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Spread of *Escherichia coli* colonizing newborn babies and their mothers

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SUMMARY

Most babies are colonized by the predominant strains of *Escherichia coli* present in their own mother's faecal flora. Those babies who did not acquire their maternal faecal flora acquired strains of *E. coli* belonging to a small number of the possible serotypes. Moreover, the same serotypes were found in several babies and other mothers, suggesting spread within the ward. These few strains included some of the O groups which had previously commonly been found as urinary pathogens. These strains may have increased potentialities for colonization of human bowel. Antigenic and biochemical variation was observed among the strains.

INTRODUCTION

In previous papers (Bettelheim *et al.* 1974*a*, *b*) it was shown that the majority of babies are colonized with strains of *Escherichia coli* which are present in the maternal faecal flora. There were some babies who did not acquire their maternal strains as far as could be ascertained with the techniques used. The strains were characterized by O and H serotypes, their ability to ferment six carbohydrate substrates and their antibiotic resistance. Using these markers, the spread of the strains from patient to patient was examined.

MATERIALS AND METHODS

The collection of strains and determination of their characteristics has been described in the two previous papers (Bettelheim *et al.* 1974*a*, *b*).

The patient numbers are those used previously. The same abbreviations are used throughout and given in Table 1. In addition to the previous 33 mothers and babies described earlier, a further 4 mothers and their babies who had been delivered by Caesarean section were studied. Their patient numbers are 9, 11, 34 and 36.

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Table 1. *Abbreviations used to distinguish strains of* Escherichia coli

Marker Drug resistance	Abbreviation	Marker Carbohydrates fermented	Abbreviation
Ampicillin	A	Dulcitol	Du
Streptomycin	S	Maltose	Ma
Tetracycline	T	Raffinose	Rf
Chloramphenicol	C	Rhamnose	Rh
Kanamycin	K	Sorbose	Ss
Sulphadimidine	Su	Sucrose	Sc
Nalidixic acid	Nal		
Trimethoprim	Tr		
Gentamicin	G		
Fully sensitive	F/S		

Table 2. *Evidence of spread of* Escherichia coli *amongst babies*

Strain of *E. coli* isolated from stool			Date of isolation	Patient
O3:H2	Su	Du, Ma	22–6 March 1972	2 mother
O3:H2	Su	Du, Ma	24–9 March 1972	2 baby
O3:H2	SSu	Du, Ma	4–6 May 1972	16 baby
O3:H2	SSu	Du, Ma	11–16 May 1972	24 baby
O3:H2	SSu	Du, Ma	18 May 1972	32 baby
O3:H2	SSu	Du, Ma	18–24 May 1972	33 baby
O3:H2	SSu	Du, Ma	21–5 May 1972	36 baby
O162:H10	T	Ma	26 April–2 May 1972	10 mother
O162:H10	T	Ma	28 April–2 May 1972	10 baby
O162:H10	T	Ma	2–3 May 1972	12 baby
O162:H10	T	Ma	13–14 May 1972	23 baby
O162:H10	F/S	Ma	26 April 1972	10 mother
O162:H10	F/S	Ma	28 April 1972	10 baby
O162:H10	F/S	Ma	2–5 May 1972	12 baby
O162:H10	F/S	Ma	13 May 1972	23 baby
O1:H−	F/S	Ma, Ss	7–12 May 1972	26 mother
O1:H−	F/S	Ma, Ss	11–16 May 1972	26 baby
O1:H−	F/S	Ma, Ss	19 May 1972	35 baby
O10:H4	F/S	Ma, Rh	3 May 1972	21 mother
O10:H4	F/S	Ma, Rh	4–5 May 1972	21 baby
O10:H4	F/S	Ma, Rh	11 May 1972	25 baby

RESULTS

In all 2,780 strains of *E. coli* were examined from 37 mothers and their babies. The characterization of similar strains isolated from mothers and their babies has been previously described. The remaining strains were then examined for common characteristics. It was noted that among the remaining strains isolated from mothers' faeces, there was a very large number of sero- and biotypes. However, from the babies' stools only a limited number of types were isolated.

