

Telemedicine System Using a Cellular Telephone for Continuous Ambulatory Peritoneal Dialysis Patients

Hidetomo Nakamoto,¹ Atsushi Kawamoto,² Yoshimasa Tanabe,² Yoshinori Nakagawa,² Eiichi Nishida,³ Takashi Akiba,³ Hiromichi Suzuki¹

We developed a new telemedicine system to monitor the condition of continuous ambulatory peritoneal dialysis (CAPD) patients by using a cellular telephone and an Internet Web site. All data for the CAPD patients—blood pressure, heart rate, body weight, ultrafiltration volume, and urine volume—are collected and sent directly by cellular telephone to a data server that was constructed at the NTT DoCoMo Company data center. The system is directly connected to Internet by application service provider (ASP) technology. Anywhere, at any time, each patient can confirm changes in their data in graph form by using a cellular telephone or a computer connection to an Internet Web site. The average of each type of data is calculated and shown at the Web site. All data collected by cellular telephone are calculated and, in real time, sent directly to the treating physician's office over the Internet. Abnormal data are sent directly to the treating physician's office and shown in the host computer with an emergency signal (emergency alarm system). In addition, CAPD patients can easily contact the medical staff in the Kidney and Dialysis Center of Saitama Medical School (main hospital) using the same telemedicine system.

We are using this telemedicine system for 46 CAPD patients being treated by Saitama Medical School. The cost of using the system is just US\$3.00 or less per month for each patient. This newly developed system has great advantages for CAPD patients, especially elderly and handicapped patients. The system can be expanded into a network that serves all CAPD patients and all hospitals in Japan.

Key words

Telemedicine, continuous ambulatory peritoneal dialysis (CAPD), cellular telephone, Internet, Web site, application service provider (ASP) technology

Introduction

Computer-assisted medical activity is increasing in a number of fields and is particularly widespread in nephrology and dialysis owing to characteristics of the patient population such as number, complexity, follow-up time, and economic cost (1). Rapid development of information and telecommunications technology during recent decades has led to those technologies being applied in the medical field.

Continuous ambulatory peritoneal dialysis (CAPD) is one treatment available for end-stage renal disease (ESRD). Some years ago, many ESRD patients were treated with CAPD in Japan. However, the proportion of patients treated by CAPD is very low, despite reports suggesting that CAPD has a lower mortality and offers a better quality of life (2,3). The main factors that negatively affected the development of CAPD were the rapid proliferation of renal units and the appearance of encapsulating peritoneal sclerosis (EPS), a serious complication for long-term CAPD patients (4). In addition, CAPD is a home dialysis system: patients must do everything for themselves, including CAPD solution exchanges, catheter exit-site care, and so on. Almost all CAPD patients have a history of trouble at home of some sort during their CAPD life.

Because CAPD patients must carry out their treatment by themselves, equipment must be failsafe. Easy techniques, safe equipment, and suitable education may enable patients and relatives to carry out a treatment normally performed by medical staff. In addition, for backup at home, CAPD patients need a medical support system. The telemedicine system described here supports at-home CAPD patients.

From: ¹Department of Nephrology, Saitama Medical School, Saitama; ²JMS Corporation, Tokyo; and ³Department of Nephrology, Tokyo Woman's Medical College, Tokyo, Japan.

Materials and methods

Newly developed telemedicine system using cellular telephone

Figure 1 shows our newly developed telemedicine system. The system has two parts: a data collection and monitoring system that uses a cellular telephone, and an Internet Web site accessible by computer. We developed the system to monitor the condition of our CAPD patients. All of our CAPD patients can use a cellular telephone as a data collection device. The software for the telemedicine system can be downloaded directly from an i-mode site that was constructed by the NTT DoCoMo Company. After software download, the cellular telephone can be used as a data collection and monitoring device as well as a personal data assistant (PDA), Figure 2. Using the cellular telephone as data collection device is very easy.

