THE ROLE OF CERTAIN VARIETIES OF *BACTERIUM COLI* IN GASTRO-ENTERITIS OF BABIES

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Many believe that certain varieties of *Bacterium coli*, known by the symbols which denote their antigenic structure (O 111, O 55, O 26, etc., with their various H antigen combinations), are the common cause of gastro-enteritis of babies. Many babies admitted to hospital with gastro-intestinal upset are infected by these organisms, but the main evidence incriminating them comes from inquiries into outbreaks in babies' hospitals and other institutions. In institutional outbreaks infection, once introduced, may linger for a long time, all the cases yielding *Bact. coli* of precisely the same antigenic structure. As there are many different antigenic varieties this evidence is of considerable value but is not conclusive proof.

Post-mortem examinations show little to account for the symptoms. The gut is not inflamed, and other tissues show the minimum of change. The liver sometimes shows degenerative changes which have not been stressed, as this organ in babies often shows such changes for apparently slight cause.

In attempts to reproduce the disease cultures of the suspected varieties of *Bact. coli* have been fed to adults (Ferguson & June, 1952; Kirby, Hall & Coackley, 1950). Some adults given very large numbers (10^9) developed diarrhoea, but it is doubtful if these were fair tests as the large numbers of bacilli swallowed do not correspond to the invasion of the body by a small infecting dose which becomes established and multiplies.

The evidence incriminating these varieties of *Bact. coli*, therefore, is epidemiological and not pathological, but more and more bacteriologists have become convinced that these organisms are the cause of disease.

It has been observed that the faeces of babies with gastro-enteritis yield virtually a pure culture of *Bact. coli*. O 111, O 55, O 26, etc., and the 'pathogenic' *Bact. coli* thus appears to have replaced the normal *Bact. coli*. Some bacteriologists assert that an unknown virus is the cause of the disease, producing conditions in the gut which favour the growth of some special but harmless varieties of *Bact. coli*. It has been shown recently, however, that in dysentery, salmonella food poisoning and enteric fever very large numbers of accepted pathogens are present in the faeces, the pathogens not being greatly outnumbered by the normal *Bact. coli* (Thomson, 1954, 1955). In respect of numbers of pathogens excreted in faeces, therefore, there is no fundamental difference between gastro-enteritis and other intestinal infections.

It is unfortunate that there is no selective culture medium available for the isolation of *Bact. coli* O 111, O 55, O 26, etc. This means that normal and 'pathogenic' *Bact. coli* must be grown side by side on the same culture medium, and it is

thus only possible to identify the suspected pathogens if they are not appreciably outnumbered (20:1) by normal *Bact. coli*.

Quantitative bacteriological examinations of faeces of cases of dysentery, salmonella food poisoning and enteric fever as well as of symptomless temporary excreters and chronic carriers yielded valuable information not suspected from the usual qualitative tests (Thomson, 1954, 1955). In the work now reported quantitative bacteriological examinations of specimens from babies with gastro-enteritis (post-mortem and during life) yielded evidence that *Bact coli*. O 111, O 55, and O 26 do not behave as normal *Bact. coli*, but that they are pathogens and that the syndrome of gastro-enteritis has many resemblances to the syndrome of cholera.

PART I

Post-mortem examinations

At the post-mortem examination of babies who had died of gastro-enteritis samples of gut contents were taken at intervals from the stomach to the rectum. Samples were also taken of gall bladder bile and of some other organs. It was known from examinations during life that the faeces harboured large numbers of *Bact. coli* O 55, B 5, H 2 (average 1,000,000,000 per gram), and care was taken to collect samples of gut contents to avoid contamination from below upwards. A sample of ascitic fluid (if present) was taken first with a sterile syringe followed by a sample of gall-bladder bile taken with a separate syringe and needle. Before the gut was opened, or handled too much, ligatures were tied at intervals to isolate segments of gut to be sampled. The segments were selected from above downwards and opened from above downwards.

