Dehydration Due to Infantile Gastroenteritis

A STUDY OF DIFFERENT APPROACHES TO TREATMENT

BY

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Introduction

For many years to come a significant number of the children who threaten the world in the shape of the "population explosion" will spend much of their infancy being treated for "summer diarrhoea." The quality of their treatment will depend mainly on where they happen to find medical care, but in general will fall into one of three groups.

(1) *Emergency Treatment*

This group is characterised by many patients and few medical staff, ward facilities are unavailable or overcrowded, no laboratory investigations are performed and hydration is attempted by the oral route, or at best by intragastric, subcutaneous or occasionally intraperitoneal drip.

(2) *Good Routine Treatment*

In this group patients are admitted to hospital or treated in adequately supervised outpatient departments. Intravenous or sometimes in suitable cases subcutaneous fluids are given, prescribed by reference to set rules derived from previous experience. Electrolyte estimations are not as a rule obtained, but may be available if special problems arise. Intermittent medical supervision, predominantly by junior house staff, is usual.

(3) *Optimal Treatment*

This group receives the best treatment possible within the limitations of present knowledge. Patients are admitted to the wards of a central hospital, laboratory investigations are routine in every case and are repeated to monitor treatment. There is frequent observation by experienced and interested medical personnel, and therapy is modified accordingly; potential complications of disease and treatment are conscientiously sought and treated. This situation can be observed only where there are more than adequate medical, hospital and laboratory facilities, or in units fanatically devoted to the study and treatment of dehydration.

The results of untreated severe dehydration under present conditions cannot be ethically studied, but mortality is likely to be well over 50 per cent. At the other extreme, in areas where malnutrition is prevalent and parents are often unable or unwilling to bring children to hospital in the early stages of illness, a group of 5 per cent. or more exists who cannot be saved by any treatment. The majority of the remainder can probably be effectively treated under (1) or (2) above; thus, in Chile, Meneghello *et al.* (1960) report a mortality of 11 per cent., or in certain circumstances much less, with outpatient intragastric therapy, and in Cape Town, Bowie (1960) used the subcutaneous route in a large number of cases with a mortality of less than 7.4 per cent. In both these studies, however, intravenous therapy and care in hospital were available to the more severe cases; and when such facilities were not available, as in the experience of Morley and Woodland (1965) in a West African village, the mortality rose to 30 per cent.

In addition there is presumably a group of patients who will not be adequately treated by (1) and (2) above, who will in fact die despite treatment under these conditions, but will be saved by treatment as in (3). Cynically, but perhaps realistically, many workers would deny that the proportion of patients in this group is significant. This view would be strenuously opposed by those engaged in applying "optimal" treatment, but even they would have to admit that the law of diminishing returns applies to the relatively small improvement in mortality which can be expected as a result of a large increase in efficiency of study and treatment. It is particularly important in a hospital where resources are already strained, as in most centres in Africa, to assess whether the increase in expense and labour involved in attempting "optimal" treatment is justified in terms of the number of patients who may benefit thereby. The present study is an attempt to provide an answer to this problem.

Material and Methods

The problem posed above obviously cannot be answered by considering results of treatment in two different populations or in one population over different intervals of time. The author was, however, in the fortunate position of having access to information collected during a study of gastroenteritis at Coronation Hospital, Johannesburg, over the period July, 1959, to June, 1964, in which patients from the same population received a variety of differing forms of treatment over the same period. This information was gathered prospectively in the course of various

aspects of the study, but has been classified retrospectively for the purpose of this paper. General information about the whole series is summarised in Table I.

Only cases with over 10 per cent. dehydration were included in the present survey, as it was felt that milder cases would probably have benefited equally from any form of treatment. Dehydration was considered to be over 10 per cent. if weight gain on rehydration (excluding over-hydration) was more than 10 per cent. of body weight, or, in cases where continuing dehydration made this criterion invalid, if severe signs of dehydra-

Table I

Summary of All Cases of Gastroenteritis—July, 1959, to June, 1964

	1959-60	1960-61	1961-62	1962-63	1963-64	TOTAL
Total cases	563	526	407	423	488	2,407
>10% dehydrated*	149	189	110	99	136	683
<10% dehydrated*	263	245	233	242	272	1,255
Dehydration unknown†	151	92	64	82	80	469
Total deaths	82	53	63	58	46	302
Percentage deaths	14.6%	10.1%	15.5%	13.7%	9.4%	12.5%

* Estimated by weight gain on rehydration.

