Coconut Water as a Rehydration Fluid

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SUMMARY

The recent epidemic of cholera on the Pacific Ocean atoll of Tarawa, Gilbert Islands renewed interest in the use of coconut water as a rehydration fluid. Fifty-one samples of coconut water from Tarawa were analysed for a variety of constituents to assess its potential usefulness in the oral and parenteral rehydration of patients with cholera and other severe forms of gastroenteritis. Compared to oral rehydration fluids known to be effective in cholera, coconut water was found to have adequate potassium and glucose content, however was relatively deficient in sodium, chloride and bicarbonate. The addition of table salt to the coconut water is suggested to compensate for the sodium and chloride deficiency. In areas of the world where coconuts are plentiful, the advantages of sterility, availability and acceptability make coconut water theoretically feasible for the oral rehydration of patients with severe gastroenteritis when conventional fluids are unavailable.

NZ Med J 1979; 90: 98-100

INTRODUCTION

The recent epidemic of cholera in the Gilbert Islands[1,2] prompted renewed interest in the use of coconut water (coconut water is the free fluid present in the nut and distinct from coconut milk which is an emulsion obtained when fresh coconut is grated with the water) as an emergency oral or parenteral fluid for rehydrating the severely fluid-depleted patient. In the situation of a major epidemic of gastroenteritis, where large numbers of people are infected in a short period of time, stores of oral and intravenous fluids can be depleted quickly in areas of limited resources. In addition to large quantities of oral fluids, it was not unusual for a single cholera patient in the Gilbert Islands to require more than 8 litres of intravenous fluid.[2] In areas of the world where coconuts are plentiful, coconut water might be an alternative rehydration and maintenance fluid when conventional fluids are depleted or not available.

MATERIALS AND METHODS

Fifty-one coconuts were collected from the coral atoll of Tarawa, Gilbert Islands during the cholera outbreak (October, 1977). The coconuts were collected from two varieties of coconut palm: (1) Fiji Dwarf Variety (Cocos nana); collections were made from three locations, the lagoon side, the centre and the ocean side of the atoll; (2) Local Tall Variety (Cocos typica); collections were made from five trees arbitrarily indicated A, B, C, D, and E.

The liquid from each of the 51 coconuts was transferred to a sterile 75ml screwtop plastic container, frozen and flown to New Zealand. The samples were kept frozen until analysed approximately one week after collection. The samples were measured for the following constituents in a routine clinical chemistry laboratory using the following methods: sodium and potassium were measured by flame photometry; reducing substances, calcium, carbon dioxide, chloride and total protein were measured on Technicon Autoanalysers (Technicon Instruments Corporation). Protein electrophoresis in agarose gel and paper chromatography for carbohydrate reducing substances were performed on the coconut water using the same techniques as for serum. Glucose was determined using the hexokinase method and magnesium levels were measured by atomic absorption. Osmolality was approximated by calculation from the values of the measured constituents.[3]

RESULTS

Table 1 gives the mean values for the measured coconut

Table 1.—Mean values for measured coconut water constituents according to type of coconut palm

Type of Coconut Palm	Calcium (mmol/l)	Sodium (mmol/l)	Potassium (mmol/l)	Magnesium (mmol/l)	Reducing Subs. (mmol/l)	Glucose (mmol/l)	Number Samples
Fiji Dwarf	5.2	1.2	38.8	6.3	272	130	11
Loc. Tall A	4.2	0	56.0	4.8	209	98	9
Loc. Tall B	4.0	0	59.0	5.1	248	112	4
Loc. Tall C	2.8	4.0	44.4	3.8	280	139	4
Loc. Tall D	5.1	5.4	47.8	4.1	192	95	14
Loc. Tall E	8.4	4.9	59.1	6.8	253	130	9
Mean and Standard Deviation of all Estimations	5.3 ± 1.9	2.9 ± 3.4	49.9 ± 11.4	5.2 ± 1.6	234 ± 64	114 ± 36	