A small amount of each sample was weighed and a 1/10 dilution made. From it tenfold dilutions up to 10^{-8} were made using a fresh sterile pipette for each step, and one drop ($\frac{1}{50}$ ml.) of each dilution was allowed to fall on to the surface of a MacConkey plate. After incubation the colonies were counted and identified (Miles & Misra, 1938). The counts were usually calculated from the dilution yielding 5 to 50 colonies from one drop, and it was thus necessary to identify all the colonies from this dilution by a slide-agglutination test. One colony was picked for full identification of O, B and H antigens. If *Bact. coli* O 55 outnumbered normal *Bact. coli* by more than 20:1 it was difficult to identify the latter. The converse was also true.

In some cases an attempt was made to count approximately the number of other organisms, including *Streptococcus faecalis*, by inoculating Robertson's meat broth and azide broth with $\frac{1}{50}$ ml. of each of the dilutions made for the enumerations of *Bact. coli*. It was thus possible to compare the highest dilutions yielding *Bact. coli* and *Strep. faecalis*, etc. Such a comparison was not possible from the MacConkey plate counts when the coliforms greatly outnumbered the streptococci.

In four instances the corpse had been placed in a refrigerator within an hour or two of death, and the autopsy was done 8–24 hr. later. One autopsy was done 3 hr. after death, and finally one was done within half an hour of death. These six

babies were infected with *Bact. coli* O 55, B 5, H 2, which was found post-mortem in large numbers throughout the whole length of the gut, and in some cases also in the gall bladder.

Results

In the following cases (Tables 1–6) the numbers of *Bact. coli* O 55, B 5, H 2 per gram of gut contents (or per ml. of bile, etc). are shown. Very few of these specimens yielded normal *Bact. coli*, but the difficulty of identifying normal *Bact. coli* when outnumbered more than 20:1 by 'pathogenic' *Bact. coli* is admitted. When normal *Bact. coli* could not be identified, possibly because of the overwhelming number of 'pathogenic' *Bact. coli*, no entry was made in the tables in case a nought might be interpreted as positive evidence that they were absent. The tables also show the highest dilution yielding various organisms including normal and 'pathogenic' *Bact. coli*. This allows an approximate comparison of the numbers of *Strep. faecalis*, etc., with *Bact. coli*.

Case 1. Autopsy 24 hr. after death. Body had been in mortuary refrigerator since shortly after death.

Table 1

Specimen	*Bact. coli* O 55 per g.	Highest dilution positive: *Bact. coli* O 55	Highest dilution positive: Other *Bact. coli*	Highest dilution positive: *Strep. faecalis*
Blood	0	Neg.	Neg.	Neg.
Ascitic fluid	0	Neg.	Neg.	Neg.
Bile	3,000,000	10^{-4}	—	Neg.
Stomach	6,500,000	10^{-4}	—	Neg.
Upper jejunum	300,000,000	10^{-6}	—	10^{-2}
Mid ileum	300,000,000	10^{-6}	—	10^{-4}
Lower ileum	500,000,000	10^{-6}	—	10^{-3}
Caecum	1,000,000,000	10^{-6}	10^{-6}	10^{-5}
Rectum	1,500,000,000	10^{-7}	10^{-6}	10^{-5}

Case 2. Autopsy 24 hr. after death. Body had been in mortuary refrigerator since shortly after death.

Table 2

Specimen	*Bact. coli* O 55 per g.	Highest dilution positive: *Bact. coli* O 55	Highest dilution positive: Other *Bact. coli*	Highest dilution positive: *Strep. faecalis*
Ascitic fluid	0	Neg.	Neg.	Neg.
Bile	150,000,000	10^{-6}	—	Neg.
Stomach	2,500,000	10^{-4}	—	10^{-4}
Upper jejunum	20,000,000	10^{-5}	—	10^{-5}
Mid jejunum	150,000,000	10^{-6}	—	10^{-4}
Mid ileum	2,000,000,000	10^{-7}	—	10^{-5}
Caecum	7,000,000,000	10^{-7}	—	10^{-7}
Trans. colon	3,000,000,000	10^{-7}	—	10^{-7}

Case 3. Autopsy 24 hr. after death. Body had been in mortuary refrigerator since shortly after death.

https://doi.org/10.1017/S002217240000084X Published online by Cambridge University Press

A few days before the baby died there were signs of pneumonia, and at autopsy the lower lobe of the left lung showed a haemorrhagic consolidation. The lung yielded a rich culture of *Streptococcus pyogenes* group C and this organism was found also in the gut. *Strep. pyogenes* group C was isolated from the whole length of the gut from dilutions varying from 10^{-2} to 10^{-4}.

