ORIGINAL ARTICLE

Outcome of *Burkholderia cepacia* colonisation in an adult cystic fibrosis centre

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Background: Colonisation with *Burkholderia cepacia* is a poor prognostic indicator in subjects with cystic fibrosis (CF), but outcome prediction is impossible since patients are colonised by different strains with differing pathogenicity. The clinical course of a large cohort of CF patients colonised with UK epidemic (ET12) *B cepacia* was followed for 5 years and compared with that of the remaining patients in the clinic.

Methods: Pulmonary function, nutritional state, and lung pathogen colonisation were recorded for 5 years before December 1997 or death for all 107 patients who had attended the Liverpool adult CF clinic since 1993. For each patient a time line from study entry to date of death or 1997 was constructed. In 1993 potential risk factors including age and sex were subjected to Cox proportional hazards analysis using the end point of mortality as the outcome variable. The analysis was supplemented by time varying covariables that described the change in FEV_1, BMI, and colonisation status across time, and the excess risk associated with *B cepacia* colonisation was calculated. Subsequently, in those patients who died between 1993 and 1997, predictive factors for death were compared within groups using complete 5 year data.

Results: Thirty seven patients had been colonised by epidemic *B cepacia* and these patients had four times the mortality of the remainder ($p<0.01$). In 1993 univariate predictors of mortality were age (alive 19.6 (0.64) *v* dead 23.8 (1.44); $p<0.005$) and baseline FEV_1 (alive 68.6 (2.5)% predicted *v* dead 43.2 (4.8)%; $p<0.001$) with a trend for BMI ($p=0.07$). However, following time varying covariate Cox proportional hazards analysis, only lower FEV_1 (hazards ratio 1.1, 95% confidence limits 1.06 to 1.14; $p<0.001$) and colonisation with *B cepacia* (hazards ratio 7.92, confidence limits 2.65 to 23.69; $p<0.001$) were identified as significant factors for death. Surviving *B cepacia* patients had similar initial lung function to the remaining surviving patients but had an accelerated loss of lung function over the study period (colonised –1.9% predicted per year *v* non-colonised –0.3% predicted per year; $p<0.05$). Deceased patients colonised with *B cepacia* had better spirometric results than the remaining deceased patients 5 years before death ($p<0.05$) but lost lung function at a greater rate than non-colonised patients (colonised –6.2% predicted per year *v* non-colonised –1.9% predicted per year; $p<0.05$).

Conclusions: This study confirms the excess mortality associated with epidemic *B cepacia* colonisation and shows that those with poor spirometric values are at the greatest risk.

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While colonisation with *Burkholderia cepacia* in cystic fibrosis (CF) may carry a poor prognosis, different strains can vary in their pathogenicity.[1] Previous studies have found it impossible to predict the outcome of such colonisation for individual patients, either because these studies had very few patients,[2] were short term,[2 3] or failed to type the *B cepacia* strains.[2–6]

In the UK one such important strain is epidemic ET12, an aggressive multiresistant form of *B cepacia* that is easily transmitted between CF patients[7] which falls into Genomovar III and is present in up to 50% of UK CF centres.[7] In Liverpool 37 patients with CF colonised by this epidemic strain have attended the regional adult unit since its inception in 1993. We have followed the course of this cohort, providing us with a unique opportunity to assess the long term effect of colonisation with a single *B cepacia* strain on infected patients. We have compared the clinical progress of this group with that of the remaining CF patients in the clinic.

METHODS

Data collection

By December 1997 107 patients had attended the Liverpool adult CF clinic since its inception in 1993. All these patients formed the study population. Over this 5 year period data for age, sex, pulmonary function, body weight, and sputum microbiology were regularly recorded. For spirometric data, the best value was taken for each patient for every 6 month period, and for assessment of nutritional state, the best body mass index (BMI) for each patient was calculated for each calendar year. Where patients had attended the Liverpool adult clinic for less than this 5 year period, information was obtained by retrospective review of the case sheets from the referring hospital. Where patients had died, information was obtained for 5 years prior to death. Thus, complete data were available for all patients for the 5 year period up to December 1997 or death. For surviving patients the baseline data were those obtained in 1993 and final data were those in December 1997. For deceased patients the baseline data were those obtained 5 years before death and the final data were those obtained immediately before death.

