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Guam Seaweed Poisoning: Symptoms and Treatment of Cases

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Abstract—Seven patients were seen in the Guam Memorial Hospital Emergency Room after ingesting a seaweed, *Gracilaria tsudai*. They typically presented with complaints of numbness and tingling sensation of the face and extremities, shortness of breath and general weakness. Most had abdominal symptoms including nausea, cramps, vomiting or diarrhea. Some had excessive tears and perspiration with skin cold to the touch. Five patients were admitted to hospital; these had developed low-grade fever, increased difficulty breathing as evidenced by laryngeal stridor or wheezing, elevated blood CO_2 and lowered blood pH, and localized muscle fasciculations. Three of these 5 patients subsequently developed generalized muscle fasciculations or tetanic seizures, increased respiratory difficulty, cardiac arrhythmias and hypotension before expiring.

I would like to describe the clinical situation that we faced when the seaweed poisoning patients were seen at Guam Memorial Hospital: how these patients presented, how they were treated and their outcome. My presentation may seem a little redundant at times as we go through these cases because they do tend to follow a common pattern of presentation, physical findings and course. For those of us who cared for these patients it was a rather frustrating experience, to say the least, so please bear with me. Five patients were admitted to hospital in connection with this incident. The first three cases I will describe died, the last two survived.

The patient that I personally cared for was a 33-year-old Filipina (C.S.) who was referred to the Family Health Program Clinic (FHP) at about 4:30 in the afternoon on the 27th of April by the Guam Memorial Hospital Emergency Room (ER). She was experiencing numbness and tingling of her lips, hands and feet as well as some abdominal pain four hours after ingesting seaweed subsequently identified as *Gracilaria tsudai* (formerly known as *Gracilaria edulis* and *Polycavernosa tsudai*). We thought she had a viral syndrome; she was treated and sent home. She returned to the hospital emergency room about 10 hours later, about 2:30 in the morning on the 28th, with watery eyes, excessive perspiration, vomiting and difficulty breathing in addition to the numbness and tingling of her hands and feet which persisted. We then learned that several other people who had also eaten seaweed purchased from the same vendor on the same day had

similar symptoms. We could not elicit a history of ingestion of fish or foods other than seaweed in common to these patients.

This patient's temperature was just over 100 °F, her respirations were 26 per minute, she was perspiring and anxious. There was some very faint inspiratory stridor (abnormal noise) noted and the extremities were cold and somewhat stiff. The patient was noted to have muscle fasiculations but the remainder of the physical was unremarkable at that time. The arterial blood gases were the one interesting laboratory test obtained, these were drawn by Dr. Cruz before I arrived and they showed a pCO_2 level of 56 mm/Hg, which is elevated, indicating that she was having difficulty breathing. Her blood pO_2 level was 59 mm/Hg which is low, particularly for a young woman who had never smoked. Her blood pH was slightly acidotic at 7.3 which would be expected with the retention of CO_2. There were no significant electrocardiogram (EKG) changes and the chest X-ray was unremarkable. Initially we felt the patient had ciguatera poisoning and we gave both mannitol and calcium intravenously for that. While still in the ER she showed increased difficulty breathing so I gave her a steroid, Solumedrol (methylprednisolone Na succinate), subcutaneous adrenalin and Benadryl (diphenhydramine HCl), and a bronchodilator, albuterol sulfate. These seemed to help a little bit and she was transferred to the Intensive Care Unit (ICU). About four hours later she developed severe upper airway obstruction with inspiratory stridor, she became cyanotic and confused, she had severe carpal pedal spasm of

Table 1. Laboratory blood test normal values and their significance.

