Contemporary Themes

Prevalence of antibody to poliovirus in England and Wales 1984-6

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Abstract

Serum from 995 subjects aged 6 months to 99 years was screened at a dilution of 1/8 for neutralising antibodies to poliovirus. Of these samples, 975 (98%) contained antibody to at least one serotype, and 763 (77%) contained antibody to all three, an improvement since previous studies. Children aged 8 to 15, however, had a low prevalence of antibody to poliovirus type 3, with only four (40%) of those aged 12 protected. This finding is possibly due to the waning of antibodies induced by the type 3 component of oral poliovirus vaccine and emphasises the continued importance of a booster dose of vaccine for those leaving school.

Introduction

Since the introduction of live attenuated oral poliovirus vaccine in 1962 Sabin related polioviruses have become the predominant strains circulating in the population of the United Kingdom. During 1981-4, 17 cases of paralytic poliomyelitis were notified, of which six were acquired abroad.¹⁻⁴ In 1985, 97 isolates of poliovirus were referred to this laboratory for confirmation of type, of which 22 were selected for marker studies on the basis of the clinical history. Eighteen were shown to be vaccine related polioviruses, but four proved to be non-Sabin like strains. Two of the four were isolated from patients with paralytic poliomyelitis acquired abroad, but the remaining two came from sisters with gastroenteritis. They belonged to a gypsy family, and there was no history of travel abroad or vaccination against poliovirus. The continued circulation of

non-Sabin like strains in some groups in the community, the danger of importation of neurovirulent polioviruses, and the risk of vaccine associated infection make it important to maintain adequate immunity in the population.

This laboratory reviews from time to time the prevalence of neutralising antibodies to polioviruses in the population as an indication of its immunity. In 1975 Mortimer and Cunningham reported that only 42% of children aged 5 to 14 had antibodies to all three types of polioviruses.⁵ A similar unsatisfactory prevalence was found in 1977 by Codd and White in the north east of England.⁶ The last survey from this laboratory examined serum collected in 1978 and showed that 95% of the population had antibodies to at least one type of poliovirus, and about 60% had antibodies to all three types.⁷ In a cohort of children born from 1963 to 1968, however, only 80% had antibody to one type and 40% to all three types. Roebuck and Chamberlain suggested that these children were inadequately protected because they had been born at the time of transition from inactivated to live vaccine when there was confusion over the dosage schedules required.⁷

This study was designed to: measure the prevalence of antibody to polioviruses in the population during 1984-6 and determine the present immunity in the cohort born from 1963 to 1968 now that they are parents exposed to vaccine strains administered to their children.

Subjects and methods

Serum—Serum was collected during 1984-6 from patients of all ages living in England and Wales. Most had been referred originally as part of a survey of antibodies to influenza viruses. The remaining samples were from antenatal patients.

Viruses—Sabin polioviruses types 1, 2, and 3 were used. The viruses were grown on monolayers of fetal rhesus monkey kidney cells (FRhK-4T), harvested when the maximum cytopathic effect was observed, and stored in aliquots of 0.05 ml at -30°C. The titre of each virus was determined in microtitre plates to estimate the tissue culture infecting dose.

Tissue culture—Fetal rhesus monkey kidney cells were grown in Eagle's minimum essential medium supplemented with fetal calf serum (6%),

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sodium bicarbonate (0.15%), tylosine (2.76 mmol/l (50 µg/ml)), and gentamicin (50 µg/ml). On the day of the test the cells were trypsinised and resuspended in growth medium to a concentration of 10⁶/ml.

Serum neutralisation test—Antibody concentrations were estimated in microtitre plates. The serum was screened at a dilution of 1/8 for its ability to neutralise 100 times the tissue culture infecting dose of each serotype of poliovirus. Unit volumes of 0.025 ml were used for the serum dilution, virus inoculum, and cell suspension. Each serum was tested in duplicate against the three polio serotypes. The serum dilutions were incubated in covered microtitre plates at room temperature with a virus suspension diluted to

booster. In older children, however, the proportion who had antibodies declined significantly, with only four 12 year olds (40%) being fully protected. Protection then began to increase again, with 80% being fully protected at 16 years of age.

Table II shows the proportion of 8 to 15 year olds who had antibodies to each serotype. With the exception of the 12 year olds there was little difference in the prevalence of antibodies to types 1 and 2 between this group and the population as a whole. The prevalence of antibody to type 3, however, was lower, and this determined the prevalence of complete protection.