All data from our CAPD patients—blood pressure, body weight, ultrafiltration volume, and urine volume—are sent directly to the main server in the NTT DoCoMo data center, where they are accumulated in a database. The database system is directly connected to an Internet Web site system by application service provider (ASP) technology. Anywhere, at any time, any CAPD patient can access the Internet Web site for patients. Using a cellular telephone or the Web site, patients can confirm changes in their data in graph form. The average of their data is also calculated and shown at the Web site.

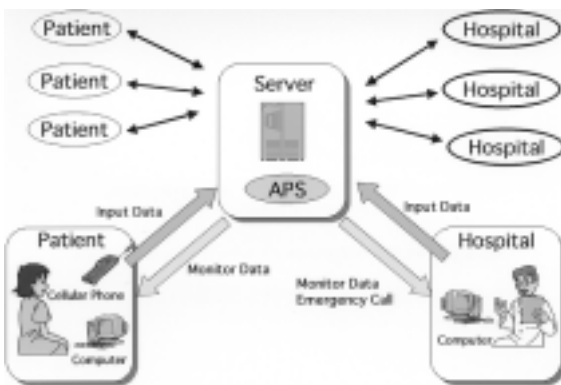


FIGURE 1 Newly developed telemedicine system using a cellular telephone. The telemedicine system has two parts: (A) a data collection and monitoring system that uses a cellular telephone, and (B) an Internet Web site accessible by computer.

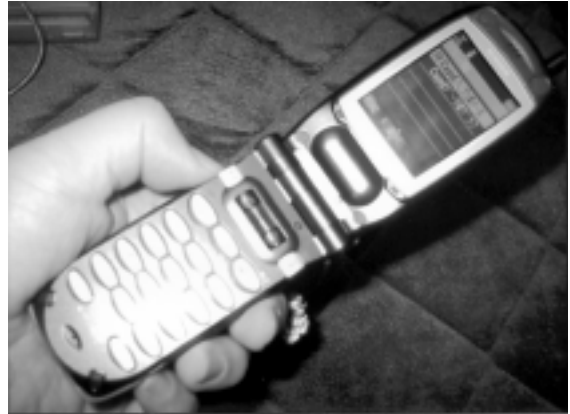


FIGURE 2 Data collection and monitoring using a cellular telephone. Once the software has been downloaded from the i-mode site, the cellular telephone can be used as a data collection and monitoring device as well as a personal digital assistant (PDA).

Costs of telemedicine system

We are now using this telemedicine system for 46 CAPD patients being treated at the Kidney and Dialysis Center of Saitama Medical School. Patients who want to use the system can obtain the software free from the i-mode site. Patients must themselves pay the cost of the cellular telephone. However, the average cost of sending data by cellular telephone is only US\$0.01 each time. The average cost of checking the data by cellular telephone is only US\$0.10 each time. The total cost of using the telemedicine system is very small, only US\$3.00 or less monthly.

Web site for CAPD patients

When patients want to monitor the data in the database, they can use a computer to access the Web site and view their own data. They can monitor the actual data, the averages, and the graphs. Figure 3 shows changes in blood pressure, body weight, and ultrafiltration volume that we retrieved from the CAPD Web site for a 40-year-old patient. Figure 4(A) shows the data input site on a cellular telephone display screen. Figure 4(B) shows, on a cellular telephone display screen, the parameter changes that can be monitored.

All data from CAPD patients are collected by an ASP system and calculated by computer. Patient can access the i-mode CAPD site by cellular telephone or the Web site by computer connection and can obtain their data whenever they want it. If medical staff want

