NCP FORUM

Clinical Rounds With Nutrition Support Services*
From The University of Michigan

The editors of *Nutrition in Clinical Practice* held a session entitled "NCP Forum: Clinical Rounds With Nutrition Support Services" at the 17th Clinical Congress in San Diego, California, last year. Two nutrition support teams presented a case and described how each member of the team interacted with the patient to effect a successful outcome. One team was from the Cleveland Clinic in Ohio; the other, from the University of Michigan in Ann Arbor.

Below are excerpts from the University of Michigan team's presentation.

The Parenteral and Enteral Nutrition Team from the University of Michigan is made up of a clinical nurse manager, three nurse clinicians, two clinical pharmacists, and two nutrition specialists. Members of the team presenting this case included:

Debra S. Kovacevich, RN, MPH, CNSN
Clinical Manager

Carol L. Braunschweig, RD, MS, CNSD
Clinical Nutrition Specialist

Patricia Couch, PharmD
Clinical Pharmacist

David August, MD, clinical director of both the Core Team and the Steering Committee managed the case but was unable to participate.

Ms Kovacevich: The patient, HH, is 19 years old; his height is 206 cm (6 ft 9 in.); and his weight is 91.8 kg (around 202 lb). He had no previous medical or nutritional history. He came to our emergency facility with a 60-hour history of severe abdominal pain. Findings on physical examination were as follows: heart rate, 150 bpm; respiratory rate, 42 bpm; temperature, 37.9°C; orthostatic hypotension. Laboratory findings were significant for a white blood cell count of 11.3×10^9/L, with 54% bands. Other findings were a serum HCO_3 of 16 mEq/L; elevated liver enzyme tests, specifically SGOT and SGPT over 2000 IU; and a prothrombin time of 19.3 seconds.

HH was immediately taken to the operating room following rapid fluid resuscitation. An exploratory laparotomy showed necrotic bowel extending from the midjejunum to the splenic flexure of the colon. The liver was ischemic. Neither the celiac axis nor superior mesenteric artery pulses were present. However, pulses were detected in the aorta and both renal arteries.

The necrotic bowel was resected, leaving an end-jejunostomy and a Hartmann's pouch up to the midascending colon; about 200 cm of viable small bowel remained. He was immediately taken to the radiology department for further evaluation of the splanchnic ischemia. Angiography (Fig. 1) showed flow to his renal arteries but no flow to the celiac or the superior mesenteric artery. He was again taken immediately to the operating room, where his liver was revascularized by means of an autogenous reverse saphenous vein graft from the right common iliac artery to the proper hepatic artery. Collateral circulation via the gastroduodenal artery also helped restore blood flow to the remaining small bowel.

Forty-eight hours later HH was taken to the operating room for a second-look laparotomy. His bowel and liver were well perfused, and a gastrostomy tube was placed to facilitate drainage and to begin early enteral feedings.

Postoperatively, the patient had persistent elevated liver function tests and sepsis. On July 3 a heart murmur was detected. A cardiac ultrasound revealed an aortic dissection and a probable marfanoid aorta, which was later confirmed by angiogram. Figure 2 shows the results of the second angiogram, which indicated that the aorta was more than twice the normal size.

The physical examination and laboratory findings

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suggested a possible diagnosis of Marfan syndrome. Let me briefly review the signs and symptoms of this disorder.

Marfan's syndrome is an autosomal dominant, inherited disorder of collagen that affects four to six people per 100,000. Clinical signs include subluxation of the lens of the eye, arachnodactyly, extreme limb length, aortic dissection, and aortic valve incompetence. HH displayed all these signs.

Life expectancy of an individual with Marfan's syndrome is about 30 to 40 years. Approximately 95% of all deaths are related to cardiovascular complications, specifically aortic rupture. The condition is diagnosed anthropometrically by measuring the arm span and comparing it with the patient's height. HH's arm span was a foot longer than his height. Normally the two measurements are about the same.