Test	Normal Values*	Full Name and Significance
BUN	10–20 mg/dL	Blood urea nitrogen. High values indicate kidney damage.
CO_2	35–45 mm/Hg	Carbon dioxide. High blood values indicate respiratory failure.
CPK	10–148 units/L	Creatine phosphokinase. High values indicate heart muscle damage.
FDP	< 8 μg/mL	Fibrin degradation products. High values suggest diagnosis of disseminated intravascular coagulation.
LDH	45–90 units/L	Lactic dehydrogenase. Test of general tissue damage.
MB fraction	< 10 units/L	MB isomer of creatine kinase. High values indicate heart muscle damage.
pO_2	80–90 mmHg	Oxygen. Low values indicate respiratory failure.
pH	7.35–7.45	Acid-base balance.
PTT	< 40 seconds	Partial thromboplastin time. Test of blood clotting ability.
SGOT	15–37 units/mL	Serum glutamic oxalacetic transaminase. Test for heart muscle or liver damage.
SGPT	30–65 units/mL	Serum glutamic pyruvic transaminase. Test for liver damage.
WBC	$< 10.8 \times 10^3/mm^3$	White blood cells. High values indicate presence of infection.

*Normal values as reported by the Laboratory Department, Guam Memorial Hospital Authority.

her extremities and she had generalized muscle fasiculations. She was given repeated doses of Solumedrol, epinephrine and Benadryl but her oxygen saturation continued to drop requiring emergency intubation and respiratory assistance. After we put her on the respirator (100 percent oxygen) her blood pCO_2 dropped to 19 mm/Hg, her pO_2 rose to 415 mm/Hg (far above normal) and her pH was 7.52, reflecting the decrease in carbon dioxide. All this suggested she was having difficulty using her muscles to breathe since when we put her on a ventilator we were clearly able to ventilate very well for her, in fact a little too well on this occasion.

About two hours later the patient suddenly became hypotensive with her blood pressure dropping to 60 over 30 mm/Hg. Her temperature rose to above 106 °F, she had tetanic muscular contractions, diffuse muscle fasiculations and ventricular ectopic (rapid, weak, and ineffectual) heart beats were noted on the monitor. The patient's blood pressure did not improve despite large doses of intravenous fluids and very high doses of dopamine administered to constrict blood vessels, raise the blood pressure and increase cardiac output. The ectopy was not controlled with intravenous lidocaine HCl which we use to suppress arrhythmias. The patient developed a wide-complex bradycardia—very slow heart rate—which did not respond to atropine. This was followed by heart failure and a flat-line EKG. A vigorous attempt at cardiopulmonary resuscitation (CPR) was totally unsuccessful.

About the same time this patient was going through this catastrophic and relentless demise, a second patient, a 32-year-old Chamorro (native Guamanian) female (R.M.), had presented to the emergency room (about 10:20 in the evening) with numbness of the extremities, posterior neck and lips and with weakness of the upper extremities. There was no other significant present or past medical history that we noted at that time. Her initial physical examination showed normal blood pressure of 140 over 90 mm/Hg and her temperature, pulse and respiration were normal but she rapidly developed more serious symptoms. She began to be short of breath with wheezing noted, primarily in the neck; I take this to mean laryngeal stridor rather than true wheezing originating in the lungs. She began perspiring and developed a cold, clammy skin. Facial twitching was noted by about four in the morning. Bilateral wheezing developed in the lungs but the remainder of the physical was still normal at that time. Initial laboratory data showed a slight elevation in the white blood cell count but the rest of the laboratory data, including all of the electrolytes, calcium, phosphorous, liver tests, kidney tests, creatinine and BUN values were normal. She had a slightly elevated SGOT (one of the muscle enzymes). Her arterial blood gases showed a pH of 7.35 (a little acidotic); her pCO_2 was 49, a little elevated as before. She was on oxygen and her blood pO_2 level was elevated to 205. Her chest X-ray and EKG were essentially normal.

