The Intravenous Use of Coconut Water

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Medical resources routinely used for intravenous hydration and resuscitation of critically ill patients may be limited in remote regions of the world. When faced with these shortages, physicians have had to improvise with the available resources, or simply do without. We report the successful use of coconut water as a short-term intravenous hydration fluid for a Solomon Island patient, a laboratory analysis of the local coconuts, and a review of previously documented intravenous coconut use.

Atoifi Hospital is located on the South Pacific Island of Malaita in the Solomon Islands. Travel to the island occurs by small fixed wing airplane or boat. There are three hospitals located on Malaita, but travel between them is difficult because of the mountainous jungle topography and absence of roads. Atoifi Hospital is a 100-bed facility equipped with one operating theater and an outpatient clinic. Diagnostic resources include plain film radiography and minimal laboratory capabilities. A university medical team composed of five emergency medicine physicians and two surgeons traveled to Atoifi in September 1997 to provide relief work to the physicians and staff at this remote hospital. In addition to the requested lectures offered to the local physicians, we exchanged ideas about patient treatment and discussed innovative ways to face medical problems with limited resources. We learned about the resourceful use of intravenous coconut water during a hospital shortage of standard intravenous fluids usually obtained from Australia. Medical records were located for a case in which coconut water was intravenously given. We present this case, a laboratory analysis of the Atoifl coconuts, and a review of previously documented intravenous coconut use.

Case Presentation

Mr. I.A., an adult male subject in his forties, presented to Atoifi Hospital on November 23, 1999 with a one-day history of left-sided paralysis. While at home, he collapsed with no apparent precipitating cause and shortly thereafter experienced speech difficulties as well as left-sided weakness. He had experienced four similar transient episodes on previous occasions and had not sought medical treatment. He denied other medical problems, allergies, or medication use. He did have a history of tobacco use.

On physical examination, his vital signs were temperature 36.5°C, respiratory rate 24 breaths/minute, heart rate 72 beats/minute, and blood pressure 130/90 mmHg. Mr. I.A. was an awake, alert, cooperative patient who appeared generally ill. The lung examination revealed bilateral basilar crackles. Cardiac examination was remarkable for an irregularly irregular heart rate with a possible gallop. The patient was able to respond appropriately, but a left facial droop with pooling of oral secretions was noted. He showed left sided motor weakness in both upper and lower extremities. The remainder of the physical examination was normal. No computed tomography scan was available.

The patient was admitted to the hospital with the presumptive diagnoses of right middle cerebral artery stroke and atrial fibrillation and was treated with digoxin and aspirin. On hospital day two, he had difficulty with swallowing and standard normal saline intravenous (IV) hydration was initiated. Because the patient continued choking on liquids and solids, a nasogastric (NG) tube was placed for delivery of fluids, medications, and nutrition. The patient complained of discomfort and hiccups from the NG tube and refused the option of gastrostomy tube placement.

On hospital day 36, the patient became weak, shaky, and dizzy. He was unable to tolerate NG tube feedings because of vomiting and IV hydration again became necessary. The hospital had no standard IV fluids available and no capability of making their own IV fluids, and was not expecting new supplies for at least two days. The nearest hospital was located one day away by foot on the opposite side of the island. Additionally, the hospital did not have the financial resources to fly supplies from the capital city, Honiara, to Atoifi. The treating physician had heard of IV coconut being used successfully in other areas in the islands and at this time decided that their only option was to administer IV coconut water.

The patient received coconut water intravenously for approximately two days, at an estimated rate of

1,200ml/day. No follow-up serum electrolytes were recorded. He did eventually recover the ability to swallow and control his secretions and did not require further parenteral hydration and nutrition. He was discharged home on hospital day 39, December 30, 1992.

Discussion

The local Solomon Islanders describe six stages of coconut development from the immature *kabauro* progressing through *leuleu, bulo, zokelebuol,* and *rauka* to the most mature coconut *kopa.* Kabauro, the most immature coconut, contains less "meat" or endosperm and is mostly fluid. Leuleu, bulo, and zokelebuol have more mature meat and zokelebuol is the best to eat. As the coconut ages, the meat thickens and becomes tougher. Because the younger coconuts contain more fluid, these are generally chosen for intravenous fluid administration. Each coconut contains approximately 500 to 1,000ml of fluid. Coconut water is the free fluid present inside the coconut in contrast to coconut milk, the emulsion of fresh grated coconut and the water.

