Bacterial lysate in the prevention of acute exacerbation of COPD and in respiratory recurrent infections

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Abstract: Respiratory tract infections (RTIs) represent a serious problem because they are one of the most common cause of human death by infection. The search for the treatment of those diseases has therefore a great importance. In this study we provide an overview of the currently available treatments for RTIs with particular attention to chronic obstructive pulmonary diseases exacerbations and recurrent respiratory infections therapy and a description of bacterial lysate action, in particular making reference to the medical literature dealing with its clinical efficacy. Those studies are based on a very large number of clinical trials aimed to evaluate the effects of this drug in maintaining the immune system in a state of alert, and in increasing the defences against microbial infections. From this analysis it comes out that bacterial lysates have a protective effect, which induce a significant reduction of the symptoms related to respiratory infections. Those results could be very interesting also from an economic point of view, because they envisage a reduction in the number of acute exacerbations and a shorter duration of hospitalization. The use of bacterial lysate could therefore represent an important means to achieve an extension of life duration in patients affected by respiratory diseases.

Keywords: bacterial lysate, COPD, respiratory recurrent infections

Background and introduction
Respiratory tract infections (RTIs) represent one of the most common and important causes of human disease in terms of morbidity, mortality, and economic cost to society. RTIs are the most common, and potentially the most severe, infections treated by health care practitioners. Lower RTIs, along with influenza, are the most common cause of death by infection in the United States. Risk factors for pneumonia and other respiratory tract infections include: extremes of age (very young and elderly), smoking, alcoholism, immunosuppression, and comorbid conditions (File 2000). We can distinguish two main clinical manifestations of relevant impact: acute exacerbations of chronic bronchitis (AECB), and recurrent respiratory infections (RRI).

Recurrent respiratory infections (RRI) are characterized by at least three episodes of fever, locoregional inflammation, cough, asthma, wheezing without severe impairment of respiratory functions. This syndrome is frequent both in pediatric and in adult patients accounting for the principal cause of absence from school and work during winter time. RRI involve both upper and lower respiratory tract and are caused by a wide panel of microorganisms. In particular, viral infections, caused by influenza viruses, parainfluenza viruses, respiratory syncitial virus, adenovirus, rhinoviruses, are the original cause of the disease but recurrences are also caused by bacteria, including Acinetobacter spp., Chlamydia pneumoniae, Enterobacteriaceae, Hemophilous influenaeae, Legionella pneumophila, Moraxella catarhulis, Mycoplasma pneumoniae, Nocardia asteroids, Pasteurella multocida, Pseudomonas aeruginosa, Staphylococcus...
Chronic obstructive pulmonary disease (COPD) is a state characterized by airflow limitation that is not fully reversible. The airflow limitation is usually both progressive and associated with an abnormal inflammatory response of the lungs to noxious particles or gases. A diagnosis of COPD should be considered in any patient who presents with symptoms of cough, sputum production, or dyspnoea, and/or has a history of exposure to the risk factors for the disease. Clinical symptoms and signs, such as an abnormal shortness of breath and increased forced expiratory time, can be used to help with the diagnosis. Chronic cough and sputum production often precede the development of airflow limitation by many years, although not all individuals with cough and sputum production go on to develop COPD. The classification of Severity is shown in Table 2. The pathogenesis of COPD is characterized by chronic inflammation throughout the airways, parenchyma, and pulmonary vasculature. Macrophages, T lymphocytes (predominately CD8), and neutrophils are increased in various parts of the lung. Inflammation of the lungs is caused by exposure to inhaled noxious particles and gases. Cigarette smoke can induce inflammation and directly damage the lungs. Pathologic changes in the lungs lead to corresponding physiologic changes characteristic of the disease, including mucus hypersecretion, ciliary dysfunction, airflow limitation, pulmonary hyperinflation, gas exchange abnormalities, pulmonary hypertension, and cor pulmonale. The destruction of alveolar attachments, which inhibits the ability of the small airways to maintain patency, plays a smaller role. In advanced COPD, peripheral airways obstruction, parenchymal destruction, and pulmonary vascular abnormalities reduce the lung’s capacity for gas exchange, producing hypoxemia and, later on, hypercapnia. Pulmonary hypertension, which develops late in the course of COPD (Stage III: Severe COPD), is the major cardiovascular complication of COPD and is associated with the development of cor pulmonale and a poor prognosis.