† Due to continuing dehydration or death.

Table II

Causes of Deaths Excluded from Survey

Cause of Death	1959-60	1960-61	1961-62	1962-63	1963-64	Total
Bronchopneumonia, empyema, lung abscess	3	0	5	4	1	13
Measles	3	0	2	0	0	5
Severe malnutrition	0	2	2	2	2	8
Poor treatment:—						
no intravenous fluid	1	0	0	0	1	2
hypernatraemia, no potassium given	1	0	0	0	0	1
M/6 lactate + sodium bicarbonate given	0	0	1	0	0	1
excess potassium with hypocalcaemia	0	0	1	0	0	1
overtreatment with hypertonic NaCl	0	0	0	1	0	1
internal jugular puncture in the presence of low prothrombin index	0	1	0	0	0	1
nursing error resulted in excess potassium administration	1	1	0	0	0	2
Death during first hour	4	2	5	6	9	26
Insufficient information to assign to either group	9	5	4	2	3	23
Not clinically >10% dehydrated	3	2	1	1	0	7
Miscellaneous: septicaemia, chicken pox, encephalitis, congenital syphilis, severe congenital abnormalities, tetralogy of Fallot, adrenal adenoma, hypoglycaemia, salicylate intoxication	1	5	3	2	3	14
TOTALS	26	18	24	18	19	105

tion usually associated with over 10 per cent. body weight loss were present. Cases who died of dehydration* were considered to have been suffering from over 10 per cent. dehydration except in a few instances where clinical signs indicated the contrary. Cases who did not receive good treatment by the criteria of routine or optimum regimes were excluded from the survey, and deaths were excluded if it was considered that factors other than dehydration were the primary cause of death, or if death occurred less than one hour after admission. Details of deaths excluded are given in Table II.

The survey finally included 853 cases and these were separated into two groups.

Group A—Optimum Treatment

Laboratory investigations (i.e., at least sodium, potassium, CO_2 combining power and blood urea, and often chloride, calcium, sugar, haemoglobin and haematocrit) were obtained in all cases on initiation of treatment. Results were obtained as soon as possible and treatment was modified accordingly and investigations repeated if indicated. At any sign of deterioration or poor response to treatment, investigations were repeated and acted upon. All cases were admitted to hospital and received intravenous therapy.

Group B—Good Routine Treatment

Patients received treatment consistent with good routine practice based on considerable previous experience at the hospital. Laboratory investigations were not carried out routinely, but were obtained if the patient's condition deteriorated or if there was doubt as to whether treatment was appropriate. Cases were also included in whom initial investigations were carried out, but in whom modification of treatment indicated according to the results was not carried out. The vast majority were admitted to hospital and all received intravenous therapy.

The reasons for patients having received differing treatment, as well as the possibilities of bias and the comparability of the two groups, are considered below under "Discussion."

RESULTS

The total numbers of cases and deaths in the two groups in each year of the survey are shown in Fig. 1, and Table III shows the figures for the whole period. Table III also shows the numbers of cases in each group who survived but required prolonged hospitalisation (10 days or longer).

Table III

RESULTS IN GROUPS A AND B

	Group A	Group B
Total number of cases	409	444
Prolonged hospitalisation	147 (35.9%)	121 (27.2%)
Deaths	42 (10.3%)	155 (35.0%)

It is clear that the mortality in Group A, the group receiving "optimal" treatment, is considerably lower than in Group B, the difference being highly significant statistically. On the other hand, Group B contained fewer patients who required prolonged hospital treatment, but this difference is not significant.