Relatives of the ill patient climb nearby trees and retrieve fresh coconuts, careful not to crack the coconuts, which would result in contamination of the fluid. The coconuts are then husked, leaving the "eye" portion intact until ready for IV set up. One large eye and two smaller eyes are seen at the base of the coconut. A 20-gauge needle is inserted through one of the smaller eyes to equalize pressure within the coconut. On first pass of the needle, coconut meat may block the needle lumen. A second needle is then passed through the same port. Single chambered blood transfusion tubing is then inserted through the large eye. The coconut set-up is placed in orthopedic netting, the base secured with tape to the netting to prevent slippage, and then hung for intravenous administration (Figure 1).

Because the drip rate is usually slow and difficult to regulate some find that IV boluses are more practical and are accomplished by aspiration from a port distal to the blood filter, to obtain filtered fluid.

Although not reported formally in the literature, the British in Ceylon and the Japanese in Sumatra allegedly first used coconut water as IV fluid during World War II.[1,2,3] In Havana, Cuba (1942), Pradera et al. showed no antigenic effects in humans or rabbits and administered this filtered fluid intravenously to 12 pediatric patients without adverse reaction.[4] The fluid infusion rate was 30 to 40 drops per minute, resulting in 24-hour volumes ranging from 1,000 to 1,870ml. With success, he also hypodermically administered up to 500ml of coconut fluid per patient in 13 patients; four patients experienced a local inflammatory reaction with no systemic reactions.

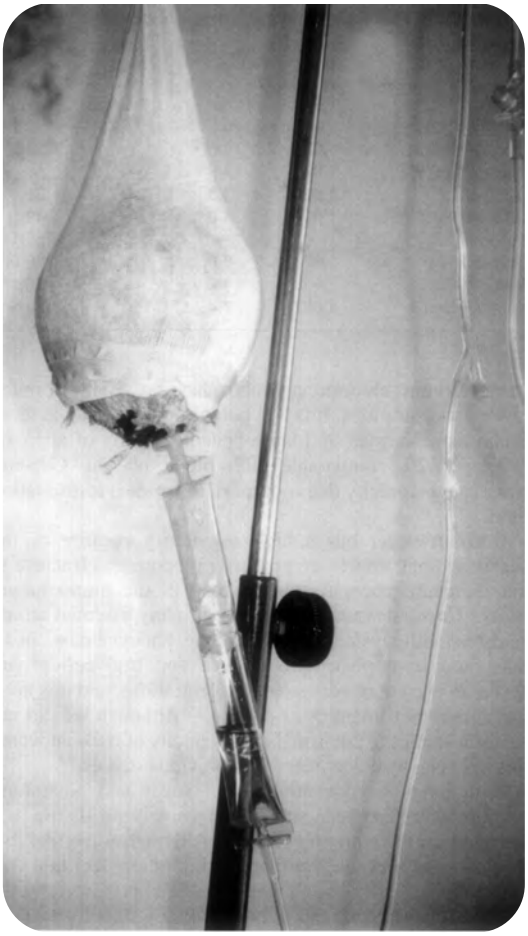

Figure 1. Intravenous coconut set-up. The coconut has singlechambered blood transfusion tubing attached, a second needle to equalize intra- luminal pressure, and is then placed in orthopedic netting.

In 1954, Eiseman conducted a prospective study in both Thailand and St. Louis in which 21 patients successfully received filtered IV coconut water without serious reactions.[3] He infused approximately 200 to 500 ml per patient over a period of 25 to 180 minutes. Patients experienced local infusion site discomfort at higher rates of infusion only.

Rajasuriya et al. also reported successful infusion of filtered coconut water in 26 Ceylonese patients.[5] Between 1965 and 1976, other investigators reported their use of intravenous coconut fluid in patients as well.[1,2,6] Iqbal; however, in 1976 reported successful direct infusion of water in Malaysia without any preliminary preparation or filtration system.[7] Since that time, coconut water has been studied only for oral rehydration use with no subsequent reports of intravenous use.

