

Lung function in adolescents after uncomplicated whooping cough in childhood

D.B. Teculescu*, C. Aubry*, Q.T. Pham*, J. Locuty**, J.P. Deschamps**, M. Manciaux*

Lung function in adolescents after uncomplicated whooping cough in childhood. D.B. Teculescu, C. Aubry, Q.T. Pham, J. Locuty, J.P. Deschamps, M. Manciaux.

ABSTRACT: Ventilatory function (forced vital capacity, forced expiratory volume in one second, forced expiratory flows), static lung volumes, phase III slope and closing volume (single-breath nitrogen washout test) were measured in 499 children and adolescents aged 10-16 yrs from a general population sample in North-East France. A history of whooping cough was given by 44 children (22 of each sex); their results were compared to those of the 455 children (215 girls) with a negative history. The only difference between the two groups was a minimal increase in the residual volume/total lung capacity ratio in cases (19.2 ± 3.1 vs $18.0 \pm 2.9\%$). We conclude that uncomplicated whooping cough in early childhood did not lead to significant pulmonary function abnormality in this population of children born after 1967.

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* INSERM Unité 115, Vandoeuvre les Nancy, France.

** Centre de Médecine Préventive, Vandoeuvre les Nancy, France.

Correspondence: Dr D.B. Teculescu, * INSERM Unité 115, Vandoeuvre les Nancy, France.

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Atelectasis, consolidation, and bronchopneumonia were frequent complications of whooping cough (WhC) 30 yrs ago [1]. With one exception [2], a higher prevalence of respiratory symptoms was reported in subjects with a history of WhC [3-6]. Respiratory infections, especially those occurring in early childhood [7, 8] usually impair pulmonary function. While multiple abnormalities of lung function were reported in 7 out of 10 adolescents who had complicated WhC before one year of age [9], in field surveys lung function impairment was either minimal, limited to children less than 7 yrs of age [6], or absent [2, 4]. It can be argued, however, that peak expiratory flow [2] or classical spirometry [6] are not sensitive enough for the detection of minimal lesions obstructing the "small airways" [4]. We report the results of a study using flow-volume curves and the single-breath nitrogen washout test in a group of adolescents from a general population in Lorraine, France.

Materials and methods

Adolescents aged 10-16 yrs were identified between June and November, 1983 on the computerized list of a Centre for Preventive Medicine offering free health screening to a population of around 3 million people in North-East France. The adolescents attended with their families. The purpose of the study was explained to both parents and children, to obtain informed consent and co-operation. The study protocol was approved by the

Nancy University Hospital Ethics Committee. A total of 535 subjects were enrolled and 506 remained after exclusion for clinical reasons or unsatisfactory forced expiration test. The child National Heart and Lung Institute-Division of Lung Disease (NHLI-DLD) questionnaire [10] was completed by interviewing one parent; the information was checked against that recorded in the child's personal health notebook (provided at birth in France since 1945). Forced expirations were performed using a pneumotachometer (Fleisch No. 3) based spirometer the output of which was linearized up to $16 \text{ l}\cdot\text{s}^{-1}$; the device met the current spirometry standards [11, 12] and was calibrated twice daily with a 3 l syringe. Best values were recorded (from at least three trials) for the forced vital capacity (FVC) and forced expiratory volume in one second (FEV_1); the forced expiratory flows ($\text{FEF}_{75-50-25\%}$ of the expired FVC) were measured from the curve with the largest $\text{FVC} + \text{FEV}_1$ [11]. The results were corrected to BTPS; predicted values were obtained from the equations of ZAPLETAL *et al.* [13].

The single-breath nitrogen test (SBN_2) was performed as suggested by the NHLI [14]. After a slow vital capacity inspiration of 100% O_2 the expired volume (pneumotachometer+integrator) and N_2 concentration (Hewlett-Packard analyser) signals were fed into a microcomputer (Apple II, Cupertino) which calculated the alveolar N_2 slope (PIII, $\% \text{N}\cdot\text{l}^{-1}$), closing volume (CV), total lung capacity (TLC), residual volume (RV) and closing capacity (CC). Calibrations were performed with a 1 l syringe and high-precision gas mixtures; details of

the procedure and repeatability of the SBN₂ test were previously reported [15, 16]. Lung volumes were divided by cubed height for adjustment.

Statistics included χ^2 tests, odds ratios and analysis of variance [17].

Results

A clear answer could not be obtained in 7 cases; among the 499 subjects, 44 (22 of each sex) *i.e.* 8.8% of the sample, gave a positive history of uncomplicated whooping cough. The age at WhC ranged between 1–9 yrs (average 3.5 yrs). Subjects with a positive history were older (13.8±1.3 vs 12.9±1.7 yrs, $p<0.001$) and taller (159±10 vs 153±11 cm, $p<0.001$). Adjusting for these differences, spirometric indices were very similar (FVC 106±10 vs 105±11 % pred; FEV₁ 106±11 vs 105±12 % pred) for subjects with and without a positive WhC history, respectively. Neither the forced expiratory flows (table 1) nor the variables derived from the SBN₂ test (table 2) indicated any differences between the groups, with the exception of the RV/TLC ratio.

No differences were found when the comparison was made separately for each sex, after excluding actively smoking adolescents (at least one cigarette per week) and after excluding subjects with "common cold" [18].