DISCUSSION

In view of the striking difference in results shown above, it must be emphasised that patients in Group B were well managed according to a system of treatment which was felt to be quite adequate in the situation obtaining in the hospital at the time, and any who received inadequate or erroneous treatment were excluded from the survey. The major point in which their treatment may be felt to have been inferior is in the lack of initial electrolyte studies, but it has been authoritatively stated (Cooke, 1955) that such investigations, though helpful, are not essential in the initial management of severe dehydration. Even from a leading world centre one may quote a series of 307 patients of whom only 105 had initial electrolyte determinations (Darrow and Welsh, 1960). The treatment of Group A arose as a byproduct of various research projects which were in fact criticised for the load they inflicted on laboratory and medical staff without any visible benefit to the patients.

As this is a retrospective study there was no true randomisation of patients entering the two groups; on the other hand, there was no obvious selection except in that the type of treatment a patient received depended on whether he was admitted during the hours of duty of the members of staff interested in the research projects or not. Admission at night made no difference to the facilities available or the treatment received. Occasionally chance factors operated—as, for instance, if a specimen was lost or results were delayed, a patient destined for Group A would enter Group B. There was also a tendency for more severely ill patients to be specially investigated and thus enter Group A, but this would be expected to produce a bias opposite to the observed results. It is implicit in this method of selection that it resulted in Group A being under more constant and accurate medical observation than Group B, but this does not detract from the value of the study, as close observation is an

* "Dehydration" is here used in its common sense of combined water loss and electrolyte disturbance.

essential part of "optimal" treatment. It does mean, however, that the better results obtained in Group A were associated with a host of factors other than the mere collection of a mass of laboratory data.

It can be seen from Fig. 1 that though the total mortality varied considerably from year to year, the relation between the mortalities of Groups A and B remained remarkably constant, supporting the conclusion that the difference was due to a consistently operating factor, not chance variation. Fig. 1 also illustrates how the Group A treatment became more popular as the study progressed until in the last year less than one-third of the patients belonged to Group B.

Comparability of Groups

In view of the possibly unsatisfactory selection of patients, an attempt was made to assess the comparability of the two groups. Factors which would be liable to affect mortality and which could be studied were age and nutritional status. Nutrition was assessed clinically, and this assessment agreed fairly closely with that based on expected weights for age. Table IV summarises this information.

Close matching of the two groups was observed with respect to age and nutrition, supporting the contention that there was not undue bias due to selection of cases. As might be expected, the superiority in the survival rate of Group A patients is somewhat more marked in the younger and more malnourished children. An attempt was made to compare the degree of dehydration in the patients of the two groups and no significant difference was demonstrated, but as in over 400 patients accurate information was not available because of death or prolonged or recurrent dehydration, no great reliance could be placed in these figures.

Problems Encountered in Group A

The following summary of the problems elucidated in the patients of Group A provides some justification for the claim that the lower mortality of this group was in fact due to the greater opportunity for rational treatment of these patients afforded by their more intensive investigation.

Hypernatraemia (sodium > 145 mEq/l.) was found in 49 patients; in these it was possible to avoid further deterioration which could have been caused by high sodium fluids, particularly in the