Patients with chronic obstructive pulmonary disease (COPD) are prone to exacerbations, which account for significant morbidity and mortality and are a key determinant of health-related quality of life. (Seemungal et al 1998) COPD exacerbations are defined as a change in the patient’s chronic respiratory symptoms sufficient to warrant a change in management (Celli et al 2004; Global Initiative for Chronic Obstructive Lung Disease 2005)

The cardinal symptoms of COPD exacerbations are increase in dyspnoea, sputum volume and sputum purulence development (named the “Anthonisen’s criteria”) (Anthonisen NR 1987). There is considerable heterogeneity in the character, frequency, and time course of COPD exacerbations, which cannot be accounted for solely on the basis of degrees of airway obstruction or disease severity.

The lower airways of 25% to 50% of COPD patients are colonized by bacteria, especially noncapsulated Haemophilus influenzae, Streptococcus pneumoniae, and Moraxella catarrhalis (Anthonisen et al 1987; Cabello 1997).

The predominant bacteria recovered in the lower airways of patients with mild exacerbations are H. influenzae, S. pneumoniae and M. catarrhalis, whereas in severe COPD requiring mechanical ventilation gram negative bacilli, and P. aeruginosa are more frequent (Papi et al 2006). Lower airway bacterial colonization is increasingly recognized as an independent stimulus to airway inflammation (Sethi et al 2001) It can modulate the character and frequency of COPD exacerbations (Patel et al 2002).

A significant role in the aetiology of acute exacerbations of chronic bronchitis seems to be played also by viruses, responsible of almost 40% of the exacerbations. (Seemungal et al 2001).

Pharmacological treatments: systemic overview
The currently available treatments for COPD therapy include:

Bronchodilators (Evidence A)
Bronchodilator medications are central to the symptomatic management of COPD (Vathenen et al 1998; Gross et al 1989; Chrystyn et al 1988; Higgins et al 1991) (Evidence A). They are given either on an as-needed basis for relief of persistent or worsening symptoms, or on a regular basis to prevent or reduce symptoms. The side effects of bronchodilator therapy are pharmacologically predictable and dose dependent. Adverse effects are less likely, and resolve more rapidly after treatment withdrawal. All categories of bronchodilators have been shown to increase exercise capacity in COPD, without necessarily producing significant changes in FEV1 (Ikeda et al 1995; Guyatt et al 1987a; Man et al 2004; O’Donnell et al 2004) (Evidence A). Regular treatment with long-acting bronchodilators is more effective and convenient than treatment with short-acting bronchodilators, but also more expensive (Mahler et al 1999; Dahl et al 2001; Oostenbrink et al 2002; Vincken et al 2002) (Evidence A).
Inhaled glucocorticosteroids
Regular treatment with inhaled glucocorticosteroids does not modify the long-term decline of FEV₁ in patients with COPD (Pauwels et al 1999; Vestbo et al 1999; Burge et al 2000; The Lung Health Study Research Group 2000). However, regular treatment with inhaled glucocorticosteroids is appropriate for symptomatic COPD patients with an FEV₁ <50% predicted (Stage III: Severe COPD and Stage IV: Very Severe COPD) and repeated exacerbations (for example, 3 in the last three years) (Mahler et al 2002; Szafranski et al 2002; Calverley et al 2003a; Jones et al 2003) (Evidence A). This treatment has been shown to reduce the frequency of exacerbations and thus to improve health status (Spencer et al 2004) (Evidence A). Withdrawal from treatment with inhaled glucocorticosteroids can lead to exacerbations in some patients. Inhaled glucocorticosteroid combined with a long-acting β₂-agonist is more effective than the individual components (Mahler et al 2002; Calverley et al 2003; Szafranski et al 2002; Hanania et al 2003; Calverley et al 2003b) (Evidence A).

Mucolytic (mucokinetic, mucoregulator) agents (ambroxol, erdosteine, carbocysteine, iodinated glycerol)
The regular use of mucolytics in COPD has been evaluated in a number of long-term studies with controversial results (Allegra et al 1996; Guyatt et al 1987b; Petty 1990). The majority of the studies showed no effect of mucolytics on lung function or symptoms, although some of them reported a reduction in the frequency of exacerbations. A Cochrane collaborative review performed a meta-analysis of all the available data, including those from a number of abstracts (Poole and Black 2003). A statistically significant reduction in the number of episodes of chronic bronchitis was found in patients treated with mucolytics compared to those receiving placebo. However, those data are not easy to interpret, as the follow-up ranged from 2 to 6 months and all the patients had an FEV₁ > 50% predicted. Although a few patients with viscid sputum may benefit from mucolytics (Siafakas et al 1995; American Thoracic Society 1986), the overall benefits seem to be very small. Therefore, the widespread use of these agents cannot be recommended on the basis of the present evidence (Evidence D).