Patients

Thirty seven patients (35%) were colonised by UK epidemic (ET12) *B cepacia* (mean age 25.2 years (range 18–38), 20 men), 58 patients (54%) were colonised with *Pseudomonas aeruginosa* (mean age 27.8 years (range 17–43), 25 men), and 12 patients (11%) were not colonised either by ET12 *B cepacia* or *P aeruginosa* (mean age 22.4 (range 18–27); five men). There was no difference between groups in age (*B cepacia* colonised mean

Table 1 Demographic characteristics of the study group stratified by death

	Survivors (n=88)	Dead (n=19)	p value
Colonised with *B cepacia* in 1993 (%, (n))	22 (19)	39 (7)	0.13
Colonised with *B cepacia* (%, (n))	28 (24)	68 (13)	<0.005
Mean (SE) age in 1993	19.6 (0.6)	23.8 (1.4)	<0.005
Sex (% male, (n))	53 (46)	47 (9)	0.82
Mean (SE) baseline FEV_1 in 1993 (% predicted)	68.6 (2.5)	43.2 (4.8)	<0.001
Mean (SE) baseline BMI in 1993 (% predicted)	20.6 (0.3)	19.5 (0.5)	0.07

FEV_1 = forced expiratory volume in 1 second; BMI =body mass index.

Table 2 Time varying Cox proportional hazards analysis

Variable	Hazard ratio	95% confidence interval	p value
FEV_1 (decreasing) per unit % predicted change	1.10	1.06 to 1.14	<0.001
Colonisation (present in 1993 or acquired)	7.92	2.65 to 23.69	<0.001
Age (years) in 1993 (covariate)	1.08	0.99 to 1.18	0.08

(SD) 21.2 (0.9) years, non-colonised 19.9 (0.8) years, p=NS) nor in the proportion of patients with diabetes mellitus or liver disease, and only two patients were pancreatic sufficient.

Microbiology

Sputum samples were cultured on chocolate, MacCorkey, and *cepacia* agar (Oxoid UK, Mast UK) for 48 hours. Mucoid colonies of *P aeruginosa* were confirmed using the C390 test (Roscoe Scientific UK). *B cepacia* colonies were strain typed using polymerase chain reaction (PCR) ribotyping, pulsed field gel electrophoresis (PFGE), and cable pilus typing by PCR as previously described.[8] Strain types were regularly reviewed using the above methods to document any changes. In practice, once patients became colonised by ET12 *B cepacia*, all their subsequent sputum samples grew this strain. Chronic colonisation with an organism was defined as three or more positive sputum cultures separated by a 6 month period.

Statistical analysis

Descriptive data are presented as means with standard errors. For each patient a time line from study entry to date of death or 1997 was constructed. Potential risk factors for all patients at 1993 (FEV_1, BMI, age, sex, colonisation status) were subjected to Cox proportional hazards analysis using the end point of mortality as the outcome variable.[9] The analysis was supplemented by time varying covariables that described the change in FEV_1, BMI, and colonisation status across time. Variables achieving significance at <0.05 were considered as risk factors for death. Given the importance of age, this was included as a covariate in the final model.

Subsequently, those factors shown to be predictors of mortality were analysed using complete 5 year data for all patients. Thus, in those patients who were deceased, this included data points prior to 1993. The changes in FEV_1 over the first 5 years preceding death or 1997 were analysed using the summary measures approach recommended by Matthews *et al*.[10] A separate linear regression line was fitted to the FEV_1 data for each subject and the slope of this line was used as an estimate of the mean rate of change in FEV_1 in that subject over the 5 years preceding death or 1997. Statistical analysis was performed using the Wilcoxon signed rank and rank sum tests as appropriate.

Finally, the excess risk associated with *B cepacia* colonisation was calculated using the χ^2 test and relative risk calculated with 95% confidence intervals.

RESULTS

Thirteen of 37 patients (35%) (five men) colonised by UK epidemic ET12 *B cepacia* died during the study period, and six of the remaining 70 patients (9%) (four men) died during the study period, all of whom were colonised by *P aeruginosa*. Univariate predictors of mortality included age at 1993 and baseline FEV_1, with a trend towards nutritional status (table 1). Following the time varying covariate Cox proportional hazards analysis, only a lower FEV_1 and colonisation with *B cepacia* were identified as significant factors for death (table 2) but, given the significant univariate effect of age, this variable was included in the model to adjust risk factors for age. The relative risk of mortality from *B cepacia* colonisation was 4.0 (95% CI 1.6 to 11.2) compared with non-colonised patients.