It was found that there were four strains of the same O and H serotypes and biotypes which occurred in several babies (Table 2). The antibiotic resistance of some of these strains was not identical but loss of a resistance to an antibiotic which is plasmid-mediated is well known. Amongst *E. coli* O/R and H+/H−

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Table 3. *O/R and H+/H− variation in* Escherichia coli *spread amongst mothers and babies*

Strain of *E. coli* isolated from stool or mucus			Date of isolation	Patient
O6:H1	F/S	Du, Ma, Rh, Ss	1 May 1972	16 mother
O6:H1	F/S	Du, Ma, Rh, Ss	3 May 1972	20 baby
O6:H−	F/S	Du, Ma, Rh, Ss	3 May 1972	20 mother
O6:H1	F/S	Du, Ma, Rh, Ss	6–11 May 1972	22 mother
O6:H1	F/S	Du, Ma, Rh, Ss	11–13 May 1972	22 baby
O2:H4	Su	Du, Ma, Ss	16 May 1972	33 baby
O2:H4	F/S	Du, Ma, Ss	20–24 May 1972	34 mother
O2:H−	A	Du, Ma, Ss	26 May 1972	34 baby
O1:H−	F/S	Du, Ma, Rh, Ss	22–7 March 1972	1 mother
O1:H−	F/S	Du, Ma, Rh, Ss	22–8 March 1972	1 baby
R:H7	F/S	Du, Ma, Rh, Ss	25–8 March 1972	1 baby
R:H7	F/S	Du, Ma, Rh, Ss	26–8 March 1972	3 mother
O1:H7	F/S	Du, Ma, Rh, Ss	5 May 1972	13 mother
R:H7	F/S	Du, Ma, Rh, Ss	5–9 May 1972	15 baby
O1:H−	F/S	Du, Ma, Rh, Ss	17 May 1972	32 mother
R:H7	F/S	Du, Ma, Rf, Rh, Ss	20–3 April 1972	7 mother
O1:H7	T	Du, Ma, Rf, Rh, Ss	2–8 May 1972	19 mother
R:H7	F/S	Du, Ma, Rf, Rh, Ss	2 May 1972	19 mother
O1:H7	F/S	Du, Ma, Rf, Rh, Ss	8 May 1972	19 mother
O1:H−	T	Du, Ma, Rf, Rh, Ss	8 May 1972	19 mother
R:H7	T	Du, Ma, Rf, Rh, Ss	8 May 1972	19 mother
R:H7	F/S	Du, Ma, Rf, Rh, Ss	4–8 May 1972	19 baby

Table 4. *Spread of serotypically related strains of* E. coli *with differing capabilities to ferment carbohydrates, amongst mothers and babies*

Strain of *E. coli* isolated from stool or mucus			Date of isolation	Patient
O18:H14	F/S	Du, Ma, Rf, Rh, Sc	27 March 1972	3 mother
O18:H14	F/S	Du, Ma, Rh	20 April 1972	5 mother
O18:H14	F/S	Du, Ma, Rh	21 April 1972	4 mother
O18:H−	F/S	Ma	2 May 1972	17 mother
O18:H14	F/S	Ma, Rf, Rh, Sc	3 May 1972	21 mother
R:H14	F/S	Ma, Rf, Rh, Sc	3 May 1972	21 mother
O18:H14	F/S	Ma, Rf, Rh, Sc	3–5 May 1972	21 baby
R:H14	F/S	Ma, Rf, Rh, Sc	3–5 May 1972	21 baby
O129:H30	F/S	Du, Ma, Rf, Rh, Sc	27 April 1972	8 mother
O129:H30	F/S	Ma, Rf, Rh, Sc	27 April 1972	8 mother
O129:H30	F/S	Ma	10 May 1972	27 baby
O19:H7	F/S	Ma, Rf, Rh, Sc	26 March 1972	2 mother
O19:H−	F/S	Du, Ma, Rf, Rh, Ss, Sc	22 April 1972	5 baby
O19:H−	F/S	Du, Ma, Rf, Rh, Sc	27 April 1972	8 mother
O19:H7	F/S	Ma	8 May 1972	23 baby
O19:H7	F/S	Du, Ma, Rf, Rh, Sc	10 May 1972	27 baby
O19:H7	F/S	Ma, Rf, Rh, Sc	10 May 1972	27 baby
O19:H−	F/S	Ma, Ss, Sc	11 May 1972	23 mother
O19:H−	F.S	Ma	11 May 1972	23 mother

Table 5. *Complex variations amongst possibly related strains of* E. coli *from mothers and babies*