Antioxidant agents
Antioxidants, in particular N-acetylcysteine, have been shown to reduce the frequency of exacerbations and could have a role in the treatment of patients with recurrent exacerbations (Boman et al 1983; British Thoracic Society Research Committee 1985; Rasmussen and Glennow 1988; Hansen et al 1994) (Evidence B). However, before their routine use can be recommended, the results of ongoing trials have to be carefully evaluated.

Antitussives
Cough, although it is sometimes a troublesome symptom in COPD, has a significant protective role (Irwin et al 1998). Thus the regular use of antitussives is contraindicated in stable COPD (Evidence D). For classification of evidences, see Table 1.

| Table 1 Classification of evidence |
|-----------------------------------|
| Evidence | Category | Sources of evidence definition |
|---------|----------|-------------------------------|
| A       | Randomized control trial | Rich body of data. Evidence is from endpoints of well designed RCTs that provide a consistent pattern of findings in the population for which the recommendation is made. Category A requires substantial numbers of studies involving substantial numbers of participants. |
| B       | Randomized control trial | Limited body of data. Evidence is from endpoints of intervention studies that include only a limited number of patients, post hoc or subgroup analysis of RCTs, or meta-analysis of RCTs. In general, Category B pertains when few randomized trials exist, they are small in size, or they were undertaken in a population that differs from the target population of the recommendation, or the results are somewhat inconsistent. |
| C       | Nonrandomized trials     | Observational studies. Evidence is from outcomes of uncontrolled or non randomized trials or from observational studies. |
| D       | Panel                  | Consensus Judgment. This category is used only in cases where the provision of some guidance was deemed valuable but the clinical literature addressing the subject was deemed insufficient to justify placement in one of the other categories. The Panel Consensus is based on clinical experience or knowledge that does not meet the above listed criteria. |
Antibiotics

In several large-scale controlled studies (Francis and Spicer 1960; Francis et al 1961; Fletcher et al 1966), the prophylactic, continuous use of antibiotics was shown to have no effect on the frequency of exacerbations in COPD. Another study examined the efficacy of winter chemoprophylaxis over a period of 5 years and concluded that there was no benefit (Johnston et al 1969). Thus, on the present evidence, the use of antibiotics, other than for treating infectious exacerbations of COPD and other bacterial infections, is not recommended (Isada and Stoller 1994; Siafakas Bouros 1998) (Evidence A).

In the case of an acute exacerbation, antibiotic therapy significantly shortens the duration of symptoms and can be cost-effective. Over the past 50 years, virtually all classes of antimicrobial agents have been studied in AECB. Important considerations include penetration into respiratory secretions, spectrum of activity and antimicrobial resistance. Those factors limit the usefulness of drugs such as amoxicillin, erythromycin and trimethoprim-sulfamethoxazole. Extended-spectrum oral cephalosporins, newer macrolides and doxycycline have demonstrated efficacy in clinical trials. Amoxicillin-clavulanate and fluoroquinolones should generally be reserved for patients with more severe disease. A number of investigational agents; including ketolides and newer quinolones; hold promise for treatment of AECB. (Dever et al 2002).

Innate and adaptive immunity modulation in preventing and treating respiratory infection

The potentiation of both specific and non specific immuneresponse has been considered a central point in the treatment of recurrences in respiratory tract infections. Specific immunity against viruses (such as influenza virus) and bacteria (Streptococcus pneumoniae) can be raised using specific treatment with vaccines. This is the case of influenza vaccines and pneumococcal vaccine.

Influenza vaccines

Influenza vaccines can reduce serious illness (Wongsurakiat et al 2004) and death in COPD patients by about 50% (Nichol et al 1994; Wongsurakiat et al 2003) (Evidence A). Vaccines containing killed or live, inactivated viruses are recommended (Edwards et al 1994) as they are more effective in elderly patients with COPD (Hak et al 1998). The strains are adjusted each year for appropriate effectiveness and should be given once (in autumn) or twice (in autumn and winter) each year.