In the survivor group we compared the effect of *B cepacia* colonisation on FEV_1 over the 5 year study period (fig 1). No difference was seen in spirometric parameters between patients colonised with *B cepacia* and the remainder in 1993. Those patients colonised with *B cepacia* had an accelerated loss of lung function with time (–1.9 (0.7)% predicted FEV_1/year) compared with the remaining patients (–0.3 (0.4)% predicted FEV_1/year; p<0.05) over the 5 year study period.

In the deceased group the effect of colonisation with *B cepacia* on spirometric data over the 5 year period before death was studied (fig 2). At baseline *B cepacia* colonised patients had a significantly higher FEV_1 than the remaining patients (mean 53.3% predicted *v* 34.6% predicted, p=0.007). However, while both subgroups had worsening pulmonary function with time

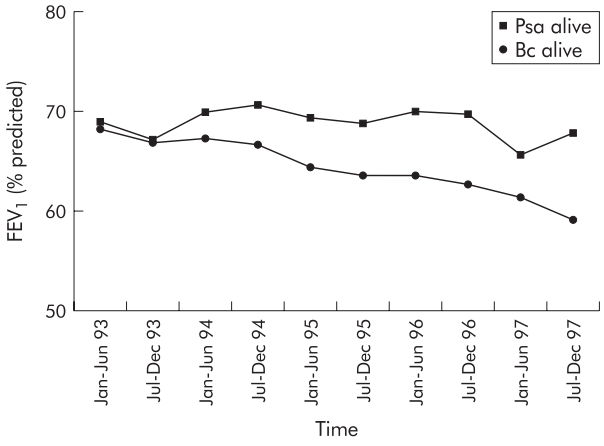

Figure 1 Subgroup FEV_1 data for surviving patients from 1993 to 1997 showing that *B cepacia* colonised patients lose lung function at an accelerated rate (–1.9% predicted/year) compared with non-colonised patients (–0.3% predicted/year; p<0.05). Psa = *Pseudomonas aeruginosa*; Bc = *Burkholderia cepacia*.

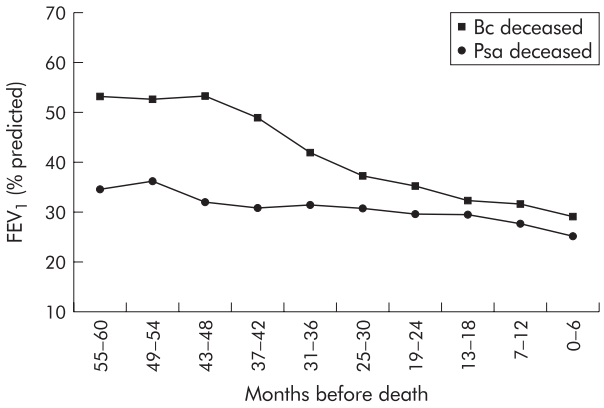

Figure 2 Subgroup FEV_1 data for deceased patients for 5 years prior to death showing that *B cepacia* colonised patients had better lung function 5 years before death than the non-colonised patients but had a greater loss over time (–6.2% predicted per year versus –1.9% predicted per year; $p<0.05$). Psa = *Pseudomonas aeruginosa*; Bc = *Burkholderia cepacia*.

($p<0.01$), the patients colonised with *B cepacia* had a greater rate of decline in spirometric data (–6.2 (1.3)% predicted FEV_1/year) than those not colonised with *B cepacia* (–1.9 (1.0)% predicted FEV_1/year; $p<0.05$) such that, at death, both subgroups had similar lung function.

DISCUSSION

There has been a marked improvement in survival in CF and over 80% of patients now survive childhood.[11] Indeed, it is estimated that those patients born in 1990 can expect to live until at least 40 years of age,[11 12] and the median survival is already 31 years.[13] While there is little doubt that patients cared for in specialist centres receive optimum care,[14] 95% of patients still die from respiratory failure caused by chronic pulmonary sepsis, usually due to *Pseudomonas aeruginosa*.[15] Previous workers have shown that increasing bacterial lung colonisation in CF is associated with increasing morbidity and mortality,[16–18] and for this reason intensive antibiotic treatment regimes are advocated.[19] While in some paediatric CF centres *P aeruginosa* colonisation rates are low, adult colonisation rates are still over 60%.[20] More recently an aggressive new multiresistant respiratory pathogen in the form of *B cepacia* has appeared in the CF population. This was first described as an opportunistic organism in CF in 1972,[21] and its prevalence increased in North America following this.[22–25] Epidemic *B cepacia* strains which can be easily transmitted between CF patients were first described in the USA in 1984,[26] and by 1989 such a strain (ET12) had entered the UK CF population.[27] We have recently shown that this strain is capable of cross-colonising CF patients already infected with *B cepacia*, often with fatal consequences,[8] and can also colonise non-CF relatives causing serious morbidity.[28] In 1993 this epidemic strain was present in up to 50% of CF centres in the UK, although in many centres only a few patients were infected. Since then the introduction of strict segregation policies and the deaths of colonised patients have decreased the prevalence of this organism,[27] and recent epidemiological surveys have revealed that 3.2% of American, 5% of European, and 6% of UK patients with CF are colonised with *B cepacia*.[29] Despite this, in our centre we still have a prevalence rate of 35%, although we have had no new cases for 3 years.