water constituents according to the variety of coconut palm. The coconut water samples from the Fiji Dwarf and local tall variety of palm contained relatively little sodium (range 0-5.4mmol/l), but comparatively large amounts of potassium (range 38.8-59.1mmol/l). Compared to serum, increased amounts of calcium (range 2.8-8.4mmol/l) and magnesium (range 3.8-6.8mmol/l) were observed. Relatively large amounts of carbohydrate reducing substances were found, of which approximately 50 percent was determined specifically as glucose. Analysis for reducing substances by paper chromatography indicated that the major components were glucose, sucrose and fructose, in a ratio of about 50:35:15. A range of 192-280mmol/l reducing substances was observed with a range of 95-139mmol/l for glucose. Osmolality was calculated for each sample and a range of 255-333mOsm/l was estimated. The range of coconut water total protein values, as measured by the Autoanalyser (biuret method), was 4-11g/l. However, electrophoresis in agarose gel failed to demonstrate any protein bands. Neither chloride ions or total carbon dioxide could be detected in any of the samples by the methods used.

Table 2 illustrates the results of the coconut water analysis according to age of the coconut. A relative fall in the amount of carbohydrate reducing substances was observed at nine months, and by 10 months the total decrease was to a level about 40 percent of the mean value found at five months. Glucose levels fell correspondingly and at 10 months, were about 35 percent of the mean value observed at five months. Reflecting these changes, the calculated osmolality also fell. From six months onwards the sodium levels rose from almost undetectable levels to 6.9mmol/l. The calcium and magnesium levels remained relatively constant with increasing age.

Table 3 gives the variation in coconut constituents according to the locality from which the coconuts were collected. It should be noted that the sample size for these determinations was small and all the samples were from the Fiji Dwarf variety of palm. The most marked change was a large increase in potassium values moving from the centre (and lagoon side) to the ocean side of the atoll (28.8-53.5mmol/l). This was paralleled by a similar increase in calcium levels (5.0-6.7mmol/l). These increases were also reflected in an increased calculated osmolality. There was some variability in sodium content, being highest (3mmol/l) in coconut water from nuts taken from the ocean side and undetectable in nuts taken from the centre of the atoll. Other constituents did not show major changes.

DISCUSSION

Virtually all of the patients in the Gilbert Islands presenting with a cholera-like illness were given some form of oral rehydration and approximately one-third required parenteral therapy.[2] During the epidemic, the stores of available fluids for parenteral rehydration of patients reached critically low levels at several points during peak use periods. Coconut water was used frequently for oral hydration to conserve parenteral fluids. Patients seemed to recover satisfactorily when given coconut water orally as an adjunct to their fluid therapy; unfortunately its use was not systematically evaluated. Supplies of parenteral fluids were adequately replenished before being confronted with resorting to the intravenous use of coconut water. However, parenteral coconut water was seriously considered if the circumstances warranted. In addition, very little information was available to us about the usefulness of coconut water in oral hydration. These circumstances prompted an investigation of the constituents of coconut water obtained from the coconut palms on the coral atoll of Tarawa, Gilbert Islands.

A simple and effective oral carbohydrate-electrolyte solution for the treatment of severe diarrhoeas contains glucose or sucrose, sodium chloride, sodium bicarbonate and a potassium salt.[4,5] Information from this study indicates the coconut water obtained from Tarawa was generally low in sodium, chloride and bicarbonate content and relatively rich in potassium and glucose. This generally agrees with previous observations.[6,7,8,9] Although optimal concentrations of all the constituents of an ideal oral replacement fluid were not present in coconut water, the isolated circumstances of Pacific islands may find the most appropriate ingredients unavailable, or in short supply, and therefore the therapeutic usefulness of coconut water needs to be evaluated. The deficiency of sodium and chloride in coconut water could be overcome by the addition of salt. Table salt (sodium chloride) is usually in good supply in these areas and supplementing coconut water with a "thumb-and-two finger pinch" of table salt to each pint (or half litre) should improve the replacement

Table 2.—Mean values for measured coconut water constituents according to the age of the coconut

Age Months	Calcium (mmol/l)	Sodium (mmol/l)	Potassium (mmol/l)	Magnesium (mmol/l)	Reducing Subs. (mmol/l)	Glucose (mmol/l)	Number Sampled
5	4.8	1.1	44.8	5.5	266	124	7
6	4.9	0.4	45.1	5.4	256	123	12
7	5.2	2.0	54.3	4.7	280	138	8
8	5.4	2.5	51.9	5.0	261	133	8
9	5.9	5.8	53.8	5.2	228	119	8
10	5.8	6.9	51.5	5.4	109	42	8