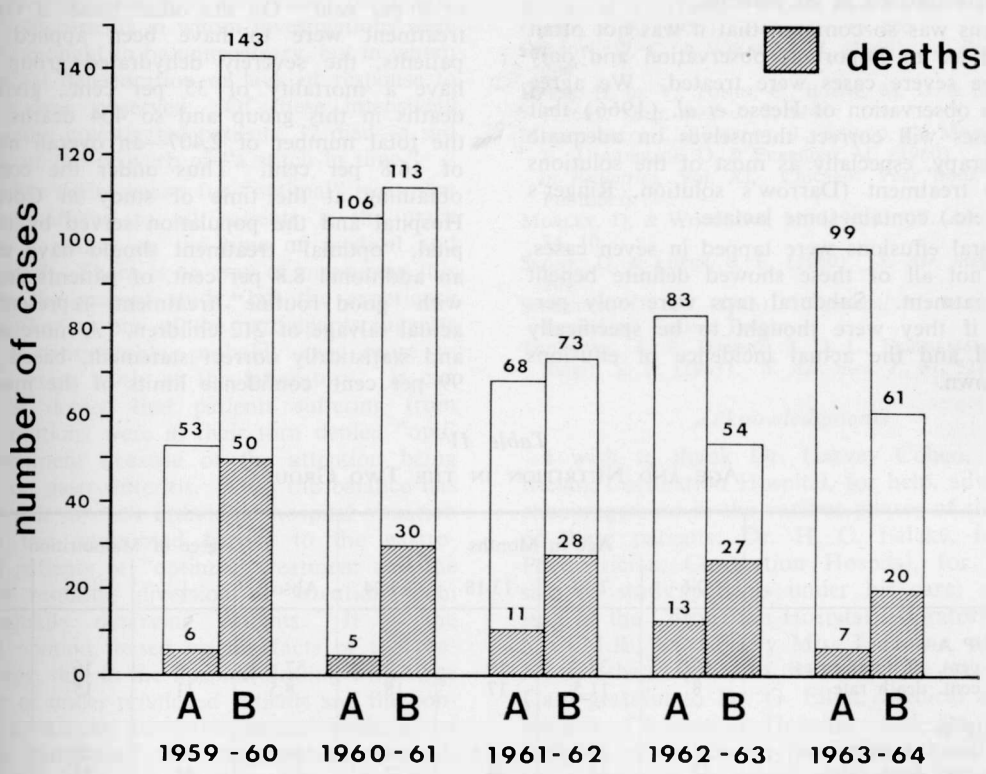

Fig. 1—Total number of cases and number of deaths in Group A ("Optimal Treatment") and B ("Good Routine Treatment").

treatment of acidosis. Definitive treatment for hypernatraemia was not considered necessary except in those patients with sodium levels over 155 mEq/l.

Hypernatraemia sodium > 125 mEq/l.) was found in 104 patients; again judicious therapy avoided deterioration, while in 34 with levels under 115 mEq/l. treatment with hypertonic sodium solutions probably saved some lives.

Hyperkalaemia (potassium > 5.5 mEq/l.) was seen in 20 patients, but was only of interest in a few of these in whom early potassium therapy was contemplated.

Hypokalaemia (potassium < 3.5 mEq/l.) occurred in 129 patients and was severe (potassium < 1.5 mEq/l.) in 38. In many of these early potassium therapy was probably life-saving, and fatalities due to glucose administration in attempts at rususcitation were avoided.

Hypocalcaemia (calcium < 3.5 mEq/l.) was seen in 14 cases, but was only considered important if it was producing symptoms, in which case treatment seemed to be beneficial. The incidence of this obscure complication may have been higher than the figures indicate, because calcium levels were not estimated in all patients.

Acidosis was so common that it was not often regarded as an important observation and only the more severe cases were treated. We agree with the observation of Heese *et al.* (1966) that most cases will correct themselves on adequate fluid therapy, especially as most of the solutions used in treatment (Darrow's solution, Ringer's lactate, etc.) contain some lactate.

Subdural effusions were tapped in seven cases, though not all of these showed definite benefit from treatment. Subdural taps were only performed if they were thought to be specifically indicated and the actual incidence of effusions is unknown.

The frequency and nature of severe electrolyte disturbances in our patients may appear unusual if judged by British and North American standards. However, they agree well with figures from Baragwanath Hospital in Johannesburg (Slone and Levin, 1960) and from Cape Town (Bowie *et al.*, 1958; Truswell *et al.*, 1963) and are probably representative of what may be expected in any similar population in Africa.

