

THE CARRIAGE OF *STAPHYLOCOCCUS PYOGENES* VAR. *AUREUS* IN THE HUMAN NOSE

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INTRODUCTION

In health *Staphylococcus pyogenes* may be isolated frequently from many areas of the skin but appears to be more constantly present in the anterior nares (Miles, 1941), and it is probably from this site that the organism is disseminated (Moss, Squire & Topley, 1948). From the nose the organism is passed to other sites on the body surface, to the clothes and thence to dust particles. The nasal carrier rate has been determined by many investigators and, based on a single examination, averages about 85% for infants (Miles, 1941; McFarlan, 1942; Martyn, 1949; Thomas & Cunliffe, 1949; Duncan & Walker, 1949; Ludlam, 1953), 57% for children (Hallman, 1937; McFarlan, 1938; Miles, 1941; Cunliffe, 1949), 45% for adolescents and young adults (Hallman, 1937; McFarlan, 1938; Gillespie, Devenish & Cowan, 1939; Miles, Williams & Clayton-Cooper, 1944; Rountree, Barbour & Thomson, 1951), 50% for adults (Hallman, 1937; McFarlan, 1938; Miles *et al.* 1944; Williams, 1946; Thomas & Cunliffe, 1949; Rountree & Thomson, 1949; Elwood, 1951) and 65% for hospital staff (Hart, 1937; Devenish & Miles, 1939; Allison & Hobbs, 1947; Barber & Rozwadowska-Dowzenko, 1949; Rountree & Thomson, 1949; Rountree, Barbour & Thomson, 1951; Martin & Whitehead, 1949). Repeated examination of the same individuals has shown that the presence of staphylococci is sporadic in some and constant in others (Williams, 1946). Whether the term 'carrier' should be applied to all such individuals is debatable since many are obviously only temporary hosts of the staphylococcus. It is perhaps better to confine the term to those who harbour the staphylococcus persistently.

Bacteriophage typing has been used for the epidemiological study of outbreaks of staphylococcal infection. The method allows one to allocate the strains to three groups which correspond to Cowan's serological types (Williams & Rippon, 1952). Differentiation within these groups is also possible.

This paper records an investigation of the nasal carriage of *Staph. pyogenes* var. *aureus*, with special reference to the duration of carriage, change in status of carriage, and bacteriophage type of the strains isolated.

METHODS AND MATERIALS

Population studied. Most of those examined came from three classes of medical students in successive years (1951-3). Each class was observed for from 3 to 12 months during which weekly examinations were made, except in vacations. The students were first examined 3 months before their hospital practice commenced. In addition, single observations were made on blood donors and patients from a city practice (Table 1).

Isolation and identification of Staph. pyogenes aureus. Throat swabs were rotated 6 times within the anterior nares so that the first half inch of each nostril was sampled. Within a few minutes each swab was stroked on milk-agar (Christie & Keogh, 1940). As very few white colonies were found to be coagulase-positive, only plates showing yellow pigmented colonies were recorded as visually positive, and an approximate colony count was made; + indicated up to 10 colonies, ++ 10–50 colonies and +++ uncountable. Subcultures in broth were used for the coagulase test and bacteriophage typing. In some cases several colonies were subcultured from each plate.

Coagulase tests were performed by the method of Fisk (1940).

Bacteriophage typing was done by the method of Williams & Rippon (1952). Each culture was tested with the basic set of phage filtrates at their Routine Test Dilutions (R.T.D.). Very weak or doubtful reactions were ignored as these tend to differ with minor variations in technique. Cultures giving no reaction with the R.T.D. were typed with undiluted filtrates, and if there was no reaction with these the cultures were denoted as 'not typable'.

RESULTS

According to the frequency of isolation of *Staph. pyogenes* we have classified carriers into three types.

Type 1: the *occasional carriers* comprised those from whom *Staph. pyogenes* was isolated on only one or a few separate occasions during the year, rarely on more than 10% of the examinations in any one individual. The staphylococci isolated at different swabbings were usually of different phage types and antibiotic sensitivity. In 80%, only a few colonies were isolated and, in about 5%, very many.