The patient had self-medicated with oral Benadryl prior to coming to the hospital. After admission she was given additional Benadryl intramuscularly and Tigan (trimethobenzamide HCl) for her nausea and vomiting. She was started on an IV with half normal saline and admitted to the ICU. There the patient

was restless and complained of visual blurring, a sore throat and chest tightness. She had increased salivation and visual hallucinations. She was treated with Tigan again and was given Solumedrol along with more Benadryl, demerol HCl, and Vistaril (hydroxyzine HCl) as well as Tylenol (acetaminophen) for pain. She was given Alupent (metaproterenol sulfate) for her shortness of breath. On the 29th the patient became more restless with increased numbness and facial twitching. She complained of what she described as "lock jaw" and had grunting respirations; although we were able to obtain 100 percent saturation of her hemoglobin on oxygen supplementation she had slurred speech, swollen tongue and cold clammy skin. By 10:30 in the morning of the next day she began thrashing about and had to be restrained. By 4:00 PM in the afternoon she was incoherent, had foamy saliva and was nauseous. She began climbing out of bed and had to be given Valium (diazepam) for sedation. She was also given calcium. She developed severe tachycardia. A neurological consultation was obtained and phenobarbital was suggested to control her muscular activity.

On the 30th, which would be about 48 hours following admission, the patient developed increased wheezing. Her arterial blood test values indicated rapid deterioration; pH dropped from 7.35 to 7.27; the pCO_2 rose from 49 to 74 mm/Hg and her pO_2 fell to 55 mm/Hg despite increasing the oxygen being given. She was given aminophylline intravenously as a bronchodilator, she was given mannitol intravenously and then she was entubated. Returned to the ventilator, her arterial blood pH was 7.5, indicating an alkylosis, her pCO_2 dropped all the way to 27 mm/Hg and the pO_2 level rose to 214; clearly we were still able to ventilate this patient very well with the respirator, even though she could not rid herself of carbon dioxide or oxygenate herself on her own. We placed a Foley catheter and obtained blood cultures. Her chest X-ray now showed bilateral air space infiltrates consistent with pulmonary edema where it had been clear before. By eleven in the morning her blood pressure started to drop; her veins collapsed and she was given large volumes of fluid intravenously. By 7:00 p.m. she developed a tachycardia of 190 beats per minute and her temperature rose to 101.2 °F. At that point fasiculations were noted all over her body, she was perspiring excessively and her arms and legs became rigid. By 8:00 p.m. a Swan-Ganz catheter was inserted to monitor cardiac function, her temperature rose to 102.7, her tachycardia continued and her systolic blood pressure dropped to about 60. At about 9:20 in the evening, her temperature rose to 106 degrees; she developed palmar and pedal spasm and her heart stopped beating. CPR was unsuccessful.

The third case to expire was a 48-year-old Filipino male (S.T.). He came to the hospital at about five in the morning of the 28th with severe abdominal pain, diarrhea, vomiting and a history of eating seaweed the previous evening. He complained about numbness of the extremities and face, severe shortness of breath and chest pain; no other significant present or past history was noted. Physical examination initially showed cool and dry skin but he soon began sweating profusely. Inspiratory and expiratory stridor and wheezing were noted, but in the neck rather than in the lungs at that time. The patient was soon noted to have difficulty talking but nothing else in the physical was abnormal. Laboratory

data showed a slightly low potassium at 3.1 meq/L but other electrolytes were normal as was the remainder of his laboratory data. His EKG showed slight left ventricular enlargement and possible left atrium enlargement, but no other abnormalities.