Such patients usually are taken immediately to the operating room to correct the dissection. However, HH still had considerable hemostatic instability and remained septic. He had a large wound to granulate; therefore, surgery was delayed until these conditions were resolved.

Dr August decided on conservative therapy, which consisted of aggressive enteral and parenteral nutrition support (basically parenteral, because enteral support failed) and antibiotic therapy. However, refractory hypertension developed, which was thought secondary to further extension of the dissection to the renal arteries. Fenestration of the dissection in the abdominal aorta was performed angiographically with a guidewire and dilating balloon (Fig. 3). The patient's hypertension improved dramatically. About 10 days after complete resolution of all his signs and symptoms of sepsis, his aortic valve, aortic root, and ascending thoracic aorta were replaced with a composite graft.

POSTOPERATIVE RECOVERY

HH recovered slowly but uneventfully from this procedure. However, during his 2 months of hospitalization, he became very dependent on his mother. He wouldn't let her out of his sight, and she became the primary decision-maker for him. This was surprising, because he seemed to be a fairly independent person.

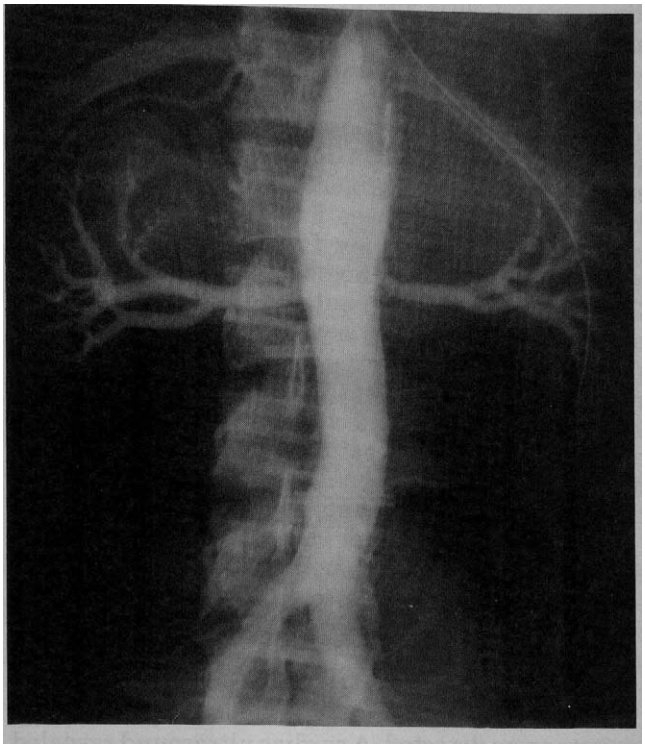

Figure 1. Abdominal aortogram obtained immediately following initial laparotomy for resection of necrotic bowel. Renal arteries are apparently normal, but the celiac and superior mesenteric arteries are not seen. There is no intimal flap visible in this study. After the angiogram, the patient was immediately returned to the operating room for revascularization of his splanchnic circulation.

