CLINICAL EXPERIENCE IN INTRAVENOUS ADMINISTRATION OF COCONUT WATER

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The clinical, hematologic, and antigenic properties of coconut water have been described earlier. The purpose of this paper is to review our clinical experience with the intravenous administration of coconut water in 157 patients and to evaluate its clinical role as an intravenous solution for use in parts of the world where pyrogen-free solutions cannot be obtained.

MATERIALS AND METHODS

Fresh coconut water was administered intravenously to patients according to the methods previously described.*

The patients used in this study were from the surgical wards of the Siriraj and Chulalongkorn Medical School Hospitals in Bangkok, Thailand (4 patients); from the surgical wards of the Barnes Hospital in St. Louis, (17 patients), and from the wards of the Tela Railroad Hospital in Tela, Honduras (136 patients). These patients were well hydrated, had a good urinary output, and were not acutely ill at the time of infusion.

The coconuts used in Thailand and Honduras were obtained locally. Those used in St. Louis were obtained from Miami, Fla.† Only clear fluid of low-fat content from the immature nut was employed in this study.

Three methods were utilized for treating coconut water prior to its infusion intravenously (Table 1). A group of eight patients received coconut water autoclaved at 15 lb. (6.8 kg.) pressure for 20 minutes prior to its administration. Another group of 71 patients received coconut water to which 100,000 units of penicillin G had been added. The final group of 75 patients received untreated coconut water as it was withdrawn from the fruit. The only precaution taken in the latter group was the removal of large particulate matter by filtration through a few layers of sterile surgical gauze.

The temperature, pulse, respiratory rate, and clinical appearance of all patients were followed during the infusion and for at least 24 hours thereafter.

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Part of the expenses involved in this study were defrayed by the United Fruit Company.

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* References 6 and 7.
† Through the courtesy of Mr. A. D. Barnes, Director, Dade County Park Department.
The rate of administering coconut water varied widely. At first, a slow rate of infusion was employed (4 drops per minute), but as confidence in the technique was gained, the rate was increased. The infusion was regularly started at a rate of 15 drops per minute in order to minimize any sensitivity reaction that might develop. When no reaction appeared within five minutes, the rate of injection was increased to about 5.2 ml per minute. Using this procedure, a 500 ml infusion was given in slightly over one and one-half hours (Table 3).

**TABLE 1.—Reactions in Patients Receiving Intravenous Coconut Water Analyzed as to Method of Preparing Infusion**

<table>
<thead>
<tr>
<th>Method of Preparing Fluid</th>
<th>Patients Infused, No.</th>
<th>Reactions, No.</th>
<th>Reactions, %</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>78</td>
<td>5</td>
<td>6.4</td>
<td></td>
</tr>
<tr>
<td>Autoclaved</td>
<td>8</td>
<td>1</td>
<td>12.5</td>
<td>Single reaction occurred in sample inadvertently autoclaved twice</td>
</tr>
<tr>
<td>Penicillin</td>
<td>71</td>
<td>5</td>
<td>7.0</td>
<td></td>
</tr>
<tr>
<td>Total cases</td>
<td>157</td>
<td>11</td>
<td>7.0</td>
<td></td>
</tr>
</tbody>
</table>

**TABLE 2.—Case Breakdown of Reactions in 157 Patients Receiving Coconut Water Intravenous Infusions**

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Reactions</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fever and urticaria</td>
<td>Inadvertently autoclaved twice; solution appeared cloudy</td>
</tr>
<tr>
<td>2</td>
<td>Fever 38.5 C. (101.2 F.), chill</td>
<td>Appeared only after 1,550 ml had been administered during 7½ hr. period</td>
</tr>
<tr>
<td>3</td>
<td>Chills, severe headache</td>
<td>No fever or other reactions</td>
</tr>
<tr>
<td>4</td>
<td>Slight transient urticaria</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Chills and fever</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Chills and fever</td>
<td>Patient had extensive burns</td>
</tr>
<tr>
<td>7</td>
<td>Fever 101 F.</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Chills and fever</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Chills and fever 38.8 C. (101.9 F.)</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Chills, fever, nausea</td>
<td>Used old rubber tubing, probably contained pyrogens</td>
</tr>
<tr>
<td>11</td>
<td>Chills, fever 38.3 C. (100.9 F.), tinnitus, headache, tingling hands</td>
<td></td>
</tr>
<tr>
<td>Total...</td>
<td>Fever, 10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Urticaria, 9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Headache, 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tingling hands, 1</td>
<td></td>
</tr>
</tbody>
</table>