Type 2: the *intermittent carriers*, were those in whom periods of a few weeks of carriage alternated with similar periods of non-carriage. The staphylococcus isolated was always of the same phage type in the same person and this served to distinguish them from occasional carriers. There was some evidence that an intermittent carrier might become more regular in yielding positive cultures, so becoming a persistent carrier (see below). Intermittent carriers varied both in the frequency of isolation of the organism and in the number of colonies obtained per culture on successive examinations. Some gave a + to ++ growth only half a dozen times a year, whilst others gave + to +++ growths for several weeks on end. Some non-carriers became intermittent carriers.

Type 3: the *persistent carriers*, comprised those from whom *Staph. pyogenes* of the same phage type was isolated at more than 90% of swabbings during a year or more. Only 2% of those examined were found to be persistent carriers of more than one phage type, the strain isolated varying from week to week. Only after a period of observation could these cases be properly assessed and distinguished from occasional carriers.

Table 1 gives the percentage of persons who yielded a culture of *Staph. pyogenes* on first swabbing. Adults of over 25 years had a 'single swab' carrier rate of 45–47% which was higher than that of the medical students who were younger than 25. The total number from whom *Staph. pyogenes* was isolated increased

Table 1. Frequency of isolation of *Staphylococcus pyogenes* from nares of healthy medical students

Persons examined	No. examined	Percentage from whom <i>Staph. pyogenes</i> isolated at least once after							Percentage from whom <i>Staph. pyogenes</i> isolated on at least					
		1st week	2nd week	3rd week	4th week	5th week	10th week	20th week	30th week	1	2	3	4	5
Adults in city practice	300	46	—	—	—	—	—	—	—	—	—	—	—	—
Blood donors	86	45	—	—	—	—	—	—	—	—	—	—	—	—
Students														
1951	183	30	45	53	62	62	68	81	83	83	52	45	35	33
1952	175	33	50	53	60	61	70	76	81	81	49	37	30	27
1953	163	36	47	56	61	67	78	—	—	78	50	41	34	30

Table 3. Results of bacteriophage typing of strains of *staphylococci* isolated

Class of students examined	All strains						Strains from persistent and intermittent carriers						Strains from occasional carriers					
	Bacteriophage group percentage						Bacteriophage group percentage						Bacteriophage group percentage					
	No.	I	II	III	Unclassified	Not typable	No.	I	II	III	Unclassified	Not typable	No.	I	II	III	Unclassified	Not typable
1951	150	26	15	24	9	26	71	32	18	30	13	7	79	20	11	19	6	43
1952	176	26	15	19	5	35	61	36	28	18	2	16	115	20	8	19	7	46
1953	134	22	14	26	8	29	71	32	20	29	8	11	63*	10	8	22	11	49
All	460	25	15	23	8	30	203	34	22	26	8	11	257	18	9	20	8	46

* Three months' observation.

steadily with the increasing number of swabbings until, at the end of 12 months, it was over 80%. This increase was due largely to the isolation of *Staph. pyogenes* from occasional carriers (Table 1). The number yielding the organism on two successive occasions was very much smaller than those yielding it once only, and the number from whom *Staph. pyogenes* was isolated on five or more successive occasions approximated to the number of intermittent and persistent carriers. Of the 520 students examined, 203 (39%) were persistent or intermittent carriers and 218 (42%) were occasional carriers (Table 2); among 358 students observed during 1951 and 1952, twenty-six persistent and intermittent carriers had become non-carriers at the end of 12 months, while twenty-four non-carriers had become persistent or intermittent carriers.

Table 2. *Relative numbers of different types of carrier*

Class of students examined	No. of students examined	Percentage			
		From whom <i>Staph. pyogenes</i> isolated	Persistent carriers	Intermittent carriers	Occasional carriers
1951	183	83	25	14	44
1952	175	79	22	13	44
1953	162	80	27	17	36
All	520	80	24	15	42

On phage typing it was found that 89% of strains from persistent and intermittent carriers and 54% of occasional carriers strains gave reactions with the filtrates. These reactions fit into the four groups of patterns described by Williams, Rippon & Dowsett (1953) and are given in Table 3. The remaining strains were non-typable.