Effect on Overall Mortality

The difference in mortality between the 10.3 per cent. of Group A and the 35 per cent. of Group B is at first sight spectacular, but it must be borne in mind that it applies only to the selected group of severely dehydrated patients and excludes the 105 deaths summaried in Table II. A more realistic way of regarding the figures is to attempt to estimate the difference in mortality which would result from the application of the methods of Group A or Group B to all cases of gastroenteritis. Thus if Group A treatment were to have been applied to all cases, one would expect a mortality of 10.3 per cent. in the whole group of severely dehydrated patients, giving 88 deaths in this group and so 193 deaths out of the total number of 2,407—an overall mortality of 8 per cent. On the other hand, if Group B treatment were to have been applied to all patients, the severely dehydrated group would have a mortality of 35 per cent., giving 299 deaths in this group and so 404 deaths out of the total number of 2,407—an overall mortality of 16.8 per cent. Thus under the conditions obtaining at the time of study in Coronation Hospital and the population served by the hospital, "optimal" treatment should have salvaged an additional 8.8 per cent. of patients compared with "good routine" treatment—representing an actual salvage of 212 children. A more cautious and statistically correct statement, based on the 99 per cent. confidence limits of the mortalities

Table IV

Age and Nutrition in the Two Groups

	Age in Months				Degree of Malnutrition			
	0-6	7-12	13-18	19-24	Absent	+	++	+++
GROUP A—								
Per cent. of total cases	57.5	30	10	2.5	57	26	16	1
Per cent. death rate	8	11.5	17	18	8.5	11	15	25
GROUP B—								
Per cent. of total cases	58	26.5	11.5	4	56	23	20	1
Per cent. death rate	32	41	34	32	23	41	55	70

in the two groups (Snedecor, 1946), would be that the expected difference in mortality between the two forms of treatment is between 5.2 per cent. and 11.7 per cent., all conditions being the same as in the present study. Application of these results requires further caution, as there are plentiful sources of error in the method of selection of cases and in the over-idealisation and possibilities of bias in the method of study. In applicatiton to different populations even more errors may arise, though it can be stated that the difference in mortality would be more marked with a greater proportion of very young or malnourished cases, and less marked where a large number of deaths are due to complications as listed in Table II.

Effect on Load on the Laboratory

As an indication of the extra load thrown on the laboratory by Group A treatment, it is interesting to note that in Group A 854 sets of investigations, each of at least four and often as many as eight individual determinations, were performed on 409 patients, whereas in Group B 506 sets, rarely of more than five determinations, were performed on 444 patients. Of these, 120 sets of investigations were performed on a subgroup of 40 patients in whom investigations were originally thought to be unnecessary, but in whom later clinical deterioration or lack of response to treatment was observed. Of these intensively but belatedly investigated patients, 32 died—a sad reminder of the proverb of "a stitch in time."

The other main reason for "optimal" treatment not being offered to all patients is the extra demands it makes on the time of medical and nursing staff. There is no way of measuring this factor in the present study, but the experience of the author as one of the participants suggests that it is considerable, probably even more so than the extra work of the laboratory. It can hardly be denied that patients suffering from other conditions were in their turn denied "optimal" treatment because of the attention being focused on gastroenteritis. Thus the balance has to be struck in each individual hospital situation between the undoubted benefit to the gastroenteritis patients of "optimal" treatment and the probable resulting diversion of attention from other equally deserving patients. It is the author's opinion, based on the facts of the present survey, that in the hospital dealing with large numbers of under-privileged patients and the consequent apparently inevitable annual epidemic of "summer diarrhoea," that the numbers of children saved can be high enough to provide ample justification for such a diversion.

Summary and Conclusions

A study is presented of the effects of treatment on the mortality rate of 853 cases of severe dehydration due to gastroenteritis over a five-year period in Coronation Hospital, Johannesburg. One group (444 cases) received good routine investigation and treatment; the other (409 cases) received the best investigation and treatment possible in the circumstances. The mortality of the two groups was 35 per cent. and 10.3 per cent. respectively. It is estimated that the two types of treatment, if applied to all cases of gastroenteritis presenting with dehydration during the five-year period (2,407 cases) would have resulted in mortality rates differing by between 5.2 per cent. and 11.7 per cent.

It is concluded that it would be justified to apply the best possible investigation and treatment to all cases, though this would result in a straining of hospital resources which could possibly be detrimental to patients suffering from other conditions.

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