ORAL REHYDRATION

A LIFESAVING TREATMENT FOR DEHYDRATION DUE TO ANY CAUSE

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CONTENTS

(If reading onscreen, open the Bookmarks pane to browse to any heading.)

Disclaimers, Warnings and Acknowledgements

Please see the disclaimers, warnings and acknowledgements relating to the whole series in the first article of the series, entitled ***About the Wanterfall eBooks Travel Health Series***.[1]

Series Context

This article should be read in conjunction with all articles in the Wanterfall eBooks Travel Health series which mention conditions that may cause excessive fluid loss with consequent dehydration. ***It is also relevant to the care of any person, regardless of age, and whether a traveller or not, who becomes dehydrated for any reason***.

Introduction

Dehydration is always dangerous, and unless it is properly treated, it frequently results in permanent disability or death. In 2009, a report published jointly by The World Health Organisation (WHO) and the United Nations Children's Fund (UNICEF) estimated that about 1.5 million children under the age of five years still die each year as a result of the commonest cause of dehydration, which is diarrhoea.[2] If deaths of older children and adults, and causes of dehydration other than diarrhoea, were included, it would obviously increase that figure considerably. And yet a few cents' worth of sugar, salt and water, given to the patient to drink, can almost always

[1] www.wanterfall.com/Travel-Health/Travel-Health-Series-Introduction.htm

[2] The United Nations Children's Fund (UNICEF)/World Health Organization (WHO). 2009. Diarrhoea: Why children are still dying and what can be done, p. 1 (Note: p.1 is identified as p. 9 when reading the PDF version onscreen). ISBN 978-92-806-4462-3 (UNICEF)

correct dehydration before it becomes serious. This article explains how to do just that.

Of course, the underlying illness may also require treatment, so unless the patient recovers quickly and fully, medical care should still be accessed as soon as possible. However, regardless of any other aspect of treatment, rehydration (the correction of dehydration) is almost always the most urgent intervention for any dehydrated patient.

Most people know that diseases like cholera, typhoid and dysentery can cause death by dehydration. But many common conditions, such as gastric flu, heat exhaustion and food poisoning, can also lead to tragic and unnecessary deaths, sometimes in the space of a few hours, simply because of untreated dehydration. Although such rapid deterioration is more common in infants, children and elderly or infirm adults, it can occur at any age.

The commonest reason for dehydration in a previously healthy person is diarrhoea and/or vomiting, and these in turn have many possible causes. However, a great many other things can also lead to dehydration. Examples include inadequate fluid intake; excessive salt intake; exercise, especially in hot, humid conditions; fever, regardless of its cause; many medical and surgical conditions; various recreational drugs, such as "ecstasy"; and many prescribed medications as well.

Some of the many causes of dehydration which are of particular significance to travellers, such as the very common condition of "traveller's diarrhoea", will be the subject of future articles in this series. In this article, though, I will not say anything more about the *causes* of dehydration. Nor will I say anything about their *specific treatments*, though treatment of the cause is obviously important whenever it is possible. In this article, I will just explain how to *correct the dehydration*, before it causes permanent disability or death.

In hospitals, of course, dehydration is often treated by intravenous therapy, infusing a solution containing water, glucose and electrolytes (mainly sodium and potassium salts) into a vein. Rehydration fluids can also be given via a nasogastric tube. However, the vast majority of cases of dehydration can be corrected by encouraging the patient to drink the appropriate fluid, and that is my topic in this article.

The Three Essential Questions: What fluid? How fast? How much?

There are really only three essential questions to ask and answer about oral rehydration:

- The first question is ***what fluid*** to give the patient, as some fluids are lifesaving, while others would be lethal
- The second question is ***how fast*** the patient should drink that fluid, for maximum benefit with minimal side effects
- The third question is ***how much*** fluid to give, before reverting to normal fluid and nutrient intake

Each of these three questions has quite a simple answer, which I will explain below. Each of those simple answers could be expanded considerably by discussing alternative approaches and special circumstances, but I will only do that to a very limited degree in the present article. There are many ways to do most things, but there is rarely any need to know all of them.

Although no medical training is required to accomplish oral rehydration, it is essential to follow the instructions very carefully. In particular, oral rehydration fluids which are too *weak* work less well, while oral rehydration fluids which are too *strong* are always harmful, and sometimes *lethal*.

Before going on to discuss the three essentials of oral rehydration, there is one very important point to stress.

Although mild or moderate degrees of dehydration can usually be corrected by oral rehydration, ***severe dehydration always requires medical treatment as a matter of urgency***, in order that fluids can be given intravenously or nasogastrically until the degree of dehydration is no longer severe.

However, if medical treatment is not readily accessible, or simply while waiting for an ambulance to arrive, whatever amount of oral rehydration fluid can be tolerated may still make the difference between life and death, or between full recovery and permanent disability. A severely dehydrated patient should therefore drink oral rehydration fluid as fast as possible while awaiting transfer to hospital. (In that situation, the oral rehydration fluid is first aid, rather than treatment.)

What Fluid to Give

Although water is the main component of most abnormal fluid losses from the body, it is never the *only* component. Because of this, replacing fluid losses with plain drinking water, though usually much better than nothing, is very far from being the ideal treatment for dehydration. The most important substance usually lost along with the water is common salt. However, the salt *cannot* be replaced simply by giving the patient salty water to drink. As will be explained, that just makes matters *worse*.

Before discussing appropriate oral rehydration fluids, it should be mentioned that breast-fed infants should continue to be breast-fed, *in addition* to receiving whatever amount of supplemental oral rehydration fluid is necessary to correct and maintain hydration. This is not only because breast milk contains many important nutrients, but also because it transfers valuable resistance to a wide range of infections.