Table 3

		Highest dilution positive		
Specimen	*Bact. coli* O 55 per g.	*Bact. coli* O 55	Other *Bact. coli*	*Strep. faecalis*
Blood	0	Neg.	Neg.	Neg.
Bile	500	10^{-1}	Neg.	Neg.
Stomach	6,500,000	10^{-4}	—	10^{-2}
Upper jejunum	50,000,000,000	10^{-8}	—	10^{-8}
Mid jejunum	50,000,000	10^{-5}	—	10^{-6}
Ileum	120,000,000,000	10^{-9}	—	10^{-7}
Caecum	9,500,000,000	10^{-7}	—	10^{-6}
Rectum	15,000,000,000	10^{-8}	—	10^{-4}

Case 4. Autopsy 8 hr. after death. Body had been in mortuary refrigerator since shortly after death.

Table 4

		Highest dilution positive		
Specimen	*Bact. coli* O 55 per g.	*Bact. coli* O 55	Other *Bact. coli*	*Strep. faecalis*
Bile	0	Neg.	Neg.	Neg.
Liver	0	Neg.	Neg.	Neg.
Duodenum	2,350,000,000	10^{-7}	—	Neg.
Ileum	2,000,000,000	10^{-7}	—	Neg.
Caecum	3,000,000,000	10^{-7}	—	—
Trans. colon	4,000,000,000	10^{-7}	10^{-6}	—
Rectum	1,750,000,000	10^{-7}	—	—

Case 5. Autopsy done 3 hr. after death.

Table 5

		Highest dilution positive		
Specimen	*Bact. coli* O 55 per g.	*Bact. coli* O 55	Other *Bact. coli*	*Strep. faecalis*
Bile	15,000,000	10^{-5}	—	Neg.
Stomach	500,000,000	10^{-6}	—	10^{-3}
Duodenum	80,000,000	10^{-5}	—	10^{-4}
Jejunum	150,000,000	10^{-6}	—	10^{-3}
Lower ileum	1,000,000,000	10^{-7}	10^{-7}	—
Caecum	2,000,000,000	10^{-7}	10^{-7}	10^{-4}
Colon	2,000,000,000	10^{-7}	10^{-7}	—

Case 6. Autopsy done within half an hour of death. The specimens were specifically examined for *Clostridium welchii* and none were found.

Table 6

Specimen	*Bact. coli* O 55 per g.	Highest dilution positive: *Bact. coli* O 55	Highest dilution positive: Other *Bact. coli*	Highest dilution positive: *Strep. faecalis*
Blood	0	Neg.	Neg.	Neg.
Bile	0	Neg.	Neg.	Neg.
Liver	0	Neg.	Neg.	Neg.
Spleen	0	Neg.	Neg.	Neg.
Stomach	200,000	10^{-3}	—	Neg.
Duodenum	7,000,000	10^{-4}	—	Neg.
Jejunum	250,000	10^{-3}	—	Neg.
Ileum	6,500,000	10^{-4}	—	Neg.
Caecum	40,000,000	10^{-5}	—	Neg.
Rectum	10,000,000	10^{-5}	—	10^{-2}

The duodenum and upper part of the small intestine are relatively free from bacteria during life. After death the bacteria of the lower gut spread upwards, but the rate at which this occurs is not known. Blacklock, Guthrie & Macpherson (1937) reported upon the flora of the gut of infants during life and after death, and were of the opinion that faecal bacteria did not spread up the gut rapidly. Blacklock, *et al.* made their post-mortem examinations of bodies which had been stored in the mortuary refrigerator since shortly after death, conditions which were similar to those obtaining in the first four cases reported here.

In the past many different bacterial species have been suspected of having an association with gastro-enteritis of babies, and a search of the literature shows that the presence of large numbers of *Bact. coli* high up in the small gut of fatal cases has been observed before. Davison (1925) recorded the presence of *Bact. coli* in the duodenum of fatal cases of gastro-enteritis but not in fatal cases of dysentery. In a footnote he remarked upon the richness of the culture of *Bact. coli*, although the bodies had been in a refrigerator since within an hour of death. Davison, however, followed the work of Moro (1916) who thought of gastro-enteritis as an endogenous infection of the small gut. Moro made post-mortem examinations immediately after death (and presumably 'immediately after death' meant just that under the conditions prevailing in German hospitals), and remarked upon the richness and purity of the coliform content of the duodenum.