**TABLE 3.—Rate of Administration of Intravenous Coconut Water to 157 Adults**

<table>
<thead>
<tr>
<th></th>
<th>Rate per Minute</th>
<th>Time Required for 500 ml Infusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>5 to 8 cc</td>
<td>1 hr., 30 min.</td>
</tr>
<tr>
<td>18 patients</td>
<td>Over 8 cc</td>
<td>Less than 1 hr.</td>
</tr>
<tr>
<td>Maximum</td>
<td>16.6 cc</td>
<td>30 min.</td>
</tr>
</tbody>
</table>

Intradermal injection of 0.1 ml of coconut water were given into the forearms of 51 patients who were examined for evidence of sensitivity 30 minutes and 24 hours after the injection. Four of these patients were from Bangkok, 20 from St. Louis, and the remaining 27 from Honduras.

Multiple infusions were given to 18 patients. The second infusion was given to six persons within 48 hours after the original administration of coconut water. Ten patients received their...
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Second dose from five to six weeks after the first. This is the time-period interval for obtaining the maximum number of antigenic reactions, should they occur. Prior to reinfusion every patient had a skin sensitivity test performed upon him; it consisted of an intradermal injection of 0.1 ml. of coconut water. Any patient manifesting sensitivity was not given more coconut water. Two patients skin-tested six weeks after their original infusion developed a local reaction and were given no further infusion.

Samples of urine were obtained from 32 patients immediately before and again immediately after the termination of the coconut water infusions. The pH of the urine samples was determined in each case by means of litmus or benzidine paper. Twenty-six patients had an aciduria prior to the infusion and therefore could be used for observing the urinary alkalinizing effect of coconut water.

The amount of coconut water employed in each infusion varied, but in all cases was in excess of 250 ml. Routinely we infused 500 ml. The maximum amount of intravenous coconut water given to a patient in one day was 2,365 ml. Eight patients have received over 1,500 ml. within a 12-hour period.

Twenty-four-hour balance studies have been carried out on five patients receiving intravenous coconut water infusions in an effort to determine whether its diuretic properties were sufficient to produce a dehydrating effect. No attempt was made to control carefully the rate of fluid administration in this section of the study.

RESULTS

Rate of Reaction.—Of the 157 patients receiving intravenous infusions of coconut water, 11 had reactions that might be ascribed to the infusion—a reaction rate of 7%. Three patients had a mild transient pyrexia (maximum of 38.3 C. [100.9 F.]) that might have been caused by factors other than the infusion. One had extensive burns; the second received an infusion through dirty rubber tubing and later had no reaction when the donor set was changed, and the third received coconut water that had inadvertently been autoclaved twice and had a turbid appearance. If these three cases were subtracted from the total number of reactors, a corrected reaction rate of 5.0% would be obtained. Table 2 gives a more detailed analysis of the 11 cases in which a reaction was recorded. Ten of these patients had fever; two had urticaria; two complained of headache, and one woman complained of tingling in her hands. None of the reactions were serious. Only one patient (Case 3, Table 2) was pyretic for more than 12 hours.

There was no significant difference in the reaction rate between the group receiving untreated coconut water and those receiving infusions to which penicillin had been added. Too few patients received autoclaved coconut water infusions to warrant any conclusions regarding the effect of autoclaving upon reaction rate. The cloudy appearance of the fluid following autoclaving and the one case in which a reaction occurred when the fluid had been autoclaved twice suggest that heat denatures the protein of the fluid. For these reasons we discontinued heat sterilization of the solutions prior to infusion.