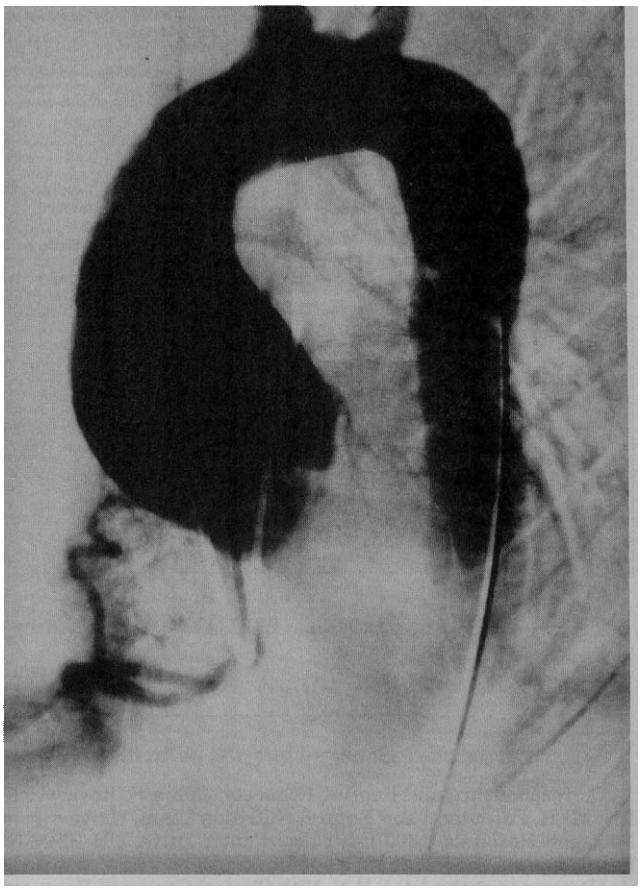

Figure 2. Thoracic aortogram obtained 5 days after admission. The aortic root is dilated and an intimal flap is barely visible in the descending thoracic aorta approximately 5 cm distal to the aortic arch.

He had graduated from high school and moved to Florida, where he completed one successful year of college. To help him regain his independence, the medical team wanted to send him home as soon as possible. We tried several times to feed him enterally but failed.

Ultimately, the patient was discharged on home parenteral nutrition (HPN) August 31. Two weeks later after his discharge, he was readmitted for catheter sepsis. At that time the medical team evaluated the risks and the long-term plan for HH. Dr August was to take down his jejunostomy in 6 months to 1 year. However, we wondered if the risk of malnutrition was greater than the risk of infection of the valve and the graft from placing another catheter.

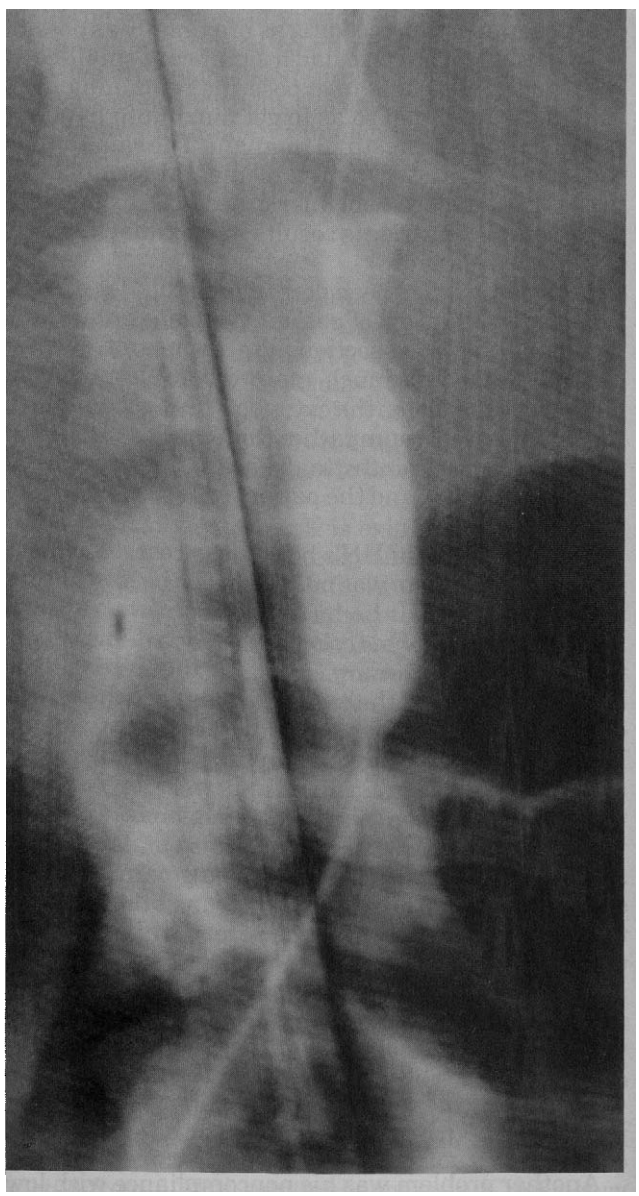

Figure 3. Fenestration of the intimal flap within the abdominal aorta to improve renal blood flow and palliate renovascular hypertension. The catheter was inserted percutaneously via the right femoral artery. The catheter was then manipulated so that the balloon traversed the intimal flap, passing from the true lumen caudal to the false lumen cephalad. Inflation of the balloon created a common lumen, augmenting renal blood flow and simplifying management of the patient's hypertension.