Colonisation with *B cepacia* can have several clinical outcomes, varying from relatively asymptomatic carriage to a rapid fulminant pneumonia and death.[26] While it is recognised that colonisation with *B cepacia* is a poor prognostic indicator in CF,[2–5 17 30 31] previous studies have given a confused picture of the consequences of such colonisation for individual patients. For example, while some workers have suggested that patients with poorer lung function are more likely to be colonised with *B cepacia*,[5] others have suggested that those who had better lung function before acquisition undergo a greater decline following colonisation.[3] Furthermore, other workers have suggested that *B cepacia* colonisation has much less impact on patients if they survive the first year of colonisation.[4]

These conflicting results may be due to the fact that most previous studies were short term[2 3 30] or contained few patients.[2 30] Furthermore, it is now known that different strains of *B cepacia* vary not only in their transmissibility but also in their pathogenicity.[1] Previous studies almost certainly looked at multiple strains of *B cepacia*[4 5 30–32] since reliable strain typing has only recently become available. Thus, predicting the outcome of *B cepacia* colonisation in the CF population has not previously been possible.

For the first time, therefore, we have been able to assess the effect of a single epidemic *B cepacia* strain on the clinical course of a substantial group of CF patients over a prolonged time period. We did not attempt to ascertain the date of first *B cepacia* colonisation of our patients for two reasons. Firstly, most of these patients were already colonised when they first came to our unit, and it may not be possible to determine colonisation status reliably prior to this. In the early 1990s many laboratories were unaware that this organism was a potential pathogen and routine culture for *B cepacia* was not available in many hospitals. Furthermore, reliable *B cepacia* culture requires expertise and inexperienced microbiology laboratories may misreport samples. Indeed, a recent survey of US CF centres found that 20% of samples labelled as *B cepacia* were, in fact, other organisms.[33] Thus, in our patients a positive *B cepacia* culture at first attendance at our unit in 1993 is unlikely to represent the date of colonisation. Secondly, it has been shown that patients may be colonised with *B cepacia* for a variable length of time before the organism can be reliably grown from sputum, such that the date of acquisition even where *B cepacia* is suspected is impossible to determine.[34] However, since the Liverpool adult CF unit opened in 1993, we have assiduously looked for *B cepacia* in the sputum of our patients and genotyped every strain, demonstrating that since this time their colonisation status is assured.

While on univariate analysis it appears that age and possibly nutritional status may be important factors determining mortality, when subjected to time related multivariate analysis the contribution of these factors as predictors of death was subsumed. In our patients this technique confirmed that a time related deterioration in lung function together with colonisation with epidemic *B cepacia* are the only independent predictors of death. By looking back at these factors for 5 years in our patients who subsequently died, we have shown that, although *B cepacia* colonised patients had much higher baseline spirometric values than non-colonised patients, their FEV_1 was still much lower than either group of survivors at 1993. This suggests that the level of pulmonary function at *B cepacia* acquisition may be an important predictor of survival in patients with CF. Furthermore, these patients had a greatly accelerated loss of lung function over the 5 year period, confirming the pathogenicity of this organism. The apparent wide variation in clinical outcome that occurs in response to colonisation with *B cepacia* remains unclear, but possible explanations include host immunological response[35] or interaction with other colonising organisms.[8]

As expected, the non-colonised patients who died appear to have had long standing poor pulmonary function with a mean FEV_1 of less than 40% predicted. It has always been assumed that even patients with CF who are well cared for would have a steady decline in lung function,[31 36] and it is therefore reassuring to find that, with modern treatment, stable adult patients can be maintained with minimal loss of lung function.