Absorption Problems

Absorption of fluids taken by mouth is especially problematic in the case of diarrhoeal illnesses. This is because inflammation of the intestinal mucosa (the inner lining of the intestine) impairs its ability to absorb water into the bloodstream. In this situation, drinking plain water is surprisingly ineffective. When the water reaches the intestine, most of it remains there, simply moving downwards until it is finally excreted. This just makes the diarrhoea more copious and more liquid, without reducing the degree of dehydration nearly as much as might be expected.

Knowing that salt has also been lost, it might be tempting to add some salt to the water offered to the patient. However, this makes matters *even worse* – in fact, it can prove fatal. When the salty water reaches the intestine, it actually sucks water *into* the intestine *from* the bloodstream, by osmosis[3], thus further exacerbating both the diarrhoea and the degree of dehydration.

Science to the Rescue

Fortunately, about fifty years ago, it was discovered that *adding sugar* to salt solutions given by mouth results in much more effective absorption of both the salt *and* the water. Experiments showed that each glucose molecule absorbed from the intestine into the bloodstream can "co-transport" one sodium atom (called a sodium "ion" when dissolved in water).[4]

The resulting concentration of glucose molecules and sodium ions in the bloodstream then causes the osmotic movement of

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[3] Osmosis is the tendency for a solvent such as water to move through a semi-permeable membrane towards the side which has the more concentrated solution, thus gradually equalising the concentrations.

[4] Crane RK, Miller D & Bihler I, "The restrictions on possible mechanisms of intestinal transport of sugars", In: Membrane Transport and Metabolism. Proceedings of a Symposium held in Prague, August 22-27, 1960. Edited by A. Kleinzeller and A. Kotyk. Czech Academy of Sciences, Prague, 1961, pp. 439-449.

water across the intestinal mucosa to occur in the *desired* direction. In other words, the desperately needed salt and water are *both* absorbed very efficiently, as long as a suitable amount of glucose (or something which is easily digested to glucose) is also present in the fluid which the patient drinks.

The discovery of the vital importance of glucose in the absorption of salt and water by the intestine when it is inflamed was arguably the most significant medical advance of the twentieth century.[5] Clinical experiments following on from this discovery gradually led to the development and widespread use of cheap and effective oral rehydration fluids.

As a result of the availability of these cheap and effective oral rehydration fluids, millions of lives are saved each year. However, millions more are not saved. For example, in the case of young children in developing countries, fewer than half of those who need this treatment actually receive it.[6] Oral rehydration fluid is cheap to make and easy to administer, but it can only save lives if it is given to the patients who need it.

Ready-made Oral Rehydration Fluids

WHO and UNICEF have taken a leading role in advising on the formulation and administration of oral rehydration fluids.[7]

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[5] On the 5th of August, 1978, an editorial in the prestigious Lancet ('Water with sugar and salt', The Lancet, Vol. 312, No. 8084, pp. 300-301) stated that "The discovery that sodium transport and glucose transport are coupled in the small intestine, so that glucose accelerates absorption of solute and water, was potentially the most important medical advance of the [twentieth] century".

[6] The United Nations Children’s Fund (UNICEF)/World Health Organization (WHO). 2009. Diarrhoea: Why children are still dying and what can be done, p. 1 (Note: p.1 is identified as p. 9 when reading the PDF version onscreen). ISBN 978-92-806-4462-3 (UNICEF)

[7] A great deal of information about the WHO/UNICEF recommendations is provided by The Mother and Child Health and Education Trust Rehydration Project, published online at http://rehydrate.org/ (accessed 21 June 2010).

The non-proprietary name for the formulation jointly recommended by these bodies is Oral Rehydration Salts (ORS) Solution.[8] The United States Centers for Disease Control and Prevention (CDC) website also provides a great deal of expert advice about oral rehydration.[9]

ORS solution is prepared by dissolving the contents of sachets of dry ingredients (or sometimes tablets) in water. The contents of each sachet must be dissolved in the *correct amount*[10], as stated on the packet, of *safe drinking water*[11]. Importantly, the contents of a packet must *not* be subdivided.[12] Clean utensils must, of course, be used at every stage in the preparation and administration of the solution.

Careful measurement is essential. Adding too *little* water makes the resulting solution too *strong*, which can harm the patient. Indeed, drinking a solution which is much too strong could easily be *fatal*. Adding too much water, though not nearly as dangerous as adding too little, makes the solution less effective. While measurement errors of ten per cent or less are

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[8] See Appendix 1 for the currently recommended formula. [Although the solution actually contains much more sugar than salts, the name "Oral Rehydration Salts Solution" is probably here to stay.]

[9] E.g. http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5216a1.htm (accessed 17 June 2010).

[10] If the wrong amount of water is used, the resulting solution will either be less effective (if it is too weak) or potentially lethal (if it is too strong).

[11] If water which is not definitely fit for drinking is used, it might contain microorganisms or toxins, so the treatment might itself cause a new illness.

[12] Even if the dry ingredients were originally mixed evenly (which is not easy) it is quite conceivable that they might become less homogeneous over time. In that case, if the contents of a sachet were divided into two or more portions, there would be no guarantee that each portion would contain exactly the same *proportions* of each ingredient.

unlikely to have serious consequences, tolerances closer to one per cent are preferable and should usually be achievable.