He was initially treated with Demerol and Phenergan (promethazine HCl) for his abdominal pain. He was given nitroglycerin paste for his chest pain which we thought might be of myocardial origin. He was given IV fluids with potassium supplement to correct his hypokalemia and Solumedrol for the stridor and difficulty breathing. The patient was transferred to the ICU; by eleven in the morning his laryngeal stridor had become much worse. The patient was given Alupent, a bronchodilator, by nebulizer along with IV aminophylline. Morphine was used to control his abdominal and chest pain. This patient was about to be entubated to provide artificial respiration when my patient (C.S.) got even worse so we had to displace him and entubate her instead. We then immediately entubated S.T. since he was now in respiratory failure also. His pH dropped to 7.09; pCO_2 rose to 62 mm/Hg, pO_2 was 78 mm/Hg on 100% oxygen. After entubation the gases were corrected as before. Laryngeal edema was noted at the time the endotracheal tube was inserted. He remained agitated and was given Valium for sedation. Blood pressure at this time was 200 over 125 and his pulse ranged between 110 and 150 per minute. By 4 p.m. he became restless and required more Valium as well as restraints. Diffuse muscle fasiculations and twitchings were noted and Pavulon (pancuronium bromide) was given to relax him so that the respirator could function more efficiently. His lungs remained clear at this time. By 6:00 in the evening his temperature had risen from 100 to 102 °F and cooling measures with a cooling blanket and antipyretics were begun. Later his temperature reached 105.2 °F despite these measures. His skin was warm and moist. Blood pressure rapidly fell to a systolic pressure of about 60 to 80 mm/Hg. IV fluids were given in huge quantities; we put in four large-bore IV's and opened them all up as fast as we could because nothing else was working. He was given IV aminophylline, sodium bicarbonate and, when everything else failed, we administered Dantrium (dantrolene Na) because this case mirrored a syndrome we worry about, malignant hyperthermia, that may occur following the use of anesthetics. Since we were having no success with the other patients we didn't know what else to do. Although the fasiculations continued and his heart rate went up to 190 per minute, the patient survived this acute episode. By the next morning, although he remained entubated, his pupils were reactive, he was responsive and he could answer questions by nodding appropriately. We noticed hematuria (blood in his urine) at this point and his serum myoglobin, a measure of muscle trauma or injury, was markedly elevated at 480,000 units/mL. By 2:15 in the afternoon a rapid decrease in urine output was noted and his blood pressure again fell. Blood pressure went back up; calcium dropped to 7.3; his magnesium was normal at 2.8; SGOT was now elevated at 1349 units/L. Renal shutdown occurred despite administration of mannitol, Lasix (furosemide) and sodium bicarbonate. We placed a Swan-Ganz catheter to try and monitor fluid balance; muscle fasiculations were noted throughout the body. Over the next six days this patient had

recurrent very high fevers and hypotensive episodes requiring fluids, cooling measures and high dose dopamine to support blood pressure. The patient responded to pain and sometimes to verbal stimuli during most of this period and his pupils remained active. He was treated with further calcium, frequent doses of mannitol and sodium bicarbonate for acidosis. When renal failure became progressively worse with rising waste products, acidosis and electrolyte imbalance the patient was begun on dialysis. By the 1st of May, we noticed disseminated intravascular coagulation evidenced by ecchymosis of the genitalia and knees, his platelet count dropped to 72,000 and then to 16,000/mL; his PTT test was elevated and the fibrin degradation products test was greater than 40. By May 2 muscle rigidity was noted and on the 3rd he began having convulsions which were treated with anticonvulsants. On the 4th of May the ecchymosis and the disseminated intervascular coagulation were worse. The patient remained on dopamine, Solumedrol, Tagamet (cimetidine), dilantin sodium, Valium, antacids and Claforan (cefotaxime Na, a broad-spectrum antibiotic). On May 6 the patient became unresponsive to all stimuli and had fixed dilated pupils; he was totally areflexic with a blood potassium level of 1.6 meq/L, which I can't explain. He was seen by a neurological consultant at that time and was felt to be brain-dead. The patient was designated a "Do Not Resuscitate" patient and transferred to a general ward on the 7th of May where he died the next day.

