treatment efficacy
- Nebulizer technique
- Dosing and frequency of nebulization

# Consensus: Assessment of patients using nebulization at home

- Regular follow-up is the key to the successful management of any chronic disease.
- Patients should be assessed for:
  - ✓ Effectiveness of the prescribed treatment
  - ✓ Adherence to the treatment
  - ✓ Need for continuing maintenance nebulization
  - ✓ Possibility of re-introducing handheld inhalers
- Initiating follow-up approximately 1 month after the start of the maintenance nebulization, with annual re-assessment.

At what time intervals should patients using nebulization at home be assessed?

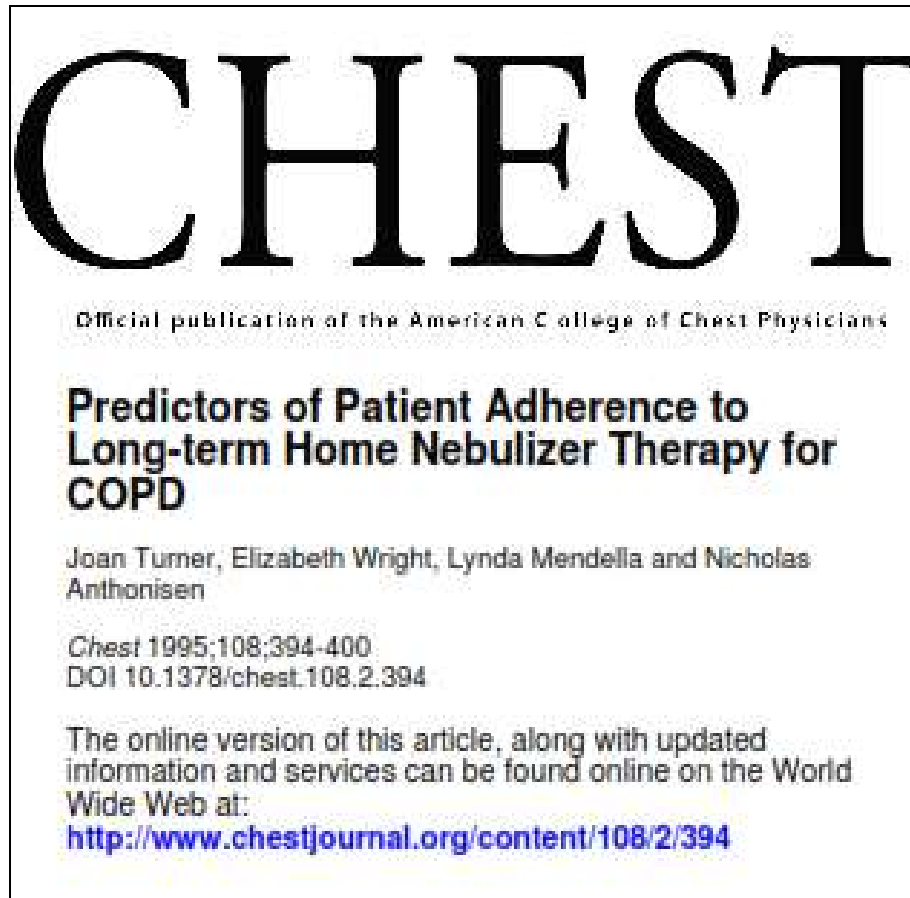
**RECOMMENDATION**

Initial follow-up should be performed 1 month after the start of maintenance nebulization and, later, at least annually.



How should the success of therapy be assessed and adherence ensured in patients using long-term nebulization?

# Which Patients Adhere to Home Nebulization?



Patients adherent (50.6%) to long term nebulizers were:

- Older (> 60 years of age)
- Better educated
- Married
- Having little smoking and alcohol history
- With history of emphysema
- Having more breathlessness
- Poorer lung function

n= 985 patients with moderate to severe COPD, 3-years of follow-up

# Assessment and adherence of the treatment

- Various surveys have shown patient satisfaction with the nebulizers. However, the treatment adherence is unknown.
- Adherence can be referred as – objective (lung function, symptom scores, exacerbation history) and subjective reports
- General strategies to improve adherence – monitoring and feedback, extensive patient education, and regular follow-up (via telephone or home visits), providing medication tables/patient diaries.

# Strategies that can improve adherence

- Pharmacist driven brief counselling followed by physician visits
- Monitoring and feedback
- Extensive patient education followed by telephonic follow up at regular intervals
- Providing medication table, techniques to improve breathing

How should the success of therapy be assessed and adherence ensured in patients using long-term nebulization?

## RECOMMENDATION

Success of the maintenance nebulization should be assessed on

1. Effectiveness of the treatment (objective and subjective)
2. Adherence to treatment
3. Need for continuing maintenance nebulization
4. Adverse effect of home nebulization
5. Possibility of re-introducing hand-held inhalers.

**Establishing a strong and participative doctor-patient relationship may help to identify and ensure adherence to maintenance nebulization**

Can home nebulization be prescribed in other chronic respiratory diseases?

# Home nebulization for other chronic respiratory diseases

- Nebulizers have been used to deliver tobramycin, dornase alfa, rhDNAse in cystic fibrosis and nebulized antibiotics in bronchiectasis.
- Nebulized antibiotics for home use – unclear, due to risk of antibiotic resistance.

Can home nebulization be prescribed in other chronic respiratory diseases?

**RECOMMENDATION**

Although nebulization is used for the administration of antibiotics in other chronic respiratory diseases such as cystic fibrosis, the prescriber has to be careful about the associated risk of antibiotic resistance.



A group of men are seated around a large, dark conference table in a meeting room. The room has dark wood-paneled walls and a patterned carpet. The men are dressed in business attire, including suits and shirts. Some are looking towards the camera, while others are looking at documents or talking to each other. There are water bottles and small floral arrangements on the table. The lighting is warm and focused on the participants.

# Thanks!

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