Adam (1922, 1923, 1927) reached the conclusion that the strains of *Bact. coli* isolated from cases of gastro-enteritis formed a definite group which he called 'Dyspepsiekoli'. The differentiation from other varieties was mainly based on biochemical reactions, and it is of interest to note that he used the fermentation of sorbitol as a distinguishing test. Goldschmidt (1933) advanced evidence that the strains of *Bact. coli* recognized by Adam formed a serologically distinct group.

The post-mortem examinations reported here indicated an infection by *Bact. coli* of the upper gut. One case was examined 3 hr. after death and another within half an hour. It appeared possible to answer the criticism that the bacilli had spread up the gut after death, but it did not appear easy to answer the possible criticism that the faecal flora had spread upwards because of violent gut movements associated with diarrhoea and vomiting.

The gall bladder bile of four of the cases contained *Bact. coli* O 55. In three of these cases, including the one examined 3 hr. after death, there were millions of bacilli per ml. of bile. It is difficult to believe this could be post-mortem extension from the gut, especially as no other bacterial species was found in these gall bladders. Moreover, bile samples taken at autopsy are usually sterile.

The stomachs harboured large numbers of *Bact. coli* O 55, but no opinion is advanced upon the possible significance of this (see later for observations during life). Possibly there had been a flow of duodenal contents into the stomach, or possibly, if the pH had been low before death, the bacilli had been established in the stomach before death.

Many of the specimens contained *Strep. faecalis*, often in considerable numbers, but this organism can usually be found in the upper gut, and post-mortem multiplication might have accounted for some of the results. *Strep. faecalis* was never found in the gall bladder.

A control series of autopsies of babies who had died of other diseases might have been useful, but it was thought much more satisfactory to settle the question beyond doubt by taking samples during life. These samples taken by catheters during life established that there is a heavy infection of the upper gut by *Bact. coli* O 111, O 55, O 26, etc., and this would not appear to be the behaviour of normal *Bact. coli*.

PART II

Specimens taken during life

There is general agreement that the contents of the duodenum and upper jejunum are almost free of bacteria. Barbero, Runge, Fischer, Crawford, Torres & Gyorgy (1952) and Davison (1925) passed duodenal tubes in babies and found the contents usually sterile. Blacklock *et al.* (1937) examined samples taken by needle at operation and found 'coliforms' rarely in the upper gut; post-mortem examinations agreed well with those made during life, and for this reason the authors concluded that *Bact. coli*, etc., do not rapidly spread up the gut if the body of a dead baby is placed in a refrigerator within an hour or two of death. Blacklock *et al.*, however, observed that coliforms (including *Bact. coli* type I, aerogenes types, *Proteus* and paracolon bacilli) were present post-mortem in the duodenum of many cases of fatal gastro-enteritis.

In adults, samples taken by tube from the duodenum, or by needle from the jejunum at operation, show so few bacteria that these are considered transient contaminants (Cregan & Hayward, 1953; Cregan Dunlop & Hayward, 1953; Barber & Franklin, 1946; Nichols & Glenn, 1940; Venables & Knott, 1924). The bacterial population of the duodenum, however, is greatly increased in achlorhydria (Ricen, Sears & Downing, 1928; Knott, 1927).

Bessau & Bossert (1919), following the work of Moro (1916) whose post-mortem examinations done immediately after death had led him to suspect that gastro-enteritis was an endogenous infection of the small gut, passed duodenal tubes in infants. In normal babies they found 'coliforms' rarely; in babies with dyspepsias of various kinds they found 'coliforms', usually *Bacillus lactis aerogenes*, not infrequently.

Methods

Samples of duodenal juice were obtained from babies following the technique of James (1951) by passing a rubber tube (size 6 English gauge) in the tip of which was a small ticonal magnet. A compass placed on the abdominal wall located the tip of the tube, and when it was clear that the tip had arrived in the stomach the baby was turned on its right side and the tube pushed farther down. With experience it was possible to push the tip of the tube into the duodenum within 5 min. The end of the tube protruding from the nose was placed inside a sterile test-tube to protect it from becoming contaminated. No special precautions were taken to prevent the tip inserted through the nose from picking up bacteria from the naso-pharynx.