The prepared solution should be kept covered, to prevent contamination from the environment. Even when so covered, any unused solution should be discarded after about 24 hours (sooner in hot weather, later if refrigerated) as some degree of contamination is inevitable. (Therefore, if too large an amount is prepared at one time, some of it may have to be wasted.)

Unfortunately, both the name Oral Rehydration Salts, and its abbreviation ORS, are very frequently used to refer to the prepared solution, as well as the dry ingredients from which that solution is prepared. However, as long as it is remembered that it is drinking the correctly prepared solution which saves life, whereas eating the dry ingredients would simply hasten death, this very common careless terminology, though foolish and potentially confusing, should do no harm.

The formulation currently recommended by WHO and UNICEF, which has not been changed since the concentrations were reduced slightly in 2002, is shown in ***Appendix 1***. Variations within a published range are considered acceptable, and reputable proprietary rehydration fluids such as Gastrolyte ® and Pedialyte ®, though usually not identical to WHO/UNICEF ORS solution, are nevertheless very effective.

The majority of "sports drinks", on the other hand, contain far too much sugar, and vary wildly in their salt content. Some of these popular and intensively marketed beverages are probably only marginally safe for consumption by healthy adults. Few, if any, would qualify as satisfactory oral rehydration fluids.

Because of the importance of the correct ingredients and their concentrations, ready-made oral rehydration fluid from a reputable source, prepared according to the accompanying directions, should always be used if available. However, various home-made alternatives can also give good results.

Home-made Oral Rehydration Fluids

In an emergency, the following alternative rehydration fluids, though not optimal, are *much* more effective than plain water.[13] Again, when measuring the ingredients, it is vital to remember that *more is NOT better*. Especially in the case of salt, too little is *much* safer than too much, and much too much can be lethal.

Many food and drink containers are labelled with their volume, which can be helpful in the absence of a measuring jug. The barrel of a syringe, if available, could also be useful for measuring dry ingredients in the absence of a 5ml teaspoon. (Remember that not all small spoons are 5ml teaspoons.)

Just as when preparing solutions from ready-made ingredients, it is obviously important to use clean utensils for measuring, mixing and administration, and to ensure that both the dry ingredients *and* the water are fit for dietary consumption, so that the prepared solution does not itself cause a new illness.

The most important thing of all to know about home-made rehydration fluids is that you must ***never add salt alone***. While leaving out the salt from the following recipes would result in a solution which would be more effective than plain water in most situations, ***water containing salt WITHOUT sugar is potentially lethal to dehydrated patients, and must therefore NOT be used as an oral rehydration fluid.***

[13] These solutions provide many of the benefits of correctly formulated ORS solution, partly because sucrose and other digestible carbohydrates are digested to glucose fairly quickly after ingestion, and partly because potassium replacement is not usually as important as sodium and water replacement.

Recipe #1

One level 5ml teaspoon of dry table salt[14]

250ml of sugar-based soft drink (*not* diet[15], *not* concentrate[16])

750ml of boiled or bottled water

Recipe #2

One level 5ml teaspoon of dry table salt[17]

250ml of fruit juice (preferably a fairly sweet-tasting juice)[18]

750ml of boiled or bottled water

Recipe #3

One level 5ml teaspoon of dry table salt[19]

Eight level 5ml teaspoons of granulated sugar

One litre of boiled or bottled water

"Rice water"

If sugar, soft drink or fruit juice is not available (as is not infrequently the case in developing countries) a fairly effective

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[14] The measure *must not* be rounded or heaped. Indeed, a slightly-less-than-level teaspoon is preferable, as a level teaspoon (5 millilitres) holds almost exactly 5 grams of table salt, and 4 grams would be quite enough.

[15] "Diet" soft drinks contain little or no sugar, so they are quite useless here.

[16] A sugar based *concentrate* (cordial) must not be used unless it has been diluted to its normal drinking strength *before* measuring the 250ml amount.

[17] As in Recipe #1, the measure must not be rounded or heaped.

[18] Fruit juice sweetened with sugar (often labelled "fruit juice drink") may be substituted – but mineral water "with added fruit juice" may *not*.

[19] As in Recipes #1 and #2, the measure must not be rounded or heaped.

oral rehydration fluid can be prepared from water in which rice has been boiled, as discussed in ***Appendix 2***.

How Fast to Give the Fluid

Why am I talking about how *fast* to give oral rehydration fluid, before discussing how *much* of it to give? Simply because dehydration is a dangerous state to be in[20] – so the sooner it is corrected, the better. Estimating how much fluid will be needed is also important, but unless you are an expert it may take some time. Meanwhile, the patient *urgently* needs to start drinking!

Of course, as soon as you start giving a patient oral rehydration fluid, you should also start keeping a record of the amount which the patient drinks. You will need to know this later, when you have had time to sit down and calculate how much fluid is likely to be needed in order to correct the dehydration.

Now, *how fast* should the patient be encouraged to drink? At the risk of stating the obvious, a dehydrated 5kg infant cannot (and does not need to) drink as fast as a dehydrated 75kg adult. In other words, the rate of fluid replacement which should be encouraged depends on the size of the patient in question.

I am therefore going to recommend a rate of administration of oral rehydration fluid, which should be encouraged while more accurate calculations are made, based on the patient's weight. This rate is best determined according to the patient's usual, *fully hydrated* weight. If that weight is not known, it will have to be estimated, as discussed in ***Appendix 3***.

As shown in Table 1 below, the rate of drinking which I suggest should be encouraged at the beginning of treatment and

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[20] Because of inevitable effects such as reduced blood pressure and increased concentrations of blood coagulation factors, a dehydrated patient is at risk of potentially fatal complications such as stroke and heart attack.

until the appropriate calculations have been made is ***three percent of the patient's usual body weight, per hour***.