Dr August elected to use the gastrostomy tube and discharged HH home on tube feedings. He was subsequently readmitted twice for dehydration; his jejunostomy was finally taken down in October and his gastrointestinal tract continuity restored. Ms Braunschweig will discuss nutrition support for the patient.

NUTRITIONAL GOALS

Ms Braunschweig: Our first goal of nutrition support is to maintain the patient's admission nutritional status. That is almost never possible for someone as critically ill–though well nourished–as HH was. Our goal for patients admitted to the intensive care unit is not to replenish but rather to maintain the admission nutritional status. We try to introduce enteral nutrition support as soon as possible.

In HH's case, the second component of management consisted of electrolyte manipulation. As mentioned earlier, HH had problems with hypertension before fenestration was performed, and we had to manipulate the electrolytes accordingly. Despite renal insufficiency, he never required dialysis; we manipulated the TPN solution to meet the requirements. He also had hypersecretion of gastric acid (routinely associated with extensive small-bowel resection); we managed that problem with H_2 antagonists.

CALORIC NEEDS

We rely heavily on our institution's metabolic laboratory, which uses indirect calorimetry to determine a patient's caloric needs. This was particularly useful with HH, who was young, very ill, and unusually large. Without indirect calorimetry I would have estimated his caloric requirements to be much higher than what they actually were.

HH's resting energy expenditure needs ranged from 2500 to 3300 kcal, and we estimated his protein needs at 1.2 to 1.5 g/kg of ideal body weight. We began his nutrition support with our standard amino acid/dextrose solution and increased the percent amino acids to 6% with 25% dextrose and one 500-mL bottle of a 20% lipid to provide appoximately 3000 kcal and 120 g of protein per day.

The electrolyte composition was distinct from our standard formulation in that we increased the sodium chloride content to about half normal saline. We maximized the amount of potassium at 80 mEq/L. We also maximized the amount of magnesium because he was being so heavily diuresed. He received the standard trace element multivitamin package and ranitidine

at 200 mg per day. This is higher than the standard dose of 150 mg per day, but because of his size the change was deemed necessary.

MICRONUTRIENT NEEDS

It is not easy to know the micronutrient needs for a physiologically unique individual such as HH (Fig. 4). HH stands about a foot taller than the average man, for whom the recommended dietary allowances (RDAs) were established, and his daily requirements are excessive–more than 3000 kcal. The RDAs were established essentially to meet 98% of the needs of healthy individuals, which is effectively what trace elements in standard vitamin supplementations are intended for. HH would represent an alpha error; he does not fit on the bell-shaped curve.

As mentioned, HH was well nourished and had no medical history when he came to us. But when I start infusing more than 3000 calories in a patient, I wonder whether the vitamins will meet the patient's requirements, because the needs for some nutrients are determined by the amount of calories received. Usually, if a patient initially receives two feedings, this is not a problem. With increased feeding, the patient receives more micronutrients, vitamins, and minerals. But for patients on TPN it is a one-size-fits-all solution, and one wonders whether it will be adequate.

The nutrients that predominantly concern us are thiamin, riboflavin, niacin, and pyridoxine. HH needed three times the normal amounts of these nutrients which were adequately provided with the standard MVI dose. We occasionally double the MVI dose for 5 to 10 days with depleted patients who have high caloric requirements. We use these trace element and vitamin packages to meet individual requirements, and with HH, we clearly needed to address this.

Figure 4. HH at age 21 (with his mother).