Duodenal juice—clear golden-yellow fluid pH 6–7·4—does not immediately flow up the tube when the tip enters the duodenum, and it was usually necessary to fit a sterile syringe to the open end and suck to aid the passage up the tube. The operation is much easier if the stomach is empty or nearly empty. It was found to be a task of great difficulty to get a sample of duodenal juice shortly after a meal.

In many cases a sample of stomach juice was also collected.

As before, bacterial counts were made on the samples. Serial tenfold dilutions were made and one drop ($\frac{1}{50}$ ml.) of each dilution was allowed to fall on to the surface of a MacConkey plate to enumerate coliforms and other bacteria which will grow on this medium. A simple test for tryptic activity was made on many of the samples of duodenal juice. Serial doubling dilutions of the juice were made in 1 % crystalline sodium carbonate, and one drop of each placed on the gelatin coating of a photographic plate (X-ray film). The film was placed in an incubator (37° C.) for half an hour, then in a refrigerator for 10 min. It was washed, and the highest dilution producing a clear plaque of digestion was recorded.

Samples were taken from four groups of babies. Group 1: babies with gastro-enteritis and excreting *Bact. coli* O 111, O 55 or O 26 in the faeces. Group 2: babies convalescing from gastro-enteritis but still excreting *Bact. coli* O 111, O 55 or O 26 in the faeces. Group 3: babies with gastro-enteritis but not infected with *Bact. coli* O 111, O 55 or O 26. Group 4: babies with no gastro-intestinal upset.

The results showed that the first group harboured large numbers of the alleged pathogenic varieties of *Bact. coli* in the duodenum.

Results

Group 1 (Table 7). Cases of gastro-enteritis infected by *Bact. coli* O 111, O 55 or O 26, and examined early in the disease.

All of the *Bact. coli* in this group were *Bact. coli* O 111, O 55 or O 26 which, from the large numbers found in the duodenum, appeared beyond all doubt to be established and flourishing there. The most interesting result was that obtained in case 7. The samples from this case were taken when the operator had gained considerable skill in passing duodenal tubes and the full account of the collection of the samples is as follows. The baby, aged 4 months, had been fed on milk at 2 a.m.

and after a short interval had vomited. At 6 a.m. the baby was given only glucose solution by mouth. At 9.30 a.m. the sterile duodenal tube was passed through the nose and down into the stomach. When the tip of the tube passed across the stomach 5 ml. of clear stomach juice came up and collected in the test-tube. The rubber tube was then pushed into the duodenum where it arrived within 2 min. of the beginning of the whole operation. The test tube enclosing the protruding end of the rubber duodenal tube was replaced by a second sterile test-tube and the

Table 7. *Number of* Bact. coli *per ml. of duodenal or gastric juice*

	Stomach		Duodenum		
Case	pH	*Bact. coli*, no. per ml.	pH	Trypsin, units per ml.	*Bact. coli*, no. per ml.
7	2·8	0	7·2	40	5,500,000,000
8	4·5	5,000,000	6	40	7,500,000
9	4·5	55,000	6·4	—	2,000,000
10	4·5	0	5	—	6,500,000
11	—	—	—	—	150,000
12	—	25,000	—	—	0
13	—	—	6·8	20	2,500
14	—	—	7	160	0
15	—	—	—	—	0

former, containing stomach juice, was placed in a bowl of ice. After 5 more minutes enough clear golden-yellow duodenal juice had collected in the second test-tube and the rubber tube was withdrawn. The second test-tube, with duodenal juice, was placed in the bowl of ice which was transported to the laboratory, and the tests were made within the hour. The stomach juice was very acid (pH 2·8) and sterile; the duodenal juice had a pH of 7·2 and contained 5,500,000,000 *Bact. coli* O 55 per ml. A sample of faeces contained not many more (10,000,000,000).

Cases 11–15 were no longer vomiting though still suffering from diarrhoea, and cases 11, 12 and 15 were receiving chemotherapeutic drugs when the specimens were collected. There thus appeared to be a correlation between the numbers of bacilli found in the upper gut and the severity of the disease.