Table 1. – Forced expiratory flows (mean±SD, percent of predicted) [13]

	History of whooping cough	
	Present	Absent
PEF	112±16	111±18
FEF _{75%}	102±21	101±19
FEF _{50%}	101±22	100±22
FEF _{25%}	98±27	95±26

PEF: Peak expiratory flow; FEF: forced expiratory flow at various levels of forced vital capacity.

Table 2. – Lung volumes (normalized for height) and intrapulmonary distribution of ventilation

	Units	History of whooping cough	
		Present	Absent
TLC	l·m ⁻³	1.01±0.10	1.01±0.11
RV	l·m ⁻³	0.19±0.04	0.18±0.04
RV/TLC	%	19.2±3.1*	18.0±2.9
Phase III	%N ₂ ·l ⁻¹	1.07±0.35	1.07±0.43
CV	l·m ⁻³	0.04±0.02	0.04±0.02
CV/VC	%	5.3±2.3	5.5±2.1
CC	l·m ⁻³	0.23±0.03	0.23±0.04
CC/TLC	%	22.8±2.82	22.2±3.3

* $p<0.05$; TLC: total lung capacity; RV: residual volume; phase III: alveolar N₂ slope; CV: closing volume; VC: vital capacity; CC: closing capacity.

Discussion

Like other authors, we had to rely on history for the retrospective diagnosis of WhC. The parents' diagnosis is considered reliable, however [19]; the bias due to recall was minimized in the present study by the use of the child's health record (kept by the paediatrician). Although self-reporting of smoking by adolescents is known to be inaccurate [20], we do not believe that a preferential distribution of smoking children with abnormal pulmonary function among those with a negative WhC history could be a cause of bias. We can confidently exclude a systematic bias in pulmonary function measurements as the tests were performed by experienced observers and index cases were uniformly interspersed among control subjects. Complicated respiratory manoeuvres may lead to bias by selectively excluding "ill" subjects; in the present study a positive WhC history was not associated with failure to perform the SBN₂ test.

Out patient attendances for respiratory conditions [6] and prevalence of respiratory symptoms [3–5] were more frequent among children with WhC, but no differences were found at physical examination [4], and curiously, the prevalence of cough was lower in the study of BRITTEN and WADSWORTH [2]. Previous respiratory illnesses were also more frequent before WhC in index cases, thus JOHNSTON and co-workers [4] concluded that WhC is more common among children already susceptible to chest disease.

SVEGER *et al.* [9] reported abnormal distribution of ventilation, alveolar hypoventilation and gas trapping in 7 of 10 adolescents who had been hospitalized before 12 months of age for WhC with bronchopneumonia. The Swansea Research Unit reported minimal spirometric impairment in 813 children with a positive history; the index cases were not a strictly representative sample, as cases with complications or who were less than 12 months old at onset were preferentially included [6]. Two other field surveys [2, 4] found no difference in lung function between children with and without a history of WhC. As indicated by JOHNSTON and co-workers [4], however, the possibility that peak flow and simple spirometry were not sensitive enough to detect small airway dysfunction could not be excluded.

JOHNSTON and co-workers [5] reported normal static lung volumes, forced expiratory flows, phase III N₂ slope and bronchial reactivity in a hospital-based, case-control study of children who had been hospitalized for WhC at a median age of 4 months. The average age at the time of the study was 9.9 yrs, and the authors did not exclude the possibility that a longer follow-up might begin to reveal differences in lung function between cases and controls. In the present population-based study we confirmed their results in a group of adolescents studied at a median age of 13 yrs. Spirometry, forced expiratory flows, phase III N₂ slope and closing volumes were very similar in the two groups. The slight increase in the RV/TLC ratio was not clinically significant.

We checked the possible associations of a positive history of WhC and found none for sex, child's respiratory symptoms or smoking habits, a history of otitis,

adenotonsillectomy, recent respiratory infections, history of doctor-diagnosed asthma or allergy, number of siblings, parental socioeconomic status or smoking habits or a family history of respiratory diseases. A positive history of WhC was significantly associated (odds ratio 1.95, 95% confidence interval 1.02-3.77) with coal heating, but this would tend to reduce lung function and thus cannot explain the result.

In conclusion, pulmonary function, including tests of small airway dysfunction (forced expiratory flows and SBN₂ washout) was found to be normal in a group of adolescents aged 10-16 yrs from the general population who had uncomplicated whooping cough in childhood.

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Fonction pulmonaire des adolescents ayant eu la coqueluche pendant l'enfance. D.B. Teculescu, C. Aubry, Q.T. Pham, J. Locuty, J.P. Deschamps, M. Manciaux.

RÉSUMÉ: Les tests spirométriques (capacité vitale forcée, VEMS, débits expiratoires maximaux), les volumes pulmonaires statiques, la pente de la phase III et le volume de fermeture (test expiration d'azote) ont été mesurés chez un échantillon de 499 enfants et adolescents âgés de 10 à 16 ans provenant de la population générale du Nord-Est de la France. 44 enfants avaient eu la coqueluche (22 garçons, 22 filles); les résultats de leur fonction pulmonaire ont été comparés à ceux des 455 enfants (215 filles) sans antécédents de coqueluche. Après correction pour les différences anthropométriques la seule différence restante était représentée par le rapport volume résiduel/capacité totale légèrement plus élevé (19.2±3.1 contre 18.0±2.9%) chez les cas. Nous concluons que la coqueluche non-complicquée contractée pendant la première enfance n'a pas laissé des séquelles fonctionnelles respiratoires dans ce groupe d'enfants nés après 1967.

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