DISCUSSION

Miles *et al.* (1944) concluded that carriage of *Staph. pyogenes* was relatively persistent. During the present investigation the nasal carriage rate remained constant because there was a balance between those who became non-carriers and those who became carriers. The number who ceased to be carriers was 7.3% of all the students examined in each 12 months, and may be taken as a measure of the persistence of carriage; thus the average length of time that any one person may be expected to carry *Staph. pyogenes* is $100/7.3 = 14$ years. Persistence for such a long time is likely to ensure a more or less constant carriage rate till middle age and this does seem to be the case (Williams, 1947).

An important factor in the acquisition of a carrier strain may be the dose of organism to which the individual is exposed. When large, lower grades of local resistance to colonization may be overcome and the carrier state attained in a greater number of persons. Such a condition prevails in hospitals where dust will contain a relatively large number of *Staph. pyogenes* disseminated from carriers and lesions; the staff have a high carrier rate and the strain most frequently acquired by a newcomer will be the predominant hospital strain. All our persistent and intermittent carriers continued to carry the same phage type of staphylococcus, and there was no evidence of replacement with different strains, nor increase

in the overall carriage rate, either before or during their period of hospital practice. This was probably due to relatively short and sporadic contact with the sources of the hospital strains.

Our results show that two strains of distinct phage type rarely occur in the same person at the same time. Occasionally one strain alternates with another, and it is only after some time that it is possible to say that both strains are carried.

There was no evidence that any one particular phage-type of *Staph. pyogenes* was especially liable to colonize the nares since the distribution of phage types was fairly uniform. The very much smaller number of 'non-typable' strains isolated from persistent and intermittent carriers shows that these strains do not colonize to the same extent. The non-typable strains appear to be disseminated in large enough numbers for them to be isolated sporadically from the noses of occasional carriers. If these occasional carriers indicate the degree of dissemination of *Staph. pyogenes* the phage types of the organism isolated from them should correspond approximately to those isolated from persistent and intermittent carriers. This is not so (Table 3). It is possible that the majority of the strains grouped under the heading 'non-typable' differ fundamentally from those that can be typed. Rountree (1953) found that very few non-typable strains were associated with clinical infections, and it was inferred that these strains were less pathogenic than the typable strains. On closer examination many of our 'non-typable' strains were found to be relatively weak coagulase producers; their colonies were often more transparent than those of the typable strains and became flat and ringed on standing whilst their pigment was a more vivid yellow-orange. Thus, at present, there is some justification for subdividing coagulase-positive strains into those which can be typed and those which cannot. Therefore, phage-typability may become a criterion of pathogenicity.

We regard persistent and intermittent carriers as true hosts of *Staph. pyogenes* in whom the organisms live and multiply. The occasional carriers do not harbour staphylococci in their nares, but appear to filter off the organism from inspired air, so that they are picked up by the swab and isolated on culture. Moreover, staphylococci isolated on different occasions from an occasional carrier were found to be of differing phage type, so that there is no evidence of persistence between swabbings. Change of phage type is therefore the most convenient basis for the differentiation of occasional from intermittent carriers; a single swabbing will not distinguish an occasional carrier from a persistent or intermittent carrier. Clearly an estimation of the carrier rate based on the results of one single observation may give a misleading figure, higher than that based on the results of repeated examination over a long period.

SUMMARY

Over 500 medical students have been examined for nasal carriage of *Staph. pyogenes* at weekly intervals over a period ranging from 3 to 12 months.

Nasal carriers were classified as persistent, intermittent and occasional. Of the students, 39% were persistent or intermittent carriers in whom the staphylococcus was believed to colonize the skin of the vestibule of the nose; 42% were

occasional carriers in whom the staphylococcus was only a chance inhabitant of the nares.

Staph. pyogenes was isolated from the anterior nares of persistent carriers on at least 90% of the occasions on which they were examined, and was of the same phage type on each occasion. From intermittent carriers it was isolated less regularly, but on at least 10% of occasions on which they were examined, and it remained of one phage type. *Staph. pyogenes* was isolated at less than 10% of swabbings from occasional carriers, and at each the organism was of a different phage type.

Eighty-nine per cent of persistent and intermittent carrier strains, and 54% of occasional carrier strains could be typed with phage filtrates. The strains not typable with phage filtrates, and found predominantly among occasional carriers, were considered worthy of separate classification, and it is suggested that typability with phage be used as a criterion of pathogenicity for *Staph. pyogenes*.

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