Group 2 (Table 8). Babies convalescing from gastro-enteritis but still excreting *Bact. coli* O 111, O 55 or O 26 in the faeces.

In none of these cases were *Bact. coli* O 111, O 55 or O 26 found in the duodenum.

Table 8. *Number of* Bact. coli *per ml. of duodenal or gastric juice*

	Stomach		Duodenum		
Case	pH	*Bact. coli*, no. per ml.	pH	Trypsin, units per ml.	*Bact. coli*, no. per ml.
16	6·5	0	—	80	0
17	7·6	0	7·6	—	0
18	—	—	6·5	—	0
19	—	—	—	—	0
20	4·6	5,000,000	6·4	—	1,000

The duodenal juice of only one case contained *Bact. coli* in small numbers (1000 per ml.), but as the stomach juice contained 5,000,000 per ml. it is likely that some traces of stomach juice in the sample of duodenal juice accounted for the result. It will be noted in this and other tables that the pH of stomach juice of babies was often surprisingly high, and a juice with a pH more than 3·5 cannot be expected to be free of bacteria.

Group 3 (Table 9). Cases of gastro-enteritis not infected by *Bact. coli* O 111, O 55 or O 26, and examined early in the disease.

Table 9. *Number of* Bact. coli *per ml. of duodenal or gastric juice*

	Stomach		Duodenum		
Case	pH	*Bact. coli*, no. per ml.	pH	Trypsin, units per ml.	*Bact. coli*, no. per ml.
21	5·2	0	7	320	0
22	4·4	0	6	160	0
23	—	—	6·6	80	0
24	4·5	0	6·5	80	0
25	—	—	6·7	10	0
26	—	—	6·7	80	0
27	—	—	6	160	0
28	—	—	7·2	40	0
29	—	—	6·7	—	0
30	4·5	0	6·4	40	0
31	3·6	0	6·2	10	0
32	6·5	0	6·8	10	0
33	5·6	500	7·2	20	0
34	—	—	6·6	20	10,000
35	—	—	—	—	500

Only two of these babies harboured *Bact. coli* in the duodenum and then only in very small numbers. These strains were not *Bact. coli* O 111, O 55 or O 26, etc.

It must be admitted that these cases on the whole were less seriously ill than were those described in Table 7.

Group 4 (Table 10). Babies with no gastro-intestinal upset. From only one case were a few *Bact. coli* isolated. They were not *Bact. coli* O 111, O 55, or O 26, etc.

In spite of the fact that duodenal intubation is not a strictly sterile operation samples of duodenal juice taken in this way were virtually free from *Bact. coli* except those taken from cases of gastro-enteritis associated with the suspected varieties of *Bact. coli* (O 111, O 55, O 26, etc.). In most of these cases very large numbers were found, the numbers leaving no doubt that the organisms were actively multiplying in the duodenum. It was indeed surprising that the numbers in the duodenum were as high as they were, considering the very large volumes of allegedly sterile fluid which pour into the duodenum from the biliary tract, the pancreas and stomach.

During the course of these studies the suspicion arose that the stomach was frequently far from being sterile, and this depended very much upon its pH. Coliforms may be present in the stomach if the pH is above 4, and in some

instances the pH was much above this. Under these circumstances small numbers may be found in duodenal juice in samples taken by tubes which have passed through the stomach. It was unfortunate that samples of stomach juice were not regularly collected, but it happened, that in the early stages of the investigation, as a result of the earlier post-mortem results, it was samples of bile that were specially sought. Attempts were made, therefore, to get the duodenal tubes through the stomach as quickly as possible before acid collected in the tube.

Table 10. *Number of* Bact. coli *per ml. of duodenal juice*

	Duodenum		
Case	pH	Trypsin, units per ml.	*Bact. coli*, no. per ml.
36	6·8	20	0
37	6·8	160	0
38	6·8	320	0
39	6·2	640	0
40	6·8	320	0
41	6·4	80	0
42	6·6	0*	0
43	6·5	4	0
44	6·8	80	0
45	6·7	320	0
46	6·7	160	0
47	6·6	80	1500

* Clinical diagnosis, fibrocystic disease.

In a number of cases *Strep. faecalis* was found in the duodenal juice in small numbers but they were not associated with any particular group of cases.