Importantly, and I hope also obviously, this unusually rapid rate of fluid administration only applies ***until rehydration has been achieved***. After that, as discussed later, the patient's normal diet will provide for normal fluid requirements, while any continuing abnormal fluid losses will still need to be replaced with oral rehydration fluid.

Equally obviously, not all patients will be *able* to drink three percent of their usual body weight per hour. For example, in the case of a 100kg adult, that would mean drinking three litres per hour, i.e. 50 millilitres (ten teaspoons) of fluid per minute. A very thirsty 100kg adult not suffering from nausea or vomiting might find that easy, and ask for more. On the other hand, another 100kg patient might find it quite impossible.

In other words, the suggested rate of 3% of usual body weight per hour is simply a starting point when deciding how much oral rehydration fluid to encourage the patient to drink. Later, after calculating the approximate amount of fluid needed, a *different* target rate may be encouraged. But both before *and* after the calculations have been completed, the amount encouraged may *not* be the same as the amount the patient drinks. The amount the patient is able to drink will *always* depend on the individual patient.

Table 1: Initial rate of rehydration by weight

Usual weight	Encourage patient to drink at this rate
5kg	150 millilitre per hour ***if tolerated***
10kg	300 millilitre per hour ***if tolerated***
15kg	450 millilitre per hour ***if tolerated***
20kg	600 millilitre per hour ***if tolerated***
30kg	900 millilitre per hour ***if tolerated***
40kg	1,200 millilitre per hour ***if tolerated***
50kg	1,500 millilitre per hour ***if tolerated***
60kg	1,800 millilitre per hour ***if tolerated***
70kg	2,100 millilitre per hour ***if tolerated***
80kg	2,400 millilitre per hour ***if tolerated***
90kg	2,700 millilitre per hour ***if tolerated***
100kg	3,000 millilitre per hour ***if tolerated***

Now, where did that figure of **3% per hour**, based on the patient's usual weight, come from? I have not actually seen it quoted by any expert authority. Rather, it is my own way of *simplifying* the enormous amount of advice provided by standard medical and paediatric textbooks, and expert bodies such as CDC and WHO/UNICEF, for a general readership.

Replacing the 10% of body weight which is the fluid deficit present in moderate dehydration[21] over four hours, as is widely recommended, obviously requires giving an amount of fluid

[21] The fluid deficits associated with different degrees of dehydration are explained later in this article.

equivalent to two and a half percent of body weight, on average, during each of those four hours. Equally obviously, that same rate of administration would replace 5% of body weight (the fluid deficit present in mild dehydration) over two hours – and that is also widely recommended.

As I am sure you noticed, I have added a further half percent. Some of that will be needed for normal fluid requirements, as discussed later in this article. That leaves very little indeed to compensate for any continuing abnormal fluid losses. However, 3% of body weight per hour is about as much as most patients can drink without causing or increasing vomiting. Indeed, it is sometimes rather an optimistic target.

That being the case, correction of moderate dehydration by giving oral fluids may take longer than the recommended four hours when there are significant continuing abnormal fluid losses. Medical treatment, in the form of intravenous or nasogastric fluids, may then be necessary. In other words, moderate dehydration with considerable continuing abnormal fluid losses and/or poor tolerance for oral fluids may require the same treatment as severe dehydration.

Some tips about fluid administration

Getting oral rehydration fluid into a patient at a reasonable rate is sometimes just a matter of preparing it, offering it and watching the patient drink it. However, if the amount of fluid involved is large, or if the patient is weak, nauseated or actually vomiting, achieving the desired rate of fluid administration can be very much easier said than done.

The secret of oral rehydration fluid administration in this situation is to *give the fluid gradually*. Although the desirable target rates shown in Table 1 have been expressed on an hourly basis, it may sometimes be necessary to offer one sixtieth of that hourly quantity each and every *minute*, in order to achieve the desired result.

When vomiting is the main problem, it may help to rest the stomach for five or even ten minutes after each vomit, and then resume offering fluid as fast as the patient can tolerate it. Very young, very old or very sick patients may need to have rehydration fluid dribbled slowly into the mouth from a teaspoon or medicine dropper, or perhaps from a syringe without a needle, while waiting for transport to hospital.

Slowly but surely, a lot of fluid can be given in this way. Every twenty teaspoons of fluid swallowed adds up to 100ml of intake, so patience and persistence can be lifesaving in this situation. Even a semi-conscious patient will usually swallow fluid if it is placed in the patient's mouth a few millilitres at a time while the patient's head is lifted a little.

Some unconscious patients will also swallow a few millilitres of fluid at a time in this way, either because the swallowing reflex is still present, or by the action of gravity. However, larger amounts of fluid must never be given to semi-conscious or unconscious patients by mouth, as most of the fluid is likely to end up in the patient's lungs, which could be fatal.

How Much Fluid to Give

As soon as the patient is drinking oral rehydration fluid at a rate as near as possible to the recommended target rate for the patient's weight, it is time to think about how long this rate of intake should be continued. Obviously, giving insufficient rehydration fluid, while better than nothing, will not fully correct the dehydration. On the other hand, giving too much fluid could sometimes be dangerous, especially to a patient with heart or kidney disease.

In practice, though, significant overhydration is unlikely when the fluid is given by mouth, as the excess fluid is usually refused by the patient. Except in the case of "hysterical polydipsia" (a psychiatric condition characterised by excessive fluid intake) dangerous overhydration is usually the result of giving too much fluid intravenously or nasogastrically.