While it has been suggested that nutrition plays an important part in maintaining the health of patients with CF,[37] there

is little evidence that weight gain diminishes the number of respiratory exacerbations or improves spirometric parameters or survival.[38] In keeping with this, univariate analysis showed that BMI had only a weak correlation with survival. This suggests that the most important factor indicating survival in CF patients is lung function, and that nutritional state merely reflects this.

Thus, in our clinic most non-*B cepacia* colonised patients remain stable with little deterioration in pulmonary function and a constant nutritional status. Only six of these patients died during the study period compared with 13 in the epidemic *B cepacia* group, giving a fourfold excess risk of mortality from ET12 *B cepacia* colonisation. Conversely, while our results show the risks associated with epidemic (ET12) *B cepacia* colonisation, the effect of colonisation by non-epidemic *B cepacia* strains is unknown. Several European studies have suggested that *B cepacia* colonisation is of less importance,[32 39] possibly because these patients were largely colonised by other (non-ET12) *B cepacia* strains which may be less harmful.

Our results illustrate the threat posed to patients with CF from epidemic ET 12 *B cepacia* and confirm the need to segregate these patients from the remainder of the CF population.

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REFERENCES

1 **Govan JRW**, Hughes JE, Vandamme P. Burkholderia cepacia: medical, taxonomic and ecological issues. *J Med Microbiol* 1996;**45**:395–407.
2 **Muhdi K**, Edenborough FP, Gumery L, *et al*. Outcome for patients colonised with Burkholderia cepacia in a Birmingham adult cystic fibrosis clinic at the end of an epidemic. *Thorax* 1996;**51**:374–7.
3 **Whiteford ML**, Wilkinson JD, McColl JH, *et al*. Outcome of Burkholderia cepacia colonisation in children with cystic fibrosis following a hospital outbreak. *Thorax* 1995;**50**:1194–6.
4 **Lewin LO**, Byard PJ, Davis PB. Effects of Pseudomonas aeruginosa colonisation on survival and pulmonary function of cystic fibrosis patients. *J Clin Epidemiol* 1990;**43**:125–31.
5 **Tablan OC**, Chorba TL, Schidlow DV, *et al*. Burkholderia cepacia colonisation in patients with cystic fibrosis: risk factors and clinical outcome. *J Pediatr* 1995;**107**:382–7.
6 **Taylor RFH**, Gaya H, Hodson ME. Pseudomonas cepacia: pulmonary infection in patients with cystic fibrosis. *Respir Med* 1993;**87**:187–92.
7 **Pitt TL**, Kaufmann ME, Patel PS, *et al*. Type characterisation and antibiotic susceptibility of Burkholderia (Pseudomonas) cepacia isolates from patients with cystic fibrosis in the UK and the Republic of Ireland. *J Microbiol* 1996;**44**:203–10.
8 **Ledson MJ**, Gallagher MJ, Corkhill JE, *et al*. Cross infection between cystic fibrosis patients colonised with Burkholderia cepacia. *Thorax* 1998;**53**:432–6.
9 **Cox DR**. Regression models and life tables. *J R Stat Soc* 1972;**34**:187–220.
10 **Matthews JNS**, Altman DG, Campbell MJ, *et al*. Analysis of serial measurements in medical research. *BMJ* 1990;**300**:230–5.
11 **Elborn JS**, Shale DJ, Britton JR. Cystic fibrosis: current survival and population estimates to the year 2000. *Thorax* 1991;**46**:881–5.
12 **Colten HR**. Screening for cystic fibrosis. *N Engl J Med* 1990;**332**:328–9.
13 **Shale DJ**. Predicting survival in cystic fibrosis. *Thorax* 1997;**52**:309.
14 **Mahadeva R**, Webb K, Westerbeek RC, *et al*. Clinical outcome in relation to care in centres specialising in cystic fibrosis: cross sectional study. *BMJ* 1998;**316**:1771–4.
15 **Maclusky I**, Levinson H. Cystic fibrosis. In: Chernick V, ed. *Disorders of the respiratory tract in children*. Philadelphia: WB Saunders, 1990:692–729.