Strain of *E. coli* isolated from stool or mucus			Date of isolation	Patient
O82:H11	F/S	Du, Ma, Rh, Sc	24 April 1972	8 mother
O82:H31	A	Du, Ma, Rf, Rh	28 April 1972	13 mother
O82:H−	ASSu	Ma, Rh	29 April 1972	9 mother
O82:H−	Su	Ma, Rh	29 April 1972	9 mother
O82:H31	F/S	Du, Ma, Rf, Rh	2–4 May 1972	13 baby
O82:H31	F/S	Du, Ma, Rf, Rh	3 May 1972	9 baby
O106:H−	F/S	Du, Ma, Rh	22 March 1972	3 mother
O106:H34	F/S	Du, Ma, Rh	8 May 1972	24 mother
O106:H7	F/S	Du, Ma, Rh	8 May 1972	24 mother
R:H7	F/S	Du, Ma, Rh	8–11 May 1972	23 mother
R:H7	F/S	Du, Ma, Rh	8 May 1972	23 baby
R:H7	F/S	Du, Ma, Rf, Rh, Sc	8 May 1972	23 baby
O7:H−	F/S	Ma, Rf, Rh, Sc	22 March 1972	2 mother
O7:H4	F/S	Du, Ma, Rh	24 March 1972	3 baby
O7:H4	F/S	Ma, Rh	26–9 March 1972	3 baby
O7:H−	F/S	Ma, Rf, Rh, Ss, Sc	16–17 April 1972	6 mother
O7:H−	F/S	Ma, Rf, Rh, Sc	16–17 April 1972	6 mother
O7:H−	F/S	Ma, Rh	28 April 1972	13 mother
O7:H−	F/S	Ma, Rf, Rh, Ss, Sc	28 April–5 May 1972	13 mother
R:H30	F/S	Ma	29 April 1972	9 mother
O7:H−	F/S	Ma, Rf, Rh, Ss, Sc	2–6 May 1972	13 baby
O7:H30	F/S	Ma	3 May 1972	13 mother
O7:H−	F/S	Ma, Rf, Rh, Sc	3 May 1972	9 baby
NT:H30	F/S	Ma	5 May 1972	13 mother
O7:H−	F/S	Ma, Rf, Rh, Ss, Sc	3–7 May 1972	9 baby
O7:H6	F/S	Ma, Ss, Sc	11 May 1972	23 mother
O7:H−	F/S	Ma, Ss, Sc	20–1 May 1972	36 baby

variation within a strain is an accepted phenomenon and therefore, if other markers are identical, the isolation of pairs of such strains may imply their relatedness. There were three such groups of strains isolated (Table 3) and in addition non-motile variants of strains listed in Table 2 were found.

The presence of tetracycline resistance and raffinose fermentation have been shown to be due to a plasmid (Ørskov & Ørskov, 1973). The strains from mother and baby 19 are therefore included with the other O1:H7 strains. The possibility that the ability to ferment other carbohydrates is plasmid borne caused the linking of strains with identical O and H antigens but differing fermentation ability (Table 4).

In our previous paper (Bettelheim *et al.* 1974*b*) we noted that within certain mother and baby pairs there was some evidence that more complex variation occurred. Table 5 shows the spread of such related strains between different mothers and different babies.

DISCUSSION

In our previous papers (Bettelheim *et al.* 1974*a*, *b*) we showed that the majority of babies were colonized by strains of *E. coli* which were present in their mothers'

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faecal flora. A few babies acquired strains not present in their maternal flora. It was noted that many different strains of *E. coli* were isolated from mothers, whereas only a few of these strains were isolated from the babies. Moreover, most of these strains were isolated on several occasions from several mothers and babies. The O groups of these strains were O1, O2, O3, O6, O7, O10, O18, O19, O82, O106, O129 and O162. Five of these twelve O groups are among the nine O groups (O1, O2, O4, O6, O7, O11, O18, O39 and O75) shown by Gruneberg, Leigh & Brumfitt (1968) to occur in urinary tract infections and in relatively large numbers in human faeces. These strains might be more prevalent in the environment or possibly have a different potentiality for colonization of babies. It has been suggested that some animal and human pathogenic strains have such differing potentialities for their hosts (Williams Smith & Halls, 1967).

Having considered in the earlier study that complex variation of sero- and biotypes may occur in the transfer of strains from mothers to their own babies, we feel that this may also occur within the maternity ward.

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REFERENCES

Bettelheim, K. A., Breaden, A., Faiers, M. C., O'Farrell, S. M. & Shooter, R. A. (1974*a*). The origin of O serotypes of *Escherichia coli* in babies after normal delivery. *Journal of Hygiene* **72**, 67–70.

Bettelheim, K. A., Teoh-Chan, Ching Haan, Chandler, M. E., O'Farrell, S. M., Rahamim, L., Shaw, E. J. & Shooter, R. A. (1974*b*). Further studies of *Escherichia coli* in babies after normal delivery. *Journal of Hygiene* **73**, 277.

Gruneberg, R. N., Leigh, D. A. & Brumfitt, W. (1968). In *Urinary Tract Infection* (ed. F. W. O'Grady and W. Brumfitt, pp. 68–80. Oxford University Press.

Ørskov, I. & Ørskov, F. (1973). Plasmid-determined H_2S character in *Escherichia coli* and its relation to plasmid-carried raffinose fermentation and tetracycline resistance characters. *Journal of General Microbiology* **77**, 487–99.

Williams Smith, H. & Halls, S. (1967). Observations by the ligated intestinal segment and oral inoculation methods of *Escherichia coli* infections in pigs, calves, lambs and rabbits. *Journal of Pathology and Bacteriology* **93**, 499–529.