Pneumococcal vaccine

A pneumococcal vaccine containing 23 virulent serotypes has been used (Williams and Moser 1986; Davis 1987; Simberkoff et al 1996) (Evidence B). The potentiation of nonspecific and specific immuneresponse against other bacteria (such as the bacteria shown as the cause of recurrent infection of the respiratory tract), can be obtained using polyvalent bacterial lysate. This category of drugs includes different kinds of bacterial extracts, and a different number of bacterial species (polyvalent extracts) obtained through different ways of lysis, both chemical or mechanical (PMBL, PCBL). We will further on discuss the effects of this kind of drugs, through an analysis of Randomized Controlled Trials published to date.

Characteristics of bacterial lysate

Bacterial lysate are constituted by a mixture of bacterial antigens derived from different bacterial species, according to the considered extract. The more often included species are: Staphylococcus aureus, Streptococcus viridans, Streptococcus pneumoniae (6 strains), Streptococcus pyogenes, Klebsiella pneumoniae, Klebsiella ozenae, Moraxella catarrhalis, Hemophilus influenzae. Each extract is prepared with billions of these bacteria. Antigens are obtained following a mass culture of reference bacterial strains, using a chemical or mechanical

Table 2 Classification of severity according to GOLD guidelines. (http://goldcopd.com/ GOLD Global Initiative for Chronic Obstructive Lung Disease)

| Stage                  | Characteristics                                      |
|------------------------|------------------------------------------------------|
| 0: at risk             | • Normal spirometry.                                 |
|                        | • Chronic symptoms (cough, sputum production).       |
| I: Mild COPD           | • FEV₁/FVC < 70%.                                    |
|                        | • FEV₁ > or = 80% predicted.                         |
|                        | • With or without chronic symptoms (cough, sputum production). |
| II: Moderate COPD      | • FEV₁/FVC < 70%.                                    |
|                        | • 50% < or = FEV₁ < 80% predicted.                   |
|                        | • With or without chronic symptoms (cough, sputum production). |
| III: Severe COPD       | • FEV₁/FVC < 70%.                                    |
|                        | • 30% < or = FEV₁ < 50% predicted.                   |
|                        | • With or without chronic symptoms (cough, sputum production). |
| IV: Very Severe COPD   | • FEV₁/FVC < 70%.                                    |
|                        | • FEV₁ < 30% predicted or FEV₁ < 50% predicted plus chronic respiratory failure. |

Based on postbronchodilator FEV₁.
Bacterial lysate is both a specific and non-specific immunostimulating agent, indicated for the prevention and treatment of respiratory infections, including sequelae to common cold and influenza. In particular, it is useful for the treatment of acute and chronic bronchitis, anginas, tonsillitis, pharyngitis, laryngitis, rhinitis, sinusitis, and otitis. It can also be used for infections resistant to common antibiotics and for the sequelae to bacterial and viral infections.

The more usual treatment schedule for PMBL is the following:
- Acute events: one tablet per day to dissolve under the tongue, (for a minimum of ten days) until the symptoms disappear.
- Long term treatment: one tablet per day to dissolve under the tongue for 10 consecutive days, followed by 20 days’ rest. The cycle is repeated for three consecutive months.

Mode of action of bacterial lysate

The capacity of a virtually intact microbe to activate resting monocytic-macrophage cells is strictly linked to the presence of structures belonging to the bacterial cell wall (for example, protido-glycane or lipopolysaccharide) against which some receptor structures (such as the so-called toll like receptors -TLR) are specific directed. TLR are expressed on the surface of monocyte membrane. The interaction between bacterial structures and TLR results in the activation of monocytes, their differentiation to immature dendritic cells and the following maturation to mature dendritic cells, able to be considered a suitable professional antigen presenting cell. The use of bacterial antigens obtained by mechanical or chemical lysis is thus able to activate monocytic-macrophagic cells of the sub-mucosa, inducing the differentiation through immature dendritic cells and their maturation in mature dendritic cells. The activation of such a mechanism results in a suitable stimulation of the immune-response.

The presentation of bacterial antigens on mature dendritic cells results in the stimulation of the T cell compartment (with a consequent induction of a powerful helper function) and of the B cell compartment of the immune-response, with a following maturation to plasmacells and secretion of antibodies specifically directed to the administered. The administration of bacterial lysate is thus able to induce a T helper function and a maturation of B specific lymphocytes resulting in the production of IgA salivary antibodies directed to the administered mixture of antigens.