There was no correlation between the rate of infusion of coconut water and reactions. Eighteen patients received infusions of 500 ml. of coconut water at an average rate of 8 ml. per minute without reaction. One patient showed no untoward effects while receiving a 400 ml. infusion at a rate of 16 ml. per minute.

Pain Along the Infused Vein.—An aching pain was experienced along the course of the vein when the fluid was infused rapidly. This aching pain disappeared as soon as the infusion was slowed. We thought initially that the pain was due to the acidity of the solution, but later realized that it was more likely due to the high potassium concentration of the infusion. The critical rate of infusion that produced distress
A. M. A. ARCHIVES OF SURGERY

along the infused vein varied remarkably from patient to patient. One of the factors was the size of the vein into which the infusion was running. Fast infusions into small veins on the dorsum of the hand were regularly painful, while fast infusions into the antecubital vein were less frequently so.

Cardiac irregularities, palpitation, and hypotension did not attend any infusions, although we carefully looked for them.

Twelve patients were skin-tested for sensitivity five to six weeks following their original infusion. Ten showed no reaction and subsequently tolerated another infusion of coconut water without incident. Two of this group showed a positive skin

Table 4.—Results of Reinusions of Coconut Water Five to Six Weeks After Original Infusion

<table>
<thead>
<tr>
<th>No. Cases</th>
<th>No. of Skins Tested</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2</td>
<td>No reinfusion given</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>Reinfusion given without reaction</td>
</tr>
</tbody>
</table>

Table 5.—Reaction of Urine Immediately Following Coconut Water Administration*

<table>
<thead>
<tr>
<th>Reaction</th>
<th>No. of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkaline</td>
<td>20</td>
</tr>
<tr>
<td>Neutral</td>
<td>1</td>
</tr>
<tr>
<td>Acid</td>
<td>1</td>
</tr>
</tbody>
</table>

Total cases tested... 28

* All cases had aciduria prior to infusion.

Table 6.—Diuretic Effect of Intravenous Coconut Water Infusion

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Coconut Water Intake (ml)</th>
<th>Urinary Output (ml)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2,000</td>
<td>3,700</td>
<td>-700</td>
</tr>
<tr>
<td>2</td>
<td>2,000</td>
<td>1,900</td>
<td>-100</td>
</tr>
<tr>
<td>3</td>
<td>2,000</td>
<td>3,400</td>
<td>-1,400</td>
</tr>
<tr>
<td>4</td>
<td>2,000</td>
<td>3,500</td>
<td>-1,500</td>
</tr>
</tbody>
</table>

* Negative water balance would include an additional daily insensible water loss of approximately 1,000 ml.

test and were given no more. Six patients received one or more reinusions within 48 hours after the original administration of coconut water; not one had any reaction (Table 4).

Twenty-three of the 26 patients who had an aciduria prior to the infusion of coconut water developed a transient urinary alkaline tide following it (Table 5). Only one patient receiving infusions of this acid solution excreted an acid urine during the immediate postinfusion period.

Eight patients received infusions of 1,000 ml. or more. Two of these patients (Cases 1 and 3, Table 2) developed fever, urticaria, and headache after more than 1,500 ml. of the fluid had been administered.

The results of the water balance studies carried out on patients receiving intravenous coconut water as their only source of fluid for 24 hours are presented in Table 6. A diuresis occurred during every infusion; in fact, the total urinary output during
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The infusion of the fluid exceeded the amount infused. The actual negative water balance is more marked than the difference between the intake and output when insensible water loss is taken into account.

Comment

It is apparent from our experience as well as others that coconut water can be administered intravenously without frequent or serious evidence of toxicity. Fresh coconut water is sterile, so treatment of the fluid with penicillin or by heat sterilization prior to infusion is unnecessary.

The aching pain occasionally noted in this series along the course of the infused vein has been described with infusions of other fluids of high potassium content. Although the potassium content of coconut water is high (40 mEq. per liter), we have found no evidence of potassium poisoning among the patients included in this study. This may in part be due to the high magnesium content of coconut water which acts as a physiologic antagonist to potassium. None of the patients included in this study were oliguric at the time of infusion. It should be emphasized that intravenous coconut water should be employed only with great care in patients with diminished renal function in order to avoid potassium intoxication.