The authors brought representative coconut water to the United States for analysis. Electrolyte analy-

Table 1. Composition of Coconut Water

Study	Specific Gravity	pH	Na+ mEq/L	K+ mEq/L	Cl- mEq/L	Glu g/L	Ca_2+ mEq/L	PO_4 mEq/L	Mg_2+ mEq/L	Pro g/L
Pradera 1942[4]	1.018	—	5	64	45.5	1.2	17	2.8	—	—
Eiseman 1954[3]	—	5.6	4.2	53.7	57.6	1.8	9	2.4	17	1.56
Rajasurya 1954[5]	1.02	4.8	—	38.2	21.3	—	14.5	4.4	—	—
DeSilva 1959[8]	1.02	4.9	—	—	—	—	—	—	19	—
Olurin 1972[1]	1.02	5.6	0.7	81.8	38.6	—	3.6	3.2	25	0.049
Iqbal 1976[7]	1.019	4.8	5	49	63	2.1	12	8	4.7	1.8
Kuberski 1979[9]	—	—	4	35.1	41	2.8	13.1	4	5.2	2.69
Msengi 1985[10]	1.023	6	2.9	49.9	—	—	5.3	—	13.4	—
Atoifi 1997	—	4.2	9.7	43.1	39.8	1.73	—	—	—	—
Normal Plasma	1.027	7.4	140	4.5	105	0.1	5	2	1.8	60

sis was performed on the coconut water at a university medical center clinical laboratory. The coconut water was analyzed at three early development stages leuleu, bulo, and zokelebulo and the results were consistent with those reported previously (Table 1).[2,3,4,5,7]

The electrolyte composition of coconut water resembles intracellular fluid more closely than extracellular plasma. The predominant cations are potassium, calcium, and magnesium. Sodium, chloride, and phosphate are found in much lower concentrations. It is a hypotonic solution that is more acidic than plasma,[1] and has a specific gravity of approximately 1.020, comparable with blood plasma. Coconut water's hypotonicity does not make it the ideal resuscitation fluid.

Coconut water has a high osmolarity because of the sugars present, which are primarily glucose and fructose in the immature coconut, and sucrose in the more mature fruits.[2] Coconut water is also rich in many essential amino acids including lysine, leucine, cystine, phenylalanine, histidine, and tryptophan.[4] Cholesterol and triglycerides are absent or present in very small concentrations, and it is not a good source of vitamins or protein.[3,7] Although we did not perform studies to confirm the antigenicity of coconut water, this has been well documented in previous studies.[1,4]

With its high concentrations of sugar and potassium, coconut water has been studied extensively for its use as a potential oral rehydration solution. Although some feel that it is an ideal oral rehydration solution others feel that it is dangerous and the oral rehydration salts promoted by the World Health Organization and UNICEF should be used exclusively. Despite numerous studies and reports, a final consensus has yet to be reached on its use as an oral rehydration solution.[11,12,13,14]

The high potassium, calcium, and magnesium content are a concern in the intravenous use of coconut water particularly when given in fluid boluses. Olurin et al. showed rises in serum potassium levels by 1.5 to 2.8mEq/L, calcium levels by 0.6 to 2.0mEq/L, and magnesium levels by less than 1.0mEq/L after infusion of 2,000 to 3,000 ml of coconut fluid over 6 to 12 hours.[1] Additionally, he measured urine electrolytes and noted that the amount of excreted potassium, calcium, and magnesium increased as the amount of infused coconut water increased.

Because of the high potassium, calcium, and magnesium content, the patient's urine output, renal function, and cardiac status should be closely monitored. It would be contraindicated to use coconut water for patients with hyperkalemia from acute renal failure, rhabdomyolysis, or severe burns. It has been postulated that the high concentrations of calcium and magnesium minimize the neuromuscular effect of potassium because these cations have antagonistic physiological activity.[3]

The low pH may theoretically worsen an already present metabolic acidosis, common in many disease processes requiring IV fluids. However, studies have shown no change in pH measured within 24 hours after infusion of as much as 3,000ml of coconut fluid.[1] It appears that the body's buffering system effectively neutralizes the acidity of the coconut water.

The acidity, hypotonicity, and high potassium do not make coconut water the ideal resuscitation solution. In the cases reviewed there have been no adverse affects reported. Certainly, the cases reported in the literature detail ill, dehydrated patients in cholera epidemics, Nigerian civil war, and gastrointestinal illness in children and the concomitant absence of IV fluids.[1,9,12] Coconut

water does not appear to be an ideal solution for long-term resuscitation use but may serve as a temporizing alternative in urgent situations.

Conclusion

In conclusion, we report a case in which coconut water was administered intravenously in a Solomon Island patient without adverse effects. Coconut fluid has been shown to be an effective form of intravenous hydration solution in small volumes over short periods of time, and can be considered a temporizing alternative to standard intravenous fluids in remote areas where supplies are scarce and coconuts, abundant and inexpensive. Additionally, it is a good source of potassium, chloride, and calcium and its use could be further indicated in situations in which these specific electrolytes need to be urgently increased. However, further studies need to be conducted to substantiate the emergency use of coconut water for intravenous rehydration solution.

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