The secretion of antibodies directed to bacterial antigens has a positive function only in the case of these antibodies having the capability to opsonize living bacterial cells, thus favouring the phagocytosis and the killing mediated by professional phagocytes, such as granulocytes.

All these findings indicate that the maturation of dendritic cells, the specific activation of the T and B cell population of lymphocytes, and the resulting production of IgA in the respiratory mucosa specifically directed to the antigens administered, characterized by the capacity of opsonizing living bacteria thus allowing their engulfment and killing in phagocytes, represent the actual pathway for the potentialization of a both nonspecific (dendritic cells and phagocytes) and specific (T and B cells) immune-response, resulting in a prophylactic effect on recurrent infections of the respiratory tract.

Bacterial lysate clinical efficacy: literature review

The effects of bacterial lysate as an immunostimulatory agent has been debated in many clinical trials.

By performing a simple research on PubMed directory of the terms “bacterial lysate”, and limiting the search only to randomized clinical trials, it is possible to find more than thirty papers. The aim of those studies, all published during the last twenty years, is to evaluate the effects of this class of drugs in maintaining the immune system in a state of alert, and in raising a defence against microbial infections, eventually leading to a reduction in their number.

Those studies are very different and heterogeneous. In fact the populations and samples of those trials are various, being representative of diverse diseases, such as: recurrent respiratory infections of upper and/or lower airways; chronic bronchitis; rhino-sinusitis and other ENT infections; chronic obstructive pulmonary disease. Even the age of patients included is different: many trials are conducted on pediatric patients (Braido et al).

We will briefly discuss the findings of these RCTs, analysing them separately, according to the characteristic of the patients included.

Pediatric trials

A pilot study involving 89 children pointed out that the administration of polivalent mechanical bacterial lysate could lead to a significant decrease in recurrent respiratory infections in patients treated with this drug, compared to the controls on the same children during the previous year; also information indexes were significantly lower in the treated
information group, and the values of B-lymphocytes were found to be increased (Rosaschino and Cattaneo 2004).

Even in patients from 3 to 6 years of age, affected by recurrent respiratory infections and IgG deficiency, a RCT proved the beneficial effect of bacterial lysate (Del-Rio-Navarro et al 2003).

Another RCT that included 232 children aged 3–5 years, showed that the treatment with PMBL significantly reduced the rate of upper respiratory tract infections, being this reduction higher in children affected more frequently by this kind of infections; the drug was also safe and well tolerated compared to placebo (Schaad et al 2002).

Another RCT involving 188 pediatric patients and lasting more than one year, put in evidence that the rate of infection was reduced of 50% in treated patients, and this was sustained for half a year after the end of drug administration; drug reactions were few, transient, expected and non serious (Ruah et al 2001).

A RCT lasting one year, including 54 children aged 1–12 years, evaluated for the two groups of patients (active/placebo) the number of acute respiratory tract infections and their duration, and also the number of antibiotic courses needed. The results showed a reduction in the number of infections, and a more significant reduction in antibiotic requirements and in the duration of the infection episodes in the treated group compared to placebo (Gutierrez-Tarango and Berber 2001).

56 young patients affected by subacute sinusitis were involved in a RCT lasting 6 months, evaluating the effects of bacterial lysate added to amoxicillin/clavulanate. The results pointed out that the cure and improvement of the patients in the active group were faster, and that these patients experienced a lower incidence of respiratory infections (Gomez Barreto et al 1998).

A bigger trial involving 423 children attending day-care centers (subjects with a higher risk of infection) showed that, during the period of treatment with bacterial lysate, treated children had a relative risk of 0.52 to present three or more episodes of upper respiratory infections (Collet et al 1993).

A much older study also revealed that, in children with rhinosinusitis, the treatment with bacterial lysate decreases the incidence and duration of infectious episodes and the number and duration of concomitant treatments; moreover, the clinical response showed a correlation with an increase in serum levels of IgA (Zagar and Loﬂ er-Badzek 1989).

Quite a big trial involving 825 children in the treatment group and 327 in the placebo one, pointed out that the administration of a bacterial lysate applied intranasally for 6 months does not reduce the number of acute respiratory diseases compared to placebo (Sramek et al 1986).