Just as the initial target rate was expressed as an amount to encourage per hour, I will now describe the calculation of the amount of fluid which will probably be needed in terms of an amount per hour, because I think that makes the calculated results easier to put into practice.[22]

Again as before, the calculated amount to attempt to give per hour will be based on giving fluid gradually throughout *each* hour, and throughout *every* hour. (For this reason, sleep should be discouraged during the rehydration phase.)

Notice that the calculated amount to attempt to give per hour will drop sharply when the rehydration phase is complete, and will drop further as continuing abnormal losses abate, finally reducing to the patient's normal fluid requirement (which should then be provided as part of a normal diet[23]).

Sometimes it may not be possible to give the full amount of fluid intended during a particular hour. If some or all of the fluid which was due to be given during that hour was missed

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[22] Standard fluid requirements are often stated as a volume per 24 hours, but fluid replacement is expressed in many different ways. Volumes quoted for different time intervals will inevitably also be different. For example, an author might talk about how much fluid to give per minute, or over fifteen minutes, or perhaps each 24 hours. If you are trying to reconcile the advice given here with advice from other sources, you must take such differences into account, otherwise the figures will make no sense at all.

[23] It is important to resume normal nutrition as soon as possible, especially in infants and children, so that whatever illness caused the dehydration is not made worse by nutritional deficiencies.

for any reason, it must be added gradually to the amounts given during future hours, until the shortfall has been made up.

To estimate the amount of oral rehydration fluid to attempt to give during any given hour, three different components have to be added together. These components are as follows:

1. A tolerable proportion of the estimated fluid deficit at the *start* of treatment (until that deficit has all been replaced)
2. Any further amount of *abnormal* fluid loss which has occurred *during* treatment (and has not yet been replaced)
3. The amount of fluid required each hour to provide for the patient's *normal* fluid requirements

The second two components prevent the degree of dehydration from getting any worse, but they do not correct whatever degree of dehydration was already present when treatment was commenced. It is only the first component which contributes to replacement of the initially existing fluid deficit.

(During the rehydration phase, and also while abnormal losses remain considerable, the third component will be very small in comparison to the other two. However, as the patient recovers, it will account for an increasing proportion of a decreasing fluid requirement, finally becoming the *only* fluid requirement, and being provided for by the patient's normal diet.)

A tolerable proportion of the initial fluid deficit

It is difficult to assess the volumes of abnormal fluid losses, such as diarrhoea and vomiting, retrospectively. Therefore, in practice, an estimate of the patient's degree of dehydration, which can be made on the basis of some characteristic features described below, is usually the best guide to the magnitude of the initially existing fluid deficit.

Determining the *tolerable proportion* of this deficit which can be replaced each hour is largely a matter of trial and error. It may be less than 10%, or more than 30%, depending on the size of the deficit and the presence of obstacles such as weakness, abdominal discomfort, nausea or vomiting.

For the purposes of this method, the estimate of fluid deficit associated with a given severity of dehydration is expressed as a percentage of the patient's usual (fully hydrated) body weight in kilograms. As one litre of water weighs one kilogram, the volume of the estimated fluid deficit in litres is exactly the same as its weight in kilograms. If the patient's usual weight is not known, it can be estimated as outlined in ***Appendix 3***.

Fluid deficit in mild dehydration

Mild dehydration is usually defined as a fluid deficit equivalent to approximately 5% of fully hydrated body weight. A mildly dehydrated person might feel thirsty and might also have a dry mouth – or might not notice any symptoms at all. An external observer might note a slightly increased pulse rate – or might not notice anything untoward at all. If some skin is pinched up between finger and thumb, it will spring back almost instantly, just as it would in the normally hydrated state.

However, when there have been abnormal fluid losses, such as vomiting and/or diarrhoea, ***mild dehydration should always be assumed***, even in the absence of any discernible symptoms or signs. Therefore, the estimate of the initially existing fluid deficit due to abnormal fluid losses in the absence of any symptoms or signs should be **5%** (one twentieth) of the patient's known or estimated fully hydrated body weight.

Fluid deficit in moderate dehydration

Moderate dehydration is usually defined as a fluid deficit equivalent to approximately 10% of fully hydrated body weight. A moderately dehydrated person will usually feel quite thirsty and may also have dry eyes, a dry tongue and/or a rapid pulse rate. If some skin is pinched up between finger and thumb, it may not spring back instantly, but it should return in less than two seconds. In many cases, it will be some time since any urine was passed (although some causes of dehydration are associated with normal or increased urine output). In the presence of some or all of these features of moderate dehydration, the estimate of the initially existing fluid deficit should be **10%** (one tenth) of the patient's known or estimated fully hydrated body weight.

Fluid deficit in severe dehydration

Severe dehydration is usually defined as a fluid deficit equivalent to significantly more than 10% of fully hydrated body weight. A severely dehydrated person will usually have the symptoms and signs already mentioned, and also some or all of the following features:

- Eyes which seem to be sunk into their sockets
- Skin which returns slowly (taking two seconds or more) after being pinched up between finger and thumb
- A pulse which feels "thready" (weak) as well as rapid
- Hands and feet which feel cold and may be pale or bluish
- Dizziness unless lying down (due to low blood pressure)
- Breathing which gradually becomes deeper and faster
- Mental slowness or apathy, muddled thinking or strange behaviour ***(in a baby, being unusually quiet or "good" may be the ONLY sign of such mental impairment)***

In the presence of some or all of the features of severe dehydration just described, the initially existing fluid deficit might be **20%** (one fifth) **or more** of the patient's known or estimated fully hydrated body weight. In very severe cases of dehydration there may be delirium and profound weakness. Further deterioration would soon lead to coma, and then death.