Table 3.—Mean values for measured coconut water constituents according to locality

Locale	Calcium (mmol/l)	Sodium (mmol/l)	Potassium (mmol/l)	Magnesium (mmol/l)	Reducing Subs. (mmol/l)	Glucose (mmol/l)	Number Sampled
Lagoon	3.6	1.0	32.6	6.7	263	130	3
Central	5.0	0	28.8	5.1	279	137	4
Ocean	6.7	3.0	53.5	7.1	273	123	4

value of this fluid.[10, 11] The glucose present in the coconut water is adequate to promote the necessary intestinal absorption of sodium and concomitantly, water.[12] In addition, if the nut is intact, the coconut water within is sterile.[7, 8] This is a distinct advantage in areas where it is not possible to prepare sterile solutions; it would also be an advantage where contaminated water supplies are a source of infection, the coconut water could be used as an alternative to water, reducing exposure.

In large explosive epidemics however, patients will unavoidably present in extremis necessitating the intravenous use of fluids. The intravenous use of coconut water must be approached with some trepidation as no thorough clinical studies on its parenteral use have been done. However, coconut water has been used intravenously with success and without any apparent serious reactions.[7, 8, 9, 13] According to the coconut water analyses of this study, the water generally would be slightly hypertonic to plasma, accepting a normal value for osmolality as 285-295m0sm/l. Calculation of the osmolality from the measured constituents is only a rough estimate and more refined studies would be necessary to determine true osmolality values. However, it is likely that coconut water could be given intravenously in at least small quantities without problems arising from tonicity differences.[7] Because of the relatively high potassium content of coconut water, careful attention to urine output would be necessary during intravenous administration. Also the pH values of coconut water are generally acid (range 4.8-6.4)[7, 14] and administration of large quanities would have to take the acid load into consideration. The measured protein content of coconuts was relatively low and presumably composed of small, simple proteins such as amino acids.[13] However, these simple proteins could be utilised advantageously for their nutritional value. Just how the intravenous infusion of coconut water would be tolerated by dehydrated, acidotic and oliguric patients needs to be evaluated further.

The biochemical findings of this study suggest that differences can be observed in the constituents of coconut water based on the area from which the coconuts are obtained. Although the observations need further confirmation, the values for calcium, sodium, potassium, magnesium, reducing substances and osmolality were all increased in coconuts taken from the ocean side of the atoll. The indigenous population of the Pacific Islands are generally aware of the "saltier" taste of the coconut water obtained from coconuts growing near the ocean.

It usually takes about 12-13 months for a coconut to completely mature. The optimal age of coconuts for use as an oral or intravenous replacement fluid appears to be about seven to nine months from this study and previous investigations.[6, 8, 14] Previous studies in the Gilbert Islands have shown that for drinking purposes, the green coconut at about seven months reaches the stage called "moimoto" where it has the greatest volume of liquid and sweetness.[14] A rough estimate of the age of a coconut can be made by counting the spathes (bearing stems) which are formed at about montly intervals or from the weight. A 3-4kg coconut from Cocos typica is usually at the stage of maximum water content.[14]

In isolated or rural Pacific islands, the logistic and economic advantages of using coconut water as a rehydration and maintenance fluid could be appreciable. Coconut water should not be used as a substitute for conventional fluid replacement, but in emergency situations it could be an effective and life-saving alternative. There are probably few instances today that coconut water would be the only resource available for fluid replacement. However, used appropriately, it could be an effective oral supplement to parenteral therapy or when used alone in the appropriate situations, as an adjunct to the conservation of potassium and glucose reserves. In addition to the advantage of its ready availability, this form of oral hydration would be particularly acceptable to Pacific island children, who consider the sweet coconut water a treat.

ACKNOWLEDGMENTS

The authors are grateful for the assistance and encouragement of Dr T. Flood, Chief Medical Officer, Ministry of Health, Tarawa, Gilbert Islands.

Reprints: Requests for reprints to Dr T. Kuberski, South Pacific Commission, BP D-5, Noumea, New Caledonia.

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In the early days of allowing mothers to stay in hospital with their children, the nurses found it extremely difficult to get used to the idea that they no longer had total authority over their patients. It would be no bad thing if throughout the hospital system that authority were broken in much the same way.
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