Nebulised bronchodilators, corticosteroids, and rhDNase in adult patients with cystic fibrosis

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Bronchodilator therapy
Bronchodilators are commonly prescribed for adult patients with cystic fibrosis and their judicious use is seen by most physicians as “good clinical practice”. There is, however, a dearth of clinically relevant research addressing their efficacy, optimal dosage, method of delivery, or responses to single and combined therapy with β agonists and anticholinergic agents. The importance of allergy and hyper-reactivity remains poorly understood. Published studies are bedevilled by small patient numbers, short term results, often heterogeneous patient groups, different outcome criteria, and a concentration on the use of metered dose inhalers.

Rationale for bronchodilator use in adult patients with cystic fibrosis
The lungs of patients with cystic fibrosis are progressively compromised by airway obstruction, and fixed structural damage to the bronchial tree from ongoing airway inflammation may all contribute to symptoms. Lung function is compromised by air trapping, loss of lung recoil, and reduced expiratory flow, with resulting wheeze and exercise limitation, but airway obstruction is not irreversible in all patients. Bronchoconstriction responsive to bronchodilator therapy makes a variable contribution to the overall airway obstruction.

Bronchodilators are beneficial during hospital admissions for intravenous antibiotic treatment of acute respiratory exacerbations when airway obstruction is often increased. Hordvik et al showed responsiveness to nebulised isoetharine increasing during hospitalisation, with the response significantly correlating with improvements in baseline forced expiratory volume in one second (FEV₁), forced vital capacity (FVC), and mid forced expiratory flow (PFE25-75) measurements. This probably reflects bronchodilator induced mobilisation of secretions with resultant increases in lung function. The ability of bronchodilator drugs to increase mucociliary clearance may be as important as their primary action and they are particularly useful before chest physiotherapy or bronchial drainage.

Bronchial hyperreactivity in patients with cystic fibrosis
Bronchial hyperreactivity, shown by short term improvement in spirometric values after bronchodilators and by positive broncho-provocation tests, has been reported in 25-66% of study populations. Although hyperreactivity may be a distinct and separate condition in patients with cystic fibrosis, it is more likely to be a reflection of the underlying disease, the progressive inflammation and epithelial damage altering mucosal permeability and histamine penetration. Both the extent and prevalence of bronchial hyper-reactivity and obstruction may increase with age. Thus, as airways become more structurally damaged they may also become more responsive to bronchodilator treatment. Probably because of the additional factor of airway instability, the bronchial hyper-reactivity seen in cystic fibrosis differs from that seen in uncomplicated asthma. The less responsive cystic fibrosis airway may require bronchodilator therapy to maximise the therapeutic response.

Patients with bronchial hyperreactivity are perhaps those most likely to respond to nebulised bronchodilator therapy, and those whom clinicians might wish to preselect for such treatment. They may form a special subgroup characterised by a more rapid clinical deterioration, more severe disease, and more respiratory exacerbations, and are thus particularly in need of maximal therapy. There is, however, no reliably easy way of identifying them.

Bronchial provocation testing is the best method for detecting bronchial hyperreactivity in patients with cystic fibrosis but it is not routinely available, is poorly repeatable, and may not predict all patients who will benefit from bronchodilators.

Evidence for the efficacy of bronchodilator therapy in cystic fibrosis
There is a paucity of acute response data to bronchodilators and no studies of long term nebulised bronchodilator therapy in cystic fibrosis. It is therefore necessary also to refer to data from work on delivery by metered dose inhaler. Inhalation of high dose nebulised bronchodilator for 10 minutes might reasonably be expected to have the greater efficacy, given the viscid mucus barrier between drug and receptor. Mixed study populations of adults and children have shown significant increases in expiratory flow in up to one third of patients after β agonist or anticholinergic bronchodilators delivered by metered dose inhaler and nebuliser. Adult patients are more likely to show a response.
Assessment of bronchodilator responsiveness in individual patients is complicated by within patient variability, reflecting the fluctuations in the degree of inflammation, secretory load, mucosal oedema, or bronchoconstriction present at different points in time, and the effect of acute infective changes on the underlying chronic lung disease. Most studies have reported no relationship between the degree of bronchodilator response and atopy.

Corticosteroid therapy

Inhaled corticosteroids, delivered by metered dose inhaler or nebuliser, are widely used in the management of adult patients with cystic fibrosis. There are few controlled studies documenting the efficacy of inhalers and no studies on the use of nebulised corticosteroids.