16 **Rosenfield M**, Davis R, Fitzsimmons S. Gender gap in cystic fibrosis mortality. *Am J Epidemiol* 1997;**145**:794–803.
17 **Winnie GB**, Cown RG. Respiratory tract colonisation with Pseudomonas aeruginosa in cystic fibrosis. Correlations between anti-Pseudomonas antibody levels and pulmonary function. *Pediatr Pulmonol* 1991;**10**:92–100.
18 **Henry RL**, Mellis CM, Petrovic L. Mucoid Pseudomonas is a marker of poor survival in cystic fibrosis. *Pediatr Pulmonol* 1992;**12**:158–61.
19 **Szaff M**, Hoiby N, Flensbory EW. Frequent antibiotic therapy improves survival in cystic fibrosis patients with chronic Pseudomonas aeruginosa infection. *Acta Paediatr Scand*. 1993;**72**:651–7.
20 **Fitzsimmons S**. The cystic fibrosis foundation patient registry report 1996. *Pediatr Pulmonol* 1996;**21**:267–75.
21 **Ederer GM**, Matsen JM. Colonisation and infection with Pseudomonas cepacia. *J Infect Dis* 1972;**125**:613–8.
22 **Laraya-Causay LR**, Lipstein M, Hunang N. Pseudomonas cepacia in the respiratory flora of patients with cystic fibrosis. *Pediatr Res* 1977;**11**:502.
23 **Baltimore RS**, Radney-Baltimore K, Von Graevenity A, *et al*. Occurrence of non-fermenting gram negative rods other than Pseudomonas aeruginosa in the respiratory tract of children with cystic fibrosis. *Helv Paediatr Acta* 1982;**37**:547–54.
24 **Thomassen MJ**, Demko CA, Klinger JD, *et al*. Pseudomonas cepacia colonisation among patients with cystic fibrosis. A new opportunist. *Am Rev Respir Dis* 1985;**131**:791–6.
25 **Corey M**, Allistin L, Prober C, *et al*. Sputum bacteriology in patients with cystic fibrosis in a Toronto hospital during 1970–1981. *J Infect Dis* 1984;**149**:283.
26 **Isles P**, Maclusky I, Corey M, *et al*. Pseudomonas cepacia infection in cystic fibrosis: an emerging problem. *J Pediatr* 1984;**104**:206–10.
27 **Govan JRW**, Brown PH, Maddison J, *et al*. Evidence for transmission of Pseudomonas cepacia by social contact in cystic fibrosis. *Lancet* 1993;**342**:15–19.
28 **Ledson MJ**, Gallagher MJ, Walshaw MJ. Chronic B cepacia bronchiectasis in a non-cystic fibrosis individual. *Thorax* 1998;**53**:430–2.
29 **Webb AK**, Egan J. Should patients with cystic fibrosis infected with Burkholderia cepacia undergo lung transplantation? *Thorax* 1997;**52**:671–3.
30 **Brown P**, Butler S, Nelson J, *et al*. Pseudomonas cepacia in adult cystic fibrosis: accelerated decline in lung function and increased mortality. *Thorax* 1993;**48**:425–6.
31 **Corey M**, Ferewell V. Determinants of mortality from cystic fibrosis in Canada 1970–1989. *Am J Epidemiol* 1997;**143**:1007–17.
32 **Jaques I**, Derelle J, Weber M, *et al*. Pulmonary evolution of cystic fibrosis patients colonised by Pseudomonas aeruginosa and/or Burkholderia cepacia. *Eur J Pediatr* 1998;**157**:427–31.
33 **LiPuma JJ**. Burkholderia cepacia. Management issues and new insights. *Clin Chest Med* 1998;**13**:473–86.
34 **Govan JR**, Deretic V. Microbial pathogenesis in cystic fibrosis: mucoid Pseudomonas *aeruginosa* and Burkholderia cepacia. *Microbiol Rev* 1996;**60**:539–74.
35 **Hendry J**, Nixon J, Dodd M, *et al*. Pulmonary function, inflammatory markers and B cepacia antibodies in cystic fibrosis adults preceding and following pulmonary colonisation with B cepacia. *Thorax* 1997;**52**(suppl 6):P124.
36 **Corey M**, Levinson H, Crozier D. Five to seven year course of pulmonary function in cystic fibrosis. *Am Rev Respir Dis* 1976;**114**:1085–92.
37 **Batten JC**. The adolescent and adult. In: Hodson ME, Batten JC, eds. *Cystic fibrosis*. Oxford: Balliere Tindall, 1983.
38 **Steinkamp G**, von der Hardt H. Improvement of nutritional status and lung function after long term nocturnal gastrostomy feeding in cystic fibrosis. *J Pediatr* 1994;**12**:244–9.
39 **Revets H**, Vandamme P, Van Zeebroeck A, *et al*. Burkholderia (Pseudomonas) cepacia and cystic fibrosis: the epidemiology in Belgium. *Acta Clin Belg* 1996;**51**:222–30.