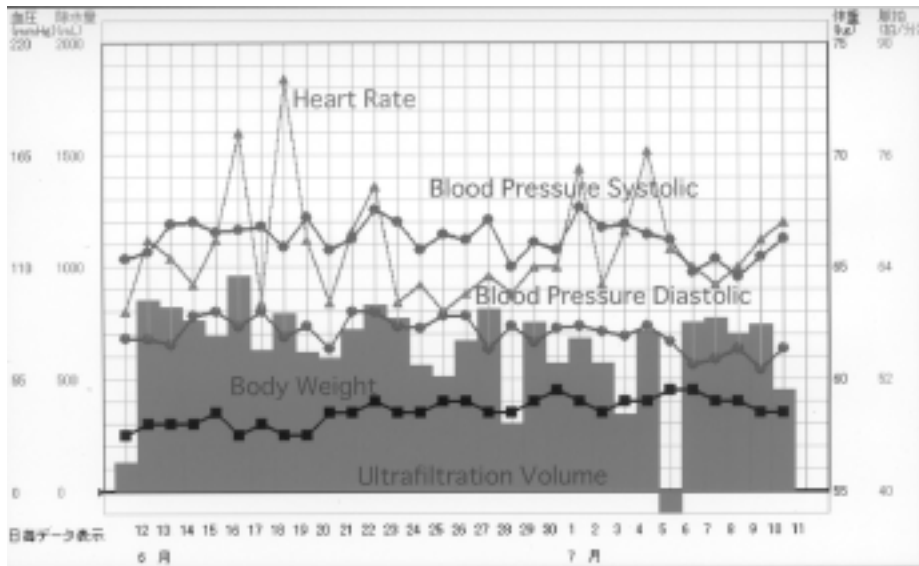


FIGURE 3 Changes in blood pressure, body weight, and ultrafiltration volume in a 40-year-old patient on continuous ambulatory peritoneal dialysis (CAPD), viewed on the telemedicine Web site.

to obtain data on the CAPD patients, they can access the Web site. If a CAPD patient has problems with therapy, the staff receives an emergency signal on the Web site. They can then call the patient on the cellular telephone and consult with the patient.

Results

Benefits of the telemedicine system

We expect that the system will have great advantages for helping our CAPD patient to maintain CAPD, especially our handicapped and elderly patients. When our patients have trouble with CAPD, we can contact them by cellular telephone and provide advice. In addition, we can use the system in conjunction with the existing network system between CAPD patients and hospitals. Patients living remotely from the main hospital can periodically attend an affiliated hospital for routine follow-up: examination of physical condition, blood chemistry, chest radiograph, electrocardiogram, and so on. A nephrologist in the main hospital can obtain all the data on the CAPD patients by using the telemedicine system. The patients can receive drugs prescribed by the nephrologist as required. Furthermore, we can use the system for emergency alarms. In an emergency call, data are available in the main

hospital, and the nephrologist can order the necessary medications. We can also use the system as data collection system. If we want use the data from our CAPD patients, then, after informed consent, we can collect and calculate a great deal of data directly from the Web site.

Discussion

Previously, we reported (5) on a telemedicine system for our patients who are using automated peritoneal dialysis (APD). In the case of APD, data are collected regarding the state of both the patient and the APD machine. Taken together, those data provide feedback information. That telemedicine system has two parts: a data collection and transport system, and an interview system ("View Send"). The APD system has had great advantages for all patients using it. However, it could only be used by at-home APD patients. In our hospital, only 20% of peritoneal dialysis patients are using APD. A lot of CAPD patients wanted to use a system of that kind but could not.

In the present study, we created a telemedicine system that our CAPD patients can use. The goal of our project was to give CAPD patients a supportive telematics monitoring service. To achieve the goal, our system had to be simple and easy to manage for