ENTERAL SUPPORT

We had to consider two areas regarding introducing enteral support: gastric versus small-bowel route, and polymeric versus defined elemental formula. The literature supports proceeding as proximally as possible with patients who have had a significant small-bowel resection. The goal is to expose the remaining intestine to the nutrition so as to get maximum hypertrophy of the gastrointestinal remnant. The same applies to the polymeric versus the elemental formula. The literature supports polymeric because exposure to more complex nutrients results in maximal hypertrophy of the remnant.

It has previously been determined that for successful nutrition support of patients who have had extensive small-bowel resection, the chance of effective enteral support is much more favorable under the following conditions: the extent of the resection is less than 80%, the jejunum rather than the ileum has been resected, no gastrointestinal disease is present in the remaining bowel, and the patient still has an ileocecal valve.

Less than 80% of HH's bowel was resected, but he had no ileum. There was no disease in the gastrointestinal remnants, but he had no ileocecal valve, and a large percentage of his colon was resected. In patients with no ileum, a primary concern is that bile acid will be depleted toward the end of each day. Such patients cannot resorb the bile acids without the terminal ileum, where this kind of absorption takes place. They also become deficient in vitamin B_{12} and for the rest of their lives must depend on B_{12} injections.

Another concern regarding HH was malabsorption as a result of bile acid loss. Only the proximal portion of the small bowel remained, and transit time through that portion of the bowel is much more rapid than it is through the more distal portion. Therefore, we tried to manipulate the enteral support for HH. It took several months for his gastrointestinal tract to become hypertrophic enough for successful oral feeding with some enteral feedings at night.

PATIENT COMPLIANCE

Another problem was his noncompliance with low-fat diet restriction. As mentioned earlier, HH regressed to about age 15 during his hospital stay. When I tried to talk to him about limiting his fat intake (he ate large quantities of high-fat foods), he said that his idea of a major compromise was to go from whole milk to 2%, nothing more. He refused any further dietary modifications.

After HH's aortic valve, aortic root, and ascending aorta were repaired, he required permanent anticoagulation. As a result of drug-nutrient interactions, some alterations in nutrition support were necessary. The need for anticoagulation created a unique situation, because our protocol is to add 5 mg of vitamin K to all PN solutions for adult patients once per week. However, the primary care service HH was using at the time initiated warfarin therapy and elected to delete the 5-mg dose of vitamin K from his PN. This regimen gradually led to vitamin K deficiency and excessive anticoagulation (prothrombin time greater than 24 seconds without warfarin). The patient's PN solution was ultimately supplemented with 1 mg of vitamin K per day, which permitted safe and predictable anticoagulation with concurrent warfarin therapy.

VITAMIN K METABOLISM

Dr Couch: The need to anticoagulate HH created for us a unique situation. Our protocol dictates the addition of 5 mg of vitamin K to each TPN solution for adults once weekly. The primary care service initially elected to delete all vitamin K from the TPN solution when HH began warfarin therapy. Before I discuss what I recommended, I want to briefly review vitamin K metabolism.

Metabolically, vitamin K is oxidized via a vitamin K-dependent carboxylase enzyme. This reaction results in the formation of 2,3-vitamin K epoxide, an inactive metabolite. This reaction, which occurs in the presence of CO_2 and molecular oxygen, is important in that during oxidation, glutamic acid residues on the precursor proteins for inactive clotting factors undergo gamma-carboxylation to form gamma-carboxyglutamate residues. Gamma-carboxylation of the clotting factors render them active, enabling them to chelate calcium ions on phospholipid membranes. This interaction facilitates clot formation following injury. In the course of its metabolism, 2,3-vitamin K is subsequently reduced, ultimately resulting in the formation of the active naphthohydroquinone cofactor. This process is highly effective in recycling vitamin K epoxide so that it can once again be oxidized and therefore activate clotting factors.