As previously mentioned, severe dehydration is a medical emergency, but whatever amount of oral rehydration fluid can be tolerated pending hospitalisation may be lifesaving.

A Few Examples

Perhaps it will make it easier to understand how to apply the principles explained above if I provide a few examples.

Example 1: Mild Dehydration

A child with diarrhoea, who has no other features of ill health whatsoever, is found to weigh 20kg. The estimated initially existing fluid deficit is **5%**[24] of **21**kg[25] i.e. 1.05kg i.e. 1.05 litres (one thousand and fifty millilitres).

Example 2: Moderate Dehydration

A three month old baby of unknown weight, with a rather dry tongue, and eyes which do not glisten with moisture, was vomiting during the night. The child is quite alert and active, and looks generally well. The estimated initially existing fluid deficit is **10**%[26] of **5**kg[27] i.e. 0.5kg i.e. 0.5 litres (500 millilitres).

Example 3: Severe Dehydration

A previously unknown adult of average size seems to be describing weakness and dizziness, but further history is vague, possibly due to a language barrier. The pulse, when found with some difficulty, is regular, with a rate of 100 per minute. The

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[24] Because the child has diarrhoea, mild dehydration should be presumed, even though no features of dehydration are present.

[25] The measured 20kg has been increased by 5%, resulting in a presumed fully hydrated weight of 21kg. As explained in a footnote to Appendix 3, multiplying by 100/95 would be more accurate, but the tiny difference (about 50g, in this case) is of no significance when estimating fluid deficits.

[26] Obvious dryness of the mouth and eyes is indicative of moderate dehydration (10% of body weight) even if everything else appears normal.

[27] 5kg is the very approximate figure for the average weight of a fully hydrated three month old baby which can be found in the table in Appendix 3.

skin, when pinched up between finger and thumb, takes about three seconds to flatten out again. No other unusual features are apparent. The estimated initially existing fluid deficit is **20**%[28] of **70**kg[29] i.e.14kg i.e. 14 litres (fourteen thousand millilitres).

An important point to remember:

As mentioned earlier, a tolerable proportion of the estimated initially existing fluid deficit should be replaced each hour until it has all been replaced. However, it is important to remember that when it ***has*** all been replaced, this major component of the estimated hourly fluid requirement ***no longer applies***.

The amount of fluid still being lost per hour

If no measuring jug or scales is available, the amounts of fluid vomited or lost as diarrhoea could be measured in empty food containers of known volume. Much less accurately, their volume could be estimated. The amount lost during any particular hour can then be replaced during the next hour.

One millilitre of fluid needs to be given to replace each one gram (or millilitre) of measured or estimated abnormal fluid loss. Unless the underlying illness causes abnormal urinary losses, urine (if any) would not be considered an abnormal loss. When losses are not easily measured, a moderately large watery stool can be very approximately estimated as 10 millilitres per kilogram of usual fully hydrated body weight. A moderate amount of vomited fluid might be very approximately 2 millilitres per kilogram of usual body weight.

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[28] The delayed flattening of pinched up skin is almost always indicative of severe dehydration. The other features described, though non-specific, are also consistent with severe dehydration.

[29] As shown in the table in Appendix 3, the average weight of a fully hydrated adult of average size is (very approximately) 70kg.

If no visible fluid other than normal urine output has been lost during a particular hour, then this second component of the fluid requirement for the following hour is zero. When abnormal losses have stopped altogether, this second component obviously no longer applies at all.

The amount of fluid normally needed per hour

Normal fluid requirements do not cease to exist when a person is unwell. They may be small in comparison to the abnormal losses, and they may be *very* small in comparison to the amounts needed in order to replace the initially existing fluid deficit within two to four hours. However, they should still be taken into account.

A person's normal fluid requirement varies, approximately, with that person's usual fully hydrated weight, although many other factors, such as surface area, exercise, ambient temperature, humidity and fever, also have significant influences. As before, if the patient's usual weight is not known, it can be estimated as discussed in ***Appendix 3***.

The values shown in Table 2 below are, of course, very approximate. The values used were derived from a number of standard resources, the fluid requirement guidelines published by The Royal Children's Hospital, Melbourne, Australia[30] being particularly helpful in this regard. (If you are mathematically inclined, you may notice that the relationship between weight and normal fluid requirement is not linear.[31])

As with all hourly targets, the volumes shown in the table must be given *every* hour in order to deliver the normal fluid

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[30] http://www.rch.org.au/clinicalguide/cpg.cfm?doc_id=5203 (accessed 10 June 2009)

[31] The explanation for this apparent anomaly has to do with body surface area (which would be a much more accurate guide, but is difficult to measure).

requirement. Therefore, amounts of fluid which have been missed for any reason still need to be given as soon as possible.

Table 2: Normal hourly fluid requirement by weight

Weight	Normal hourly fluid requirement
5kg	20ml per hour
10kg	40ml per hour
15kg	50ml per hour
20kg	60ml per hour
30kg	70ml per hour
40kg	80ml per hour
50kg	90ml per hour
70kg	100ml per hour
90kg	110ml per hour

Always remember that the hourly fluid requirement increases with higher ambient temperature or humidity, as well as with fever or exertion. These factors can sometimes lead to a fluid requirement which is double that shown in Table 2, or occasionally even more than double. When in doubt, it is better to give more fluid, as long as the patient can tolerate it.