The fourth patient I would like to tell you about briefly is one of the two hospitalized patients that survived. This was a 33 year old Chamorro male (A.U.) who presented to the ER at 4:25 a.m. on the 28th of April with numbness of the face and both hands, abdominal cramps, chest pain and choking sensation in the throat. The patient had been seen earlier in the ER complaining of tingling and numbness of the face and extremities and general weakness but declined treatment. He returned to the ER when his symptoms continued and he learned of the other people who had been poisoned. He had a history of hypertension, diabetes and anxiety. On physical examination, his skin was warm and dry; facial twitching was noted but there were no other significant findings. Laboratory data showed a blood count that was normal, even serum myoglobin in this patient was checked and was initially normal. His initial CPK was 276 units/L; this rose to a level of 593 (MB fraction 10), then dropped back to 364 (MB fraction 8). His EKG showed nonspecific ST-T wave changes; there was no evidence of acute infarction. The patient was admitted to our telemetry unit—our ICU was full of patients by this time—and he had only occasional premature ventricular contractions and sinus tachycardia. He was treated with Demerol and Phenergan for his discomfort, Tylenol for pain as well as Benadryl and mannitol for his other symptoms. He was given Zestril (lisinopril) for his high blood pressure, Xanax (alprazolam) for his anxiety and Alupent for his dyspnea. On the 30th he had more shortness of breath and was given a steroid, Solu-cortef (hydrocortisone Na succinate). His other medications included cimetidine, Vistaril, Procardia (nifedipine), Halcion (triazolam), and Micronase. The patient continued to have intermittent muscular fasiculations, chest tightness, and abdominal pain. Numbness or tingling sensation of the skin continued over the following week. His

initial temperature of 100.6 °F gradually resolved over the first four days of his hospitalization and he was discharged on the 8th of May, essentially without symptoms.

The last patient I would like to review for you is a 61-year-old Filipina (A.E.) who presented at 9:58 a.m. on the 28th with nausea, vomiting, numbness and tingling of the legs and mouth and claiming to have eaten seaweed the previous day. She had a history of hyperlipidemia but nothing else of significance. She had a temperature of 100.1 °F and some slight wheezing was noted but the rest of her physical was normal. Her laboratory data showed a rather high WBC of 18,700 but was otherwise normal. Her CPK at this time—note she was a little later coming in than the others—was markedly above normal at 1723 units/L: that is about 6 or 7 times normal. Her LDH was 256 units/L, about twice normal, and the MB fraction was 29: that's less than 2 percent of the total CPK, so not suggestive of a heart attack. Her EKG showed some ST elevations and T-wave changes. Her chest X-ray was normal. The patient was given mannitol several times, also Nitropress (Na nitroprusside) and aspirin, and then observed on the telemetry ward. She had slight intermittent numbness and tingling and was given further mannitol and Benadryl. Her temperature gradually resolved to normal over the next 4 days. The patient left the hospital on the 5th of May with a discharge diagnosis of intramural myocardial infarction (MI). I would suggest that her course was more consistent with the Guam seaweed poisoning syndrome than with an acute MI as her EKG, when discharged, was essentially identical to that on admission.

These case histories provide a poignant picture of the problems we faced. They also provide a distinct pattern of signs and symptoms that we may be able to recognize in the future. All of these cases presented with numbness and tingling of the extremities and face; this was invariable. They all had some degree of shortness of breath and weakness. Most of them experienced abdominal pain with nausea and vomiting and sometimes diarrhea. They almost always had excessive perspiration and some of them had cold skin and tears. Upon physical examination they all showed muscle twitchings or fasiculations; there was invariably some stridor or wheezing. Initial low grade fever was present in essentially all of them and there was evidence of respiratory paralysis in those that were severely intoxicated. Generalized muscle fasciculations or tetanic seizures, high fever, arrhythmias and hypotension leading to heart failure was the inevitable course among the three who died. Initial laboratory data was not helpful at all except for the arterial blood gases which showed elevations in the carbon dioxide level, declines in the oxygen level and a drop in pH. Later laboratory data showed marked elevations in serum enzyme levels including SGOT, CPK, SGPT, and LDH. In the final analysis, it is my opinion that the treatment regimens that were used probably did not affect the course of these patients at all.