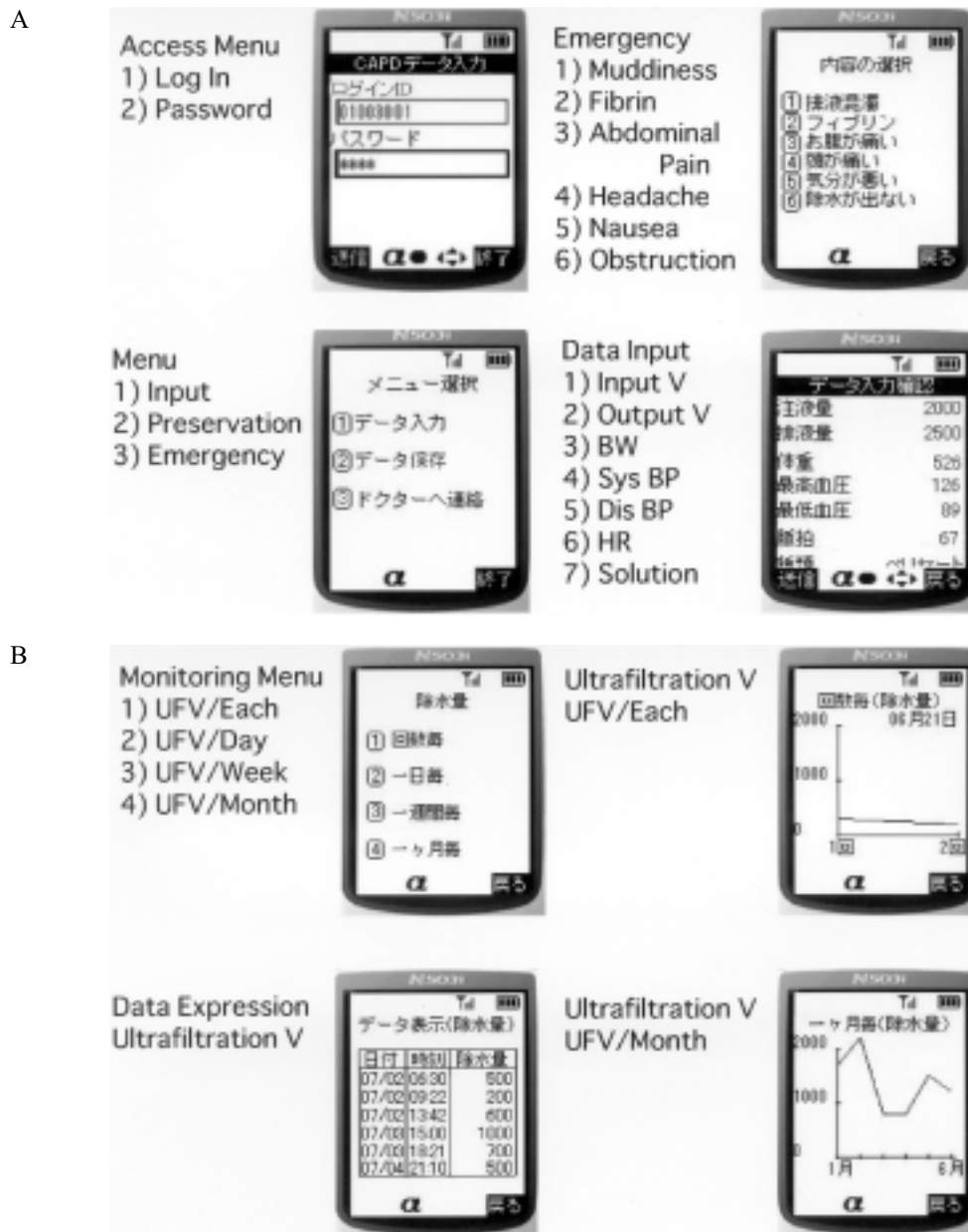


FIGURE 4 (A) Data input site shown on the display screen of a cellular telephone. V = volume; BW = body weight; BP = blood pressure; HR = heart rate. (B) Data monitoring site shown on the display screen of a cellular telephone. Changes in the patient's parameters—blood pressure, heart rate, body weight, and ultrafiltration volume (UFV)—can be seen on the display screen of a cellular telephone.

all CAPD patients, including elderly and handicapped patients. To that end, we constructed a system that uses a cellular telephone as the data collection device. All data from our CAPD patients are collected by cel-

lular telephone and sent directly to main data server at the NTT DoCoMo data center. The system is directly connected to the Internet system by ASP technology. We confirmed that the telemedicine system

had great advantages for helping our CAPD patients to maintain CAPD.