**Adult patient trials**

Concerning the studies focused on samples of adult patients (Ahrens and Wiedenbach 1984; Keller 1984; Heintz et al 1989; Cvoriscec et al 1989; Debbas and Derenne 1990; Debelic and Eckenberger 1992; Orcel et al 1994; Collet et al 1997; Rutishauser et al 1998; Tielemans et al 1999; Li et al 2004; Steurer-Stey et al 2004; Tricarico et al 2004; Macchi and Vecchia 2005), we will discuss them separately, according to the disease considered (recurrent respiratory infections, chronic bronchitis, and COPD).

**Recurrent respiratory infections**

A recent study, a RCT involving 140 patients with a history of recurrent respiratory infections, compared the effects of bacterial lysate obtained through mechanical lysis (pts in the first group) to the effects of bacterial lysate obtained through chemical lysis (pts in the second group) and to the effects of no treatment at all (pts in the third group, control); the end points were: the number of upper respiratory tract infections, the number of patients free from disease, the duration of infectious episodes, the number of working days lost because of the disease, the need for antibiotic treatment. The results for each one of the end points showed the efficacy of the two treatments, but the best results were achieved with the treatment with the bacterial lysate obtained through mechanical lysis, and were significantly superior to those achieved with placebo and also with the bacterial lysate obtained through chemical lysis (Macchi and Vecchia 2005).

A particular study evaluated the efficacy of bacterial lysate in preventing upper respiratory tract infections in subjects belonging to a specific setting, that is a community of cloistered nuns. 47 nuns were allocated into two different groups, active treatment and placebo. The results showed a significant lower number in respiratory infections, and a shorter duration, in the active treatment group; moreover, a significant increase in serum IgA and salivary IgA was recorded in the active treatment group (Tricarico et al 2004).

Other trials have shown the efficacy of bacterial lysate in treating patients with recurrent respiratory infections (Ahren and Wiedenbach 1984; Debelic and Eckenberger 1992; Rutishauser et al 1998 ), even in group of patients with an increased risk, such as patients in hemodialysis treatment (Tielemans 1999). A particular attention was also given to the investigation of the tolerability of such kind of treatments,
The results of all the data results in high heterogeneity, and the difference between active extracts and placebo does not reach statistical significance. The metanalysis also showed a shorter duration of exacerbations in the active treatment groups. The improvement of symptoms, as assessed both by the patients and the observers; was in favour of bacterial extracts. Hospitalization admission resulted lower in the bacterial extracts group (but data were drawn only from one study) (Collet et al 1997). This systematic review clearly points out that a strong evidence for the prevention of exacerbation in COPD patients through the use of bacterial extracts is still missing; nonetheless, an improvement in symptoms has been underlined, as well as a shorter duration of exacerbation, and a reduction of hospitalization. Anyway, those conclusions are relevant as there could be some important economic consequences if a reduction of hospitalization can be prospected by the use of those relatively cheap drugs, which can be applied intermittently. Also a benefit on symptoms, as perceived by the patients, is important, as a reflection of a better quality of life.
### Table 3 Pediatric trials

| Author            | Year  | Disease                                | Patients | Preparation | Results                                                                 |
|-------------------|-------|----------------------------------------|----------|-------------|-------------------------------------------------------------------------|
| Rosaschino        | 2004  | Recurrent respiratory infections       | 89       | PMBL        | Infections, markers of inflammation, Lymph B                             |
| Del Rio Navarro   | 2003  | Recurrent respiratory infections       | 40       | OM85-BV     | Clinical benefit                                                         |
| Schaad            | 2002  | Upper respiratory tract infections     | 232      | OM85        | URTI rate, good safety and tolerance                                     |
| Ruha              | 2001  | Respiratory tract infections           | 188      | LW50020     | Infection rate, safety assessment, infections, antibiotics requirements, duration of infections |
| Gutierrez-Tarango | 2001  | Acute respiratory tract infections     | 54       | OM85-BV     | Effective, incidence of respiratory infections                           |
| Gomez-Barreto     | 1998  | Sub-acute sinusitis                    | 56       | OM85-BV     | Effective, incidence of respiratory infections                           |
| Collet            | 1993  | Upper respiratory infections           | 423      | OM85-BV     | Risk of presenting > or = 3 episodes of URI                              |
| Zagar             | 1998  | Rhinosinusitis                          | 51       | BV          | Infection number and duration, IgA levels                               |
| Sranek            | 1986  | Acute respiratory diseases             | 1252     | IRS19 (intranasal) | Not effective in ARD                                                   |