The urinary alkaline tide noted following administration of strongly acid coconut water is similar to that found after the intravenous administration of potassium chloride. This seeming paradox is due to the rapid renal excretion of potassium, compared to the less prompt elimination of chloride. Since chloride cannot immediately be excreted with potassium, bicarbonate ions are excreted instead, producing a urine of high potassium bicarbonate content which is alkaline in character despite the acidic nature of the intravenous infusion.

The diuretic effects of intravenous coconut water have previously been noted, but neither the cause nor the extent of diuresis has been quantitatively measured.

It is of prime importance in the clinical evaluation of coconut water to determine whether the intravenous administration of this material results in an absolute dehydration of the body to a water content lower than preinfusion levels. Substances of this nature are called ecuretic diuretics. Although further water balance studies must be made in patients receiving intravenous coconut water, our evidence would indicate that intravenous coconut water is an ecuretic diuretic and should not be utilized in an attempt to hydrate a patient unable to take oral fluids. We had hoped that coconut water might be employed as a parenteral source of water, but if the present data on water balance are confirmed, its diuretic properties preclude its use as a source of water. In other words, the administration of coconut water intravenously is attended by dehydration, not hydration.

One of the factors in coconut water producing diuresis is its potassium content. Wolf has found that potassium salts are ecuretic only when administered in concentrations above 70 mEq. per liter. This figure, which he describes as the limiting isorheic concentration for potassium, is far greater than the maximum concentra-

References

- References 4, 21, 17, and 26.
- References 8, 10, 18, and 22.
- References 16 and 18.
- References 13, 14, 30, and 31.
- References 2 and 19.
- References 4, 17, 21, and 26.
tion found in coconut water. Normal man can produce urine with potassium concentrations of 300-400 mEq. per liter, a figure some 10 times that found in coconut water. It seems evident, therefore, that there is some substance in coconut water other than potassium that accounts for its marked diuretic effect.

There is a relatively high magnesium concentration in coconut water. Signs of magnesium poisoning, such as weakness, anesthesis, progressive bradycardia, and respiratory depression, did not appear in the patients included in this study. This is probably due to the fact that all of these patients had an adequate urinary output and eliminated the magnesium in this manner.

A clinical evaluation of intravenous coconut water administration requires some mention of its high fructose content. Although there is some question of detail concerning its benefits, fructose appears to be more quickly and efficiently utilized as a source of calories than does intravenously administered glucose. With a carbohydrate content of 4 to 7 gm. per 100 cc., fat-free coconut water furnishes an efficient source of up to 240 calories per liter of fluid.

SUMMARY AND CONCLUSIONS

Coconut water has been administered intravenously to a series of 157 patients. There were 11 reactions in this series of infusions—a reaction rate of 7%. The reactions were transitory and of no serious clinical significance.

Intravenous readministration of coconut water to a series of 12 patients five to six weeks after the initial infusion has produced no evidence of sensitization.

The clinical implications of the high concentrations of potassium and magnesium in coconut water have been discussed. No evidence of toxicity ascribable to these cations has been noted.

When coconut water is infused at a rapid rate, a majority of patients will complain of some discomfort along the course of the infused vein due to the high potassium content of the fluid. When the infusion is slowed, this discomfort disappears.

The data available to us at this time indicate that the diuretic action of coconut water given intravenously is so marked that actual dehydration follows its infusion.

On the basis of present evidence, the diuretic effect of this material makes it of no clinical value in improving depleted states of hydration of a patient. It can be used as a source of potassium, a source of calories, or as a vehicle for the injection of sodium salts added to it for the emergency treatment of hypovolemia when other sterile pyrogen-free fluids are unavailable.

REFERENCES


† References 5, 10, 16, 20, 23, and 25.
‡ References 9, 24, and 27.
§ References 28 and 29.
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