Adding up the three amounts

All that is necessary now is to add together the three components of hourly fluid requirement which have already been discussed. In other words, add together a tolerable proportion of the estimated initially existing fluid deficit (until that deficit has been replaced) **plus** any abnormal losses during the previous hour **plus** the normal hourly requirement. The total of these three amounts is the amount that should, if possible, be given during the next hour.

For example, consider the case of an initially mildly dehydrated adult in comfortable climatic conditions, whose usual fully hydrated weight is 70kg, who is rather nauseated, and who has, during the past hour, lost 150ml as diarrhoea fluid and 100ml by vomiting.

The estimated initially existing fluid deficit will be 5% of 70kg i.e. 3½kg i.e. 3,500ml. Assuming that it has so far only been possible to replace 20% of that deficit per hour, and that at least 20% of it still remains to be replaced, the amount to offer during the coming hour can be calculated as follows:

20% of estimated initially existing fluid deficit:	700ml
Losses during previous hour (150ml + 100ml):	250ml
Normal hourly fluid requirement:	100ml
Total volume of fluid to offer during coming hour:	**1,050ml**

As you can see, this is considerably less than the 3% of usual body weight recommended as an initial target rate until the calculations have been made and the patient's fluid tolerance has been discovered. The initial target rate, for this 70kg patient, would have been 2,100ml. This is a good example of the need to adjust the initial rate of fluid replacement according to the calculated fluid requirement (as soon as it is known) *and also* according to the patient's fluid tolerance (at all times).

The new figure (in this case, 1,050ml) would also be subject to adjustment according to circumstances. For example, if the patient were thirsty, some extra fluid could be given, as long as it did not cause or exacerbate vomiting to any significant degree. On the other hand, if the patient did not succeed in drinking the calculated amount, replacement of the initially existing fluid deficit would simply take longer to achieve.

If the calculations resulted in the patient being encouraged to drink *more* fluid than was needed (and if the patient succeeded in doing so) the excess fluid would probably be passed as urine. However, as mentioned earlier, too much fluid can sometimes be dangerous, especially if there is pre-existing heart or kidney disease. Most people will refuse to drink if you try to give them a large amount of fluid when they are no longer dehydrated. However, in some cases, offering too much fluid might result in *overhydration*.

If the excess fluid is spread throughout the body's soft tissues, which is most likely, overhydration will manifest itself as *pitting oedema*, which is most noticeable in the parts of the body nearest the ground. Pressure applied over the sacrum, buttocks, ankles etc will then leave an obvious dent, which takes some time to disappear. Swelling of the face, especially the eyelids, may also be noticeable.

While pitting oedema is not immediately dangerous in and of itself, it is usually a sign that the amount of fluid given per hour should be reduced. Therefore, if pitting oedema develops, it might be best to cease fluid administration altogether for an hour or so, and then offer fluid at a somewhat reduced rate.

However, if the excess fluid collects in the lungs *(pulmonary oedema)* the overhydration will manifest itself as shortness of breath, and if this becomes severe it can be very dangerous.[32] ***Shortness of breath due to pulmonary oedema requires immediate cessation of fluid administration until the patient can breathe freely again.***

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[32] This type of shortness of breath, in which the patient "cannot breathe enough" (and may consequently look blue, or sometimes just pale) is quite different from the rapid or deep breathing sometimes seen *before* fluid replacement. Before fluid replacement, the patient may seem to "breathe too much", which is the body's way of attempting to correct the hyperacidity sometimes associated with dehydration, by washing carbon dioxide out of the blood.

Of course, medical treatment must also be accessed as soon as possible in this situation. In the meantime, the patient should rest in a sitting position, with the trunk as nearly vertical as possible and the feet on the floor, to encourage the movement of fluid into the tissues rather than the lungs. Any constricting clothing should be loosened, and plenty of fresh air would also help (or oxygen, of course, if available).

The End Result of Oral Rehydration

The end result of the oral rehydration process is a patient who is not thirsty, shows none of the signs of dehydration previously mentioned and has begun to pass urine normally. If there are continuing abnormal losses at this time, they will still need to be replaced as previously discussed. If there are no abnormal losses, the patient will simply require a normal diet (which includes sufficient fluids for normal requirements).

The underlying illness, which was the original cause of the dehydration, may of course still be present. Diarrhoeal illnesses, which are the commonest cause of dehydration, often resolve quite quickly as long as the fluid losses are replaced. However, if the underlying illness persists, it will need to be treated on its merits, and medical advice sought as necessary.

A Few Points about Nutrition

Although most aspects of nutrition are outside the scope of this article, I think there are a few points that should be made about its relationship to oral rehydration, as follows:

- As previously mentioned, dehydrated breast-fed infants should continue breastfeeding, while *also* receiving supplementary oral rehydration fluid as needed. Their normal nutrition will then not be interrupted at all.

- Dehydrated bottle-fed infants should initially be transferred to oral rehydration fluid, but should resume their usual bottle feeds as soon as the dehydration has been corrected. However, although bottle feeding provides amply for *normal* fluid requirements[33], continuing *abnormal* fluid losses, unless very slight, will need to be replaced by giving supplementary oral rehydration fluid.
- Some infants and children may be intolerant of lactose for a while after recovering from a diarrhoeal illness, so they may need a lactose-free diet for the first few weeks.
- Adults can usually commence a normal diet as soon as they have been rehydrated. However, if the underlying illness caused vomiting and/or diarrhoea, spicy or fatty foods should be avoided for a few days at least.
- In the management of diarrhoeal illnesses in developing countries, zinc supplementation has been shown to reduce the duration and severity of the diarrhoea.[34] This is a useful *addition* to treatment, especially in the case of infants and children, but zinc tablets are *NOT* a substitute for oral rehydration, which is still the mainstay of therapy.