COMBINED β AGONIST AND ANTICHOLINERGIC THERAPY

Nebulised bronchodilator therapy appears to be a useful adjunct in the management of acute respiratory exacerbations. Hordvik et al showed significant improvements in baseline spirometric tests in patients admitted to hospital treated with either nebulised albuterol or placebo before physiotherapy. The potential for an additive bronchodilator effect by combining ipratropium bromide and a β agonist has not been widely addressed. Weinitraub et al studied the acute response to inhaled placebo, ipratropium bromide 40 µg, metaproterenol 1500 µg, and combined bronchodilator therapy delivered by metered dose inhaler in 10 randomly selected adult patients. Eight had a clinically significant improvement with at least one of the regimens, with a tendency for those who responded to one regimen to respond to the others. Only two of the 10 patients showed a marked benefit from combination therapy. Sanchez reported a better response of respiratory function tests (FEV1 increasing by 17%) and airway resistance to albuterol 5 mg and ipratropium bromide 250 µg delivered by nebuliser and face mask than to either drug when used alone in a mixed patient group of children and adults. Ipratropium bromide was needed to achieve a fall in FRC and residual volume (RV).

Ipratropium bromide appears to be more effective in patients with negative bronchoconstriction test results. We recommend that all patients should have respiratory function tests before and after inhalation of both β agonists and anticholinergic bronchodilators, singly and in combination, to determine the optimal treatment regimen.

POTENTIAL FOR A DETRIMENTAL BRONCHODILATOR EFFECT ON LUNG FUNCTION IN ADULT CYSTIC FIBROSIS

Zach has proposed, on theoretical grounds, that bronchodilation may reduce end expiratory airway flow rates and thus perhaps reduce coughing efficiency. The relevance of this to clinical practice is uncertain. Deterioration after inhaled bronchodilator treatment is rare and is not a problem in practice.

CONCLUSION

A significant percentage of adult patients with cystic fibrosis may benefit from bronchodilator therapy. There is no reliable method for predicting those patients who will respond and all patients should be given a trial of nebulised bronchodilators when clinically indicated.
rhDNase (Dornase alpha, Pulmozyme)

The epithelial lining fluid from the lung of patients with cystic fibrosis shows a large predominance of polymorphonuclear leucocytes compared with normal controls.\textsuperscript{57} The thick purulent sputum characteristic of cystic fibrosis is enriched with DNA derived from disintegration of these neutrophils\textsuperscript{58} as the inflammatory process outstrips the ability of deoxyribonuclease 1 (DNase 1), a naturally occurring human enzyme, to digest extracellular DNA.\textsuperscript{39} The latter is a viscous polymer and a major determinant of the viscosity of the respiratory secretions. DNA containing fractions of the sputum may further decrease the efficacy of treatment by binding aminoglycoside antibiotics.\textsuperscript{51, 52} The more powerful CR60 antibiotics,\textsuperscript{53, 54} the latter group has since shown a significant efficacy of treatment by binding aminoglycoside antibiotics.\textsuperscript{55, 56}

Human DNase 1 has been cloned, sequenced, and expressed as recombinant DNase 1, rhDNase (Pulmozyme), and shown to reduce dramatically the viscosity of the spum in cystic fibrosis.\textsuperscript{49-50} Well defined phase I, II, and III trials of rhDNase in patients with mild to moderate cystic fibrosis (FVC \textgreater{} 40\% predicted) have shown that it results in a modest improvement in respiratory function and a modest decrease in the frequency of respiratory exacerbations.

**SUMMARY OF PHASE I, II, AND III TRIALS**

In phase I studies\textsuperscript{55, 61} rhDNase was well tolerated to a maximum dose of 30 mg/day without development of DNase antibodies and with significant improvement in lung function. FEV\textsubscript{1} increased by 10-20\% from baseline but returned to pretreatment levels within one week of the study. As the total sputum volume did not increase with treatment it was hypothesised that rhDNase enhanced the removal of mucus from areas where the normal cough and mucociliary mechanisms were ineffective.\textsuperscript{62}

Phase II studies confirmed the safety profile of the drug and showed short term efficacy.\textsuperscript{55, 56} Almost one third of patients showed a \textgreater{} 20\% increase in FEV\textsubscript{1}, with 2.5 mg rhDNase twice daily.\textsuperscript{58} Both studies reported a significant reduction in infective exacerbations by further clinical trials. Only jet nebulisers have been shown to deliver rhDNase effectively. Ultrasonic devices may cause thermal coagulation of rhDNase. Battery operated compressors have insufficient power.

**LATEST RESEARCH**

Early studies of rhDNase use in acute respiratory exacerbations and severe disease (FVC \textless{} 40\%) were not sufficiently powerful to assess efficacy but showed good patient tolerance of the drug.\textsuperscript{64} An open label 12 week study in the latter group has since shown a significant increase in lung function,\textsuperscript{65} perhaps not surprising as all severely affected patients are likely to have markedly increased levels of DNA in their sputum. Compared with placebo, FEV\textsubscript{1} increased by 7\% and FVC by 5\% with treatment. The study power was insufficient to show a significant reduction in infective exacerbations in the treatment group.