### Table 4 Adult trials

| Author | Year  | Disease                                | Patients | Preparation | Results                                                                 |
|--------|-------|----------------------------------------|----------|-------------|-------------------------------------------------------------------------|
| Macchi | 2005  | Recurrent respiratory infections       | 140      | PMBL/CLBL   | Effectiveness of both treatments                                         |
| Tricarico | 2004  | Recurrent respiratory infections       | 47       | MLBL        | Infections, duration of infections, Ig and salivary IgA                 |
| Rutischauser | 1998  | Recurrent respiratory infections       | 620      | LW50020     | Effective, treatment benefit, excellent tolerability, frequency and severity of infections |
| Debelic | 1992  | Recurrent respiratory infections       | 230      | BV          | Significant protective effect                                           |
| Ahrens  | 1984  | Recurrent respiratory infections       | 40       | IBE         | Effectiveness in pts in hemodialysis                                   |
| Tielemans | 1999  | Recurrent respiratory infections       | 284      | BV          | Effectiveness of treatment                                              |
| Heintz  | 1989  | Chronic purulent sinusitis             | 354      | OM85-BV     | Lower respiratory tract infections                                      |
| Orcel   | 1994  | Chronic bronchitis                     | 104      | BV          | Acute episodes, antibiotics utilization, IgA and T-Lymph                |
| Cvoricsec | 1989  | Chronic bronchitis                     | 75       | BV          | No significant differences                                              |
| Keller  | 1984  | Chronic bronchitis                     | 265      | OM85-BV     | Infections, antibiotics intake, = risk of at least one acute exacerbation, days of hospitalization |
| Debbas  | 1990  | Chronic obstructive Pulmonary disease  | 381      | OM85-BV     | Frequency of acute exacerbations, antibiotics need, symptom score       |
| Collet  | 1997  | Chronic obstructive Pulmonary disease  | 90       | BV          |                                                                        |
Discussion and conclusions

As we have previously reported, bacterial lysates are powerful inducers of a specific locoregional immune response that significantly enhance the concentration of antibodies directed to antigenic structures of bacteria most commonly observed during infections of the upper respiratory tract. Those antibodies have the capability of opsonizing living bacteria, thus allowing the engulfment and killing mediated by human phagocytes, such as granulocytes. This activity is linked to the capacity of inducing a significant reduction (or a complete disappearance) of signs and symptoms related to respiratory infections.

This effect comes out also from the systematic analysis of medical literature, and is reflected in the results of the randomized clinical trials. Those results underline an overall protective effect, with a different level of significance, depending on the study design, the disease considered, and the type of patients involved. Both in pediatric and adult trials, as reported in the Tables 3 and 4, we can find a positive trend in the results: a general reduction of infection rates, a reduction of their duration, a beneficial effect on symptoms, a reduction in the use of antibiotics.

Those effects also have, as a direct consequence, important economic implications. In the case of COPD, a reduction in the number of acute exacerbations, or a shorter duration of hospitalization, could represent an actual opportunity for curtailing costs of management of such patients. In fact, patients with a moderate-severe COPD can experience a mean of at least 2 AECB/year (Miravitlles et al 1999). The most serious patients, besides experiencing more frequent exacerbations, are more frequently hospitalized, and for longer periods (Donaldson et al 2002). We also have to consider that AECB represent an important cause of death. A trial reported that, in a sample of 1000 hospitalized patients affected by severe COPD, when dismissed, 20% of them die within two months, 33% within six years, and 43% within one year. (Hilleman et al 2000) The risk of death in COPD patients is strictly correlated with the frequency and gravity of exacerbations. As a consequence, it would be extremely useful to obtain a reduction of exacerbations, in order to extend the life duration of this kind of patients. Therefore, the use of bacterial lysate could represent an important means to achieve this prominent result.

In conclusion, even though the results of the analyzed studies are encouraging, it would be worthwhile to build up new trials. Those new trials should include a higher number of patients, selected according to the disease and its severity, and should be well-designed trials in term of blinding and randomization procedures. This could permit to get even stronger evidence of their beneficial effect, both on symptoms and on prevention of infections.

Disclosure of interest

The authors do not have any conflict of interest related to the pharmaceutical companies whose drugs are cited in this article.

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Bacterial lysate: effects on prevention of respiratory infections

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