TABLE I—Proportion of subjects by age with antibody to each type of poliovirus

Age (years)	No of serum samples examined	No (%) of subjects with antibodies			No (%) of subjects		
		Type 1	Type 2	Type 3	With complete immunity*	With partial immunity†	With no immunity
<5	104	94 (90)	95 (91)	90 (87)	87 (84)	10 (10)	7 (7)
6-10	74	69 (93)	73 (99)	62 (84)	60 (81)	13 (18)	1 (1)
11-15	66	55 (83)	60 (91)	45 (68)	40 (61)	22 (33)	4 (6)
16-20	155	137 (88)	150 (97)	127 (82)	121 (78)	31 (20)	3 (2)
21-25	158	146 (92)	155 (98)	133 (84)	126 (80)	32 (20)	
26-30	71	65 (92)	69 (97)	61 (86)	56 (79)	15 (21)	
31-40	109	99 (91)	104 (95)	95 (87)	86 (79)	22 (20)	1 (1)
41-50	56	45 (80)	51 (91)	45 (80)	37 (66)	18 (32)	1 (2)
51-60	35	29 (83)	31 (89)	30 (86)	26 (74)	7 (20)	2 (6)
>60	167	156 (93)	153 (92)	140 (84)	124 (74)	42 (25)	1 (1)
Total	995	895 (90)	941 (95)	828 (83)	763 (77)	212 (21)	20 (2)

*Antibody to all three types present. †Antibody to one or two serotypes present.

TABLE II—Proportion of children aged 8 to 15 with antibodies to each type of poliovirus

Age (years)	No of serum samples examined	No (%) of subjects with antibodies			No (%) of subjects		
		Type 1	Type 2	Type 3	With complete immunity	With partial immunity	With no immunity
8	16	15 (94)	15 (94)	12 (75)	12 (75)	3 (19)	1 (6)
9	13	12 (92)	13 (100)	9 (69)	9 (69)	4 (31)	
10	14	13 (93)	14 (100)	12 (86)	11 (79)	3 (21)	
11	13	11 (85)	10 (77)	8 (62)	8 (62)	3 (23)	2 (15)
12	10	7 (70)	9 (90)	4 (40)	4 (40)	5 (50)	1 (10)
13	13	12 (92)	12 (92)	9 (69)	9 (69)	3 (23)	1 (8)
14	15	12 (80)	14 (93)	13 (87)	10 (67)	5 (33)	
15	15	13 (87)	15 (100)	11 (73)	9 (60)	6 (40)	
Total	109	95 (87)	102 (94)	78 (72)	72 (66)	32 (29)	5 (5)

contain 100 times the tissue culture infecting dose. After a minimum of four hours a suspension of fetal rhesus monkey kidney cells was added to each well, and the plates were incubated at 37°C in an atmosphere containing 5% carbon dioxide. Virus titrations and standard control serum were included. Plates were examined for cytopathic effects at three and four days with an inverted microscope.

Results

A total of 1001 serum samples were examined. Six came from children aged under 6 months and were excluded because of the possible persistence of maternal antibodies. The 995 samples included in the final analysis came from subjects aged 6 months to 99 years.

Table I shows the proportion of each age group in the population examined with antibodies at a titre of at least 1/8 to each type of poliovirus. Of the 995 samples tested, 975 (98%) had antibody to at least one type of poliovirus, with 763 (77%) being fully protected by antibodies to all three types. The proportion of samples with antibody to the individual serotypes confirmed earlier findings that protection against poliovirus type 3 is lower than that against types 1 and 2 in virtually all age groups.

The figure represents the proportion of subjects aged under 30 who had antibody to all three serotypes. The points at which inactivated and live vaccines were introduced are indicated. A high proportion of children aged under 8 had antibodies to all three types of virus. After the initial response to primary oral poliovirus vaccine a further increase in the proportion with antibody was apparent in children aged 5, possibly due to the preschool

Proportion of population aged under 30 who had antibodies to all three types of polioviruses.

This finding prompted a further examination of serum from this age group. Serum shown to have a titre of less than 1/8 to poliovirus type 3 in the screening test was titrated from 1/2 to 1/8. Of the 18 serum samples available, 16 had antibodies to type 3 detectable at these lower dilutions, and only two had titres of less than 1/2.

The cohort born from 1963 to 1968, now aged 17 to 22, had higher complete immunity than that reported from their serum collected in 1978. Table III shows the prevalence of antibodies to the three serotypes of virus in this group. In contrast to the serum collected in 1978, 195 samples (99%) contained antibody to at least one serotype, with 154 (78%) fully protected.