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[33] Bottle feeding routinely exceeds the minimum fluid requirement, in order to provide a sufficient quantity of nutrients.

[34] Bhandari, N, et al, "Effectiveness of Zinc Supplementation plus Oral Rehydration Salts Compared with Oral Rehydration Salts Alone as a Treatment for Acute Diarrhea in a Primary Care Setting: A cluster randomized trial", *Pediatrics*, vol. 121, no. 5, 2008, pp. e1279-e1285.

Appendix 1:
The WHO/UNICEF ORS solution formulation

From 1984 to 2002, a formulation with a total osmolarity of 311mOsm/l was recommended. Since May 10, 2002, slightly reduced glucose and salt concentrations have been recommended, and this current ("reduced osmolarity") formulation[35] is shown below.

Table 3 shows the concentration of each ingredient of the solution in g/L. Table 4 shows the concentrations of the ions and molecules in the solution in mmol/L. (For reasons which are outside the scope of this article, the total osmolality of the solution in mmol/L is numerically equivalent to its total osmolarity in mOsm/L.)

The formulation is included here for information only, and should not be taken as a suggestion that you measure and mix your own ingredients. To do so would involve numerous opportunities for error, and therefore it cannot be recommended as a routine procedure. In most cases, the simpler recipes previously provided in the text should be used for home-made oral rehydration fluids.

Table 3:
WHO/UNICEF ORS

Ingredient	g/L
Sodium chloride	2.6
Potassium chloride	1.5
Glucose, anhydrous	13.5
Trisodium citrate dihydrate	2.9
Total	20.5

Table 4:
ORS Osmolalities

Particle	mmol/L
Sodium	75
Potassium	20
Glucose	75
Chloride	65
Citrate	10
Total	245

[35] This is the recommended "reduced osmolarity" formulation published at http://rehydrate.org/ors/who-unicef-statement.html (accessed 21 June 2010).

Appendix 2:
"Rice Water"

It must be stressed that although "rice water" can be quite effective[36] *everything about its composition is variable*. Some of the reasons for variation in the composition of "rice water" are as follows:

- Different types of rice leave different amounts of digestible carbohydrate in the resulting "rice water"
- Different proportions of water to rice also alter the final concentration of digestible carbohydrates
- Washing the rice before cooking it, which is quite a common practice, removes a variable amount of digestible carbohydrate, which is thus lost completely
- The amount of salt added to water in which rice is to be cooked varies "according to taste"

It should be clear from the above notes that "rice water" should only be used as a rehydration fluid if none of the previously discussed alternatives is available. However, as rice and salt are usually available in developing countries, while sugar, let alone ready-made ORS solution, is often in short supply, this traditional remedy should always be remembered whenever more suitable fluids are not available.

Very Important: If ***salt*** is not available, unsalted "rice water" is probably more effective than plain water. However, if ***rice*** is not available, ***salt must never be added*** to plain water which is to be given to a dehydrated patient.

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[36] Sathanakrishnan BR & Sankaranarayanan VS, "Rice water solution in diarrheal dehydration", Indian Journal of Pediatrics 1985 (September), vol. 52, no. 5, pp 479-482.

Some Theoretical Suggestions

Although I do not know of any evidence to support them, it seems to me that the following suggestions *might* theoretically improve the suitability of "rice water" as a rehydration fluid.

- Do not wash the rice before adding it to the boiling water
- Use three cups of water for each cup of rice to be cooked
- Do not add any salt to the water until after the rice has been cooked and removed
- Cover and simmer, rather than boiling briskly, so that not too much water boils away
- After straining to remove the cooked rice, add a "pinch"[37] of salt per cup (250ml) of "rice water" while it is still hot, and stir well to dissolve the salt completely
- Cover the "rice water" while it cools, and keep it covered until it is offered (in a *clean* container) to the patient
- Discard any unused "rice water" after 12 hours if the weather is warm, or 24 hours if the weather is cool.

[37] Using dry table salt which pours smoothly, an adult can usually pinch and hold about half a gram of salt between the thumb and index finger, so this might equate to **approximately** two grams of salt per **litre** of "rice water". Damp salt, or coarsely granulated salt, cannot reliably be measured in this way. I would not use more than one "pinch" per cup, as the carbohydrates in the rice water, when digested, would probably yield much less glucose than is present in correctly formulated ORS solution.

Appendix 3: Estimating Fully Hydrated Weight

Firstly, if a patient's weight is measured *after* the fluid loss has occurred, it will have to be increased by about 5%[38] to adjust for mild dehydration, about 10% to adjust for moderate dehydration, or 20% or more to adjust for severe dehydration.

Secondly, if a patient's usual weight is not known and the present weight cannot be measured, weight can be estimated *very approximately* by reference to Table 5 below, which is based broadly on the weight for age charts published by the United States Centres for Disease Control[39].

Table 5: Typical weight by age

(Only use this table if the weight is not known)

Age	Typical weight *(very approximate)*
3 months	5kg
1 year	10kg
3 years	15kg
6 years	20kg
9 years	30kg
12 years	40kg
15 years	50kg
Adult	70kg

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[38] The correct method of adjusting for a presumed weight loss of x% is to multiply the measured weight by 100/(100 – x). However, simply adding x% to the measured weight is close enough for the present purpose.

[39] http://www.cdc.gov/growthcharts/clinical_charts.htm (accessed 10 June 2009)

Links

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