It is clear that the results would not have been so impressive if the tests had not been made on a quantitative basis. In the usual qualitative tests 50 normal *Bact. coli* per ml. from a normal baby and 5,000,000,000 *Bact. coli* O 55 per ml. from a baby with gastro-enteritis would carry equal weight, both being positive. There is clearly a place for bacteriological tests to be made on a quantitative basis.

In Asiatic cholera there is severe diarrhoea associated with vomiting leading to serious dehydration; at autopsy the gut is not inflamed in the pathological sense; vibrios are present in enormous numbers in the lumen throughout the whole length of the small intestine, and at autopsy are found in the majority of cases to be present in the bile in large numbers. Clinically, pathologically and bacteriologically, therefore, there are striking resemblances between gastro-enteritis of babies and cholera. The old name 'cholera infantum' was apt.

SUMMARY

1. In gastro-enteritis of babies caused by pathogenic varieties of *Bact. coli* the infection extends up the whole length of the small gut. Quantitative bacteriological examinations showed the contents of the upper intestine to harbour *Bact. coli* in numbers usually found only in faeces.

2. *Bact. coli* O 111, O 55, O 26, etc. are pathogens.

3. The syndrome of gastro-enteritis of babies associated with *Bact. coli* resembles cholera clinically, pathologically and bacteriologically.

4. There is a place in bacteriology for quantitative tests as distinct from qualitative tests.

I owe my thanks to many people: to Dr A. H. James for teaching me his methods of getting samples of duodenal juice; to Prof. A. G. Watkins, Dr P. T. Bray, Dr Emrys Harries, Dr S. Rosehill, Dr Bowen Owen and Dr W. R. Nash for allowing me access to their patients; to Dr T. E. Parry, Dr W. Mackay and Dr R. D. Gray for allowing me to attend and collect specimens from autopsies; it would be ungracious not to thank several ward sisters to whom I must have been a great nuisance. To my technician John Smith I am exceedingly indebted.

REFERENCES

Adam, A. (1922). *Jb. Kinderheilk.* **99**, 86.
Adam, A. (1923). *Jb. Kinderheilk.* **101**, 295.
Adam, A. (1927). *Jb. Kinderheilk.* **116**, 8.
Barber, M. & Franklin, R. H. (1946). *Brit. med. J.* i, 951.
Barbero, C. J., Runge, G., Fischer, D., Crawford, M. N., Torres, F. E. & Gyorgy, P. (1952). *J. Pediat.* **40**, 152.
Bessau, G. & Bossert, O. (1919). *Jb. Kinderheilk.* **89**, 213, 269.
Blacklock, J. W. S., Guthrie, K. G. & Macpherson, I. (1937). *J. Path. Bact.* **44**, 321.
Cregan, J. & Hayward, N. J. (1953). *Brit. med. J.* i, 1356.
Cregan, J., Dunlop, E. E. & Hayward, N. J. (1953). *Brit. med. J.* ii, 1248.
Davison, W. C. (1925). *Amer. J. Dis. Child.* **29**, 743.
Ferguson, W. W. & June, R. C. (1952). *Amer. J. Hyg.* **55**, 155.
Goldschmidt, R. (1933). *Jb. Kinderheilk.* **139**, 318.
James, A. H. (1951). *Lancet*, i, 209.
Kirby, A. C., Hall, E. G. & Coackley, W. (1950). *Lancet*, i, 201.
Knott, F. A. (1927). *Guys Hosp. Rep.* **77**, 1.
Miles, A. A. & Misra, S. S. (1938). *J. Hyg., Camb.*, **38**, 732.
Moro, E. (1916). *Jb. Kinderheilk.* **84**, 1.
Nichols, A. C. & Glenn, P. M. (1940). *J. Lab. clin. Med.* **25**, 388.
Ricen, L., Sears, H. J. & Downing, L. M. (1928). *Amer. J. med. Sci.* **175**, 386.
Thomson, S. (1954). *J. Hyg., Camb.*, **52**, 67.
Thomson, S. (1955). *J. Hyg., Camb.* (in the Press).
Venables, J. F. & Knott, F. A. (1924). *Guys Hosp. Rep.* **74**, 245.

(*MS. received for publication* 25. iv. 55)