TABLE III—Proportion of subjects aged 17 to 22 with antibodies to each type of poliovirus

Age (years)	No of serum samples examined	No (%) of subjects with antibodies			No (%) of subjects		
		Type 1	Type 2	Type 3	With complete immunity	With partial immunity	With no immunity
17	26	20 (77)	24 (92)	16 (62)	15 (58)	9 (35)	2 (8)
18	39	36 (92)	36 (92)	32 (82)	32 (82)	6 (15)	1 (3)
19	41	38 (93)	41 (100)	34 (83)	33 (80)	8 (20)	
20	29	26 (90)	29 (100)	28 (97)	25 (86)	4 (14)	
21	39	35 (90)	37 (95)	33 (85)	30 (77)	9 (23)	
22	24	23 (96)	24 (100)	19 (79)	19 (79)	5 (21)	
Total	198	178 (90)	191 (96)	162 (82)	154 (78)	41 (21)	3 (2)

Discussion

The prevalence of antibody found in this study is generally higher than that reported in previous surveys. It is also higher in the cohort identified by Roebuck and Chamberlain in 1982. The members of this group gave cause for concern as they may now be parents exposed to vaccine strains given to their children. Although it is recommended that the polio vaccination state of parents is checked before vaccine is given to their infants, it seems that often this is not done. Unprotected individuals are therefore at risk of vaccine associated infections, which may include paralytic poliomyelitis.

The most important finding of this study is the decline in complete protection seen in children aged 8 to 15, mainly owing to a low prevalence of antibody to type 3 virus. There are several possible explanations. Until 1975 the acceptance rate of poliovirus vaccine was about 80%, and, unlike pertussis vaccine where there was a dramatic decline in uptake in the mid-1970s, the prevalence of vaccination against poliomyelitis never fell below 75% of those eligible.⁸ This study showed that the prevalence of antibodies to serotypes 1 and 2 remains high, indicating that vaccine was administered. An indirect effect due to the adverse publicity given to pertussis vaccine would appear to be unlikely.

Another possible reason for the low protection in this group is that the type 3 component in the vaccine failed to produce an antibody response. There is no evidence, however, that the vaccine supplied from 1970 to 1977 was deficient. The detection of a low prevalence of antibody to type 3 in most of the serum that was

negative on screening at a dilution of 1/8 indicates that those subjects had been exposed to poliovirus type 3.

The third and most likely possibility is that, despite complete primary courses of vaccination and booster doses at school entry, antibodies raised by the type 3 component of oral poliovirus vaccine do not persist. Waning of antibody concentration has been reported in previous studies.^{5,9} The subsequent increase in antibody prevalence is probably due either to the children receiving a booster dose when they leave school or to them coming into contact with

recently vaccinated subjects. The well recognised instability and reversion to neurovirulence of vaccine strains of polioviruses, particularly of type 3, and the subsequent risk of vaccine associated disease make contact with recently vaccinated subjects an undesirable way of boosting antibody prevalence in the community.

This study has shown that protection against poliovirus infection has improved but that the prevalence of antibody against type 3 in children aged 8-15 is inadequate. This is probably due to the waning of vaccine induced antibodies and emphasises the continuing importance of a booster dose of poliovirus vaccine for school leavers.

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Could a severe local reaction to a second triple immunisation in infancy be the result of hyperimmunisation with tetanus and therefore not a reason for discontinuing pertussis?

Severe local reactions among infants to triple vaccines containing adsorbed diphtheria and tetanus toxoids and pertussis antigen occur with a frequency of 0.4% to 1.1%.¹ These reactions are normally attributed to the pertussis component and are a contraindication to receiving further doses of pertussis. Hypersensitivity to tetanus toxoid is largely due to the toxoid antigen itself rather than impurities or other components of the vaccine.² The incidence of tetanus hypersensitivity reactions is related to the number of previous immunisations and the height of pre-existing antibody responses.² A severe local reaction to a third dose of DTP vaccine due to tetanus hypersensitivity has recently been documented in a 6 month old infant,³ although this is rare, and hypersensitivity reactions occur mainly in adults who have received

multiple booster doses. So it is unlikely that a severe reaction to a second dose in infancy would be the result of tetanus hyperimmunisation. It may be possible to investigate this by immediate and delayed hypersensitivity skin tests to tetanus toxoid; a positive result, however, does not necessarily exclude a reaction to the pertussis component and would not justify continuing pertussis. The current recommendation of discontinuing pertussis after a severe local reaction to a previous dose of DTP should be adhered to. —NORMAN BEGG, senior registrar in community medicine (epidemiology), London.

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