In HH, or any patient receiving anticoagulant therapy, this cycle is interrupted. Specifically, warfarin blocks the action of the reductase enzymes, prohibiting regeneration of the active form of vitamin K. If vitamin K is not regenerated endogenously and is also deleted from a TPN solution, a vitamin K deficiency may result in conjunction with the existence of nonfunctional clotting factors. A vitamin K deficiency, coupled with warfarin therapy, may predispose a patient to excessive anticoagulation and increase the risk of hemorrhage.

In addition, vitamin K is an important cofactor in the gamma-carboxylation of other proteins, such as osteocalcin, which is involved in bone formation.

Finally, proteins C and S, which are involved in inactivation of clotting factors V and VIII, also require gamma-carboxylation for activation.

We did not want HH to become vitamin-K deficient, but our current protocol of administering 5 mg of vitamin K once per week was not ideal, either, because we could overcorrect his coagulation status or block the action warfarin for an extended period. At this point we needed to develop an alternative method of administering vitamin K to HH.

In 1975 Anderson and Godal administered 1 mg of intravenous vitamin K to 20 patients who were receiving warfarin therapy. Before receiving vitamin K, all 20 patients had thrombotests within the therapeutic range of 5% and 10% of normal, indicative of a steady state of hypocoagulability. Administration of the 1 mg of vitamin K resulted in a moderate reduction of warfarin's anticoagulant effect, evidenced by a thrombotest >12%. The investigators believed, therefore, that they were able to maintain a predictable state of anticoagulation and prevent excessive bleeding by using 1 mg of vitamin K.

In 1992 Shetty and colleagues studied 31 patients receiving warfarin therapy who were in a steady state of anticoagulation. They divided the patients into two groups; one group (21 patients) received 0.5 mg of intravenous vitamin K, and the second group (10 patients) received 1 mg. International normalized ratios (INRs) were between 2 and 5.5 in the group of patients receiving 0.5 mg of vitamin K 24 hours after the dose was given. This is consistent with a stable state of anticoagulation. According to the guidelines established by the British Society of Haematology, INRs between 4.5 to 7 reflect excessive anticoagulation. Thus these investigators believed that the 0.5-mg dose was enough to maintain predictable anticoagulation.

It is interesting that 5 of the 10 patients in the group receiving the 1-mg dose had INRs less than 2, which is thought to correlate with inadequate anticoagulation. Thus these investigators concluded that 0.5 mg of vitamin K was sufficient for maintaining a predictable state of anticoagulation in patients receiving concurrent warfarin therapy.

Because of HH's unusually large size, we elected to maintain him on 1 mg of vitamin K daily while he received TPN and a daily dose of warfarin. With this regimen we were able to maintain a predictable state of anticoagulation, evidenced by the patient's prothrombin times, which averaged between 15 and 18 seconds.

When HH was discharged from the hospital, he was no longer receiving TPN therapy and was able to obtain the necessary amount of vitamin K from his diet. He has done well since, continuing with 5 mg of warfarin per day and maintaining a predictable state of anticoagulation.

OUTCOME

Currently, HH is doing well. He is maintaining adequate nutritional status with a low-fat oral diet

and 500 mL of a moderate protein, isotonic tube feeding on a nightly basis. He is also working full time.

AUDIENCE QUESTIONS

Question: You indicate that there were several attempts to feed the patient. What products were used in these attempts? How long was the gut inactive before enteral feeding was attempted? On what basis did you decide that enteral feeding was not possible?

Ms Braunschweig: The products used were initially Osmolite HN–not tolerated at 20 mL/hr, switched to 1/2 strength Criticare–not tolerated at 20 mL/hr. Attempts at enteral feeding were tried on the fifth postoperative day. Feedings were stopped because of distention and high residuals (> twice the previous hourly volume).

Question: If enteral nutrition cannot be used to deliver all the nutrients required, was any consideration given to providing some of the feeding enterally?

Ms Braunschweig: Initially enteral feedings were not used because everything infused came out rapidly and with little digestion. With time, the gut did adapt and enteral support was provided in the evenings. TPN was weaned and the patient was maintained on an oral diet with cyclic night enteral feedings.

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