**PRACTICAL ASPECTS OF rhDNASE ADMINISTRATION IN CYSTIC FIBROSIS**

Patients should commence treatment with rhDNase under the guidance of a cystic fibrosis centre to ensure that they receive the proper training for drug administration, and the maintenance and cleaning of the equipment.\textsuperscript{66} Daily treatment is necessary to maintain the therapeutic benefit. Patients must use a recommended nebuliser system only and inspire at a normal rate and depth through a mouthpiece while sitting upright. Currently recommended delivery systems include the Hudson T Up-draft II, Marquest Acorn 11, or the Respigard II with the DeVilbiss Pulmo-Aide compressor, the Pari LC nebuliser/Pari Proneb compressor, the AirLife Misty with Tee Adapter, the Pari LL with the Inhalierboy or Almost one third of patients showed a \textgreater{} 20\% increase in FEV\textsubscript{1}, with 2.5 mg rhDNase twice daily.\textsuperscript{58} Both studies reported a significant reduction in subjective perception of cystic fibrosis related symptoms. Adverse events were limited to mild upper airway irritation.

A double blind placebo controlled phase III study\textsuperscript{67} in 968 patients over 24 weeks showed a sustained improvement in FEV\textsubscript{1}, of approximately 6\% and a reduced relative risk of a respiratory exacerbation requiring intravenous antibiotics of 31\% in patients treated with rhDNase 2.5 mg once or twice daily. Patients experienced less dyspnoea and a reduced sense of well being. The major side effect was transient voice alteration. This trial was continued as an open label study of rhDNase, 2.5 mg daily, and the treatment continued to be well tolerated at two years. The risk of infection related respiratory infection remained lower than during placebo treatment and the improvement in respiratory function was maintained.\textsuperscript{68} Subgroup analysis of the phase III study showed that patients with mild lung disease (baseline FVC \textgreater{} 85\% predicted) also benefited from treatment with a decrease in the relative risk of pulmonary exacerbations and an increase in FVC of about 4\%. Chronic inflammation is present even in the mildly affected lung. By mobilising secretions and decreasing the incidence of respiratory exacerbations, rhDNase may effect a delay in the progression of lung disease in these patients.
cool boxes can be obtained for use when travelling. rhDNase should not be used if it has been exposed to room temperature for 24 hours or longer, or if it becomes cloudy or discoloured.

(2) rhDNase must not be combined with any other medications in the nebuliser as changing the characteristics of the solution might alter the rhDNase protein.

(3) We recommend that rhDNase should be inhaled after morning physiotherapy or in the late afternoon or evening. This will maximise the effect of the before bed physiotherapy session. It is advisable to leave about two hours and an absolute minimum of half an hour between rhDNase inhalation and physiotherapy. Similarly, at least half an hour should be allowed between nebulised rhDNase and any nebulised antibiotic inhalation.

Because of the cost of rhDNase and the importance of continued evaluation of this new therapy, the response of all treated patients must be repeatedly assessed by monitoring spirometric values, the frequency of respiratory exacerbations, and subjective changes in dyspnoea, cough, sputum production, fatigue, apnoea, sleep, exercise tolerance, and ease of sputum clearance. Patients with moderate impairment of respiratory function are likely to respond within two weeks of starting treatment. More severely affected patients may benefit from a reduction in the frequency of respiratory exacerbations and should be assessed over a period of months.

**Recommendations for rhDNase use in adult cystic fibrosis**

Studies to date document objective and subjective benefits from rhDNase 2.5 mg daily in patients with a wide range of disease severity. The recommendations of the North American Consensus Committee for initiating treatment with rhDNase are noticeably unrestrictive. The only criterion is the physician’s judgement that there is sufficient lower airway inflammation for rhDNase to be of benefit. Any patient should be considered eligible for consideration to receive DNase if such therapy is deemed appropriate by the cystic fibrosis specialist treating the patient.

We would endorse these recommendations, remembering that in a disease characterised by an annual fall in lung function that is eventually fatal at a mean age of about 30 years, any stabilisation is an important gain and any treatment that offers the possibility of improvement must be fully explored. The increase of about 6% in FEV1 values and no significant sputum production session. It is advisable to leave about two hours and an absolute minimum of half an hour between rhDNase inhalation and physiotherapy. Similarly, at least half an hour should be allowed between nebulised rhDNase and any nebulised antibiotic inhalation.

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