Many trials of telemedicine systems for ESRD have been reported. Recently, Moncrief reported the Texas Telemedicine Project (TTP), which was designed in Giddings, TX, to evaluate the economic practicality of delivering medical care through bidirectional interactive video. Since March of 1990, dialysis patients have been monitored and primary care has been delivered through the electronic medium (6,7). The TTP offered the physician participants an opportunity to explore the best delivery system for successful use of telemedicine in the practice of medicine. Between April 1991 and April 1993, the TTP sponsored the contact and records management. During that period, 1,500 patient contacts were documented. After termination of the project, the transmission lines were maintained between the central dialysis center and the satellite facility. Between 1993 and 1996, another 12,000 patient contacts were made. Dialysis monitoring accounted for approximately 80% of contacts. The other 20% of contacts were non dialysis (primary care) contacts. Patients quickly became comfortable with interactive healthcare delivery and preferred it as a means of receiving primary care and continuous physician monitoring during dialysis treatments. From that large-scale project, the researchers concluded that telematic healthcare delivery would be successful when the patient-physician relationship most closely mimicked face-to-face contact (6,7).

The Moncrief report was the first that used a telemedicine system with a large number of dialysis patients. Recently, other reports have noted the efficacy of telemedicine systems to monitor home hemodialysis (HD) patients (8,9). New computer-based videoconferencing systems are capable of interfacing with dialysis machines and clinical information systems to achieve a paperless medical record, including capture of vascular access images, a dialysis parameter database, and so on (8,9).

Home HD for the regular treatment of ESRD has been taking place since 1964. However, use of that treatment modality has declined progressively in the United States. Recently, Agroyannis *et al.* (9) combined home HD with a telematics monitoring service for supporting ESRD patients who need home or satellite HD treatment. According to the data collected, disturbances of HD machine function were visible and

audible in the central control station, and the user messages were always observed.

Conclusion

Telemedicine for the care of dialysis patients is being studied and used routinely in several centers throughout the world (5-9). The prominent characteristic of telemedicine is its fast, two-way electronic network, which allows interactive communication between doctors and patients. However little has been reported about the use of a telemedicine system to monitor home CAPD patients. In the present study, we report a newly developed telemedicine system that uses a cellular telephone. We have 46 patients undergoing CAPD who are using the telemedicine system. From our results, we suggest that a telemedicine system for CAPD patients, especially elderly and handicapped patients, has several advantages:

- It assists medical and nursing staff at the central hospital with the task of monitoring CAPD parameters (ultrafiltration volume) and the clinical condition of the patient (body weight, blood pressure, and heart rate), and of assessing patient condition.
- It confirms the changes in CAPD parameters to the patient on CAPD through the computer Web site.
- It assists CAPD patients and their partners at home in receiving critical advice from the medical and nursing staff at central hospital in normal and alarm conditions.

We speculate that, in future, telemedicine systems will become more routine in medical practice. We think that our telemedicine system provides ESRD patients under CAPD with the benefit of supervised autonomy. In addition, our telemedicine system can be networked to serve all CAPD patients and all hospitals world-wide.

References

- 1 Formica M, Quarello F, Stramignoni E, *et al.* Informatics support and teledialysis [Italian]. *Minerva Urol Nefrol* 1994; 46:11-16.
- 2 Baillod RA. Home dialysis: lessons in patient education. *Patient Educ Couns* 1995; 26:17-24.
- 3 Woods JD, Port FK, Stannard D, Blagg CR, Held PJ. Comparison of mortality with home hemodialysis and center hemodialysis: a national study. *Kidney Int*

- 1996; 49:1464–70.
- 4 Nakamoto H, Kawaguchi Y, Suzuki H. Encapsulating peritoneal sclerosis in patients undergoing continuous ambulatory peritoneal dialysis in Japan. *Adv Perit Dial* 2002; 18:119–23.
 - 5 Nakamoto H, Hatta M, Tanaka A, *et al.* Telemedicine system for home automated peritoneal dialysis. *Adv Perit Dial* 2000; 16:191–4.
 - 6 Moncrief JW, Sorrels PA. Primary care and hemodialysis monitoring through telemedicine. *Stud Health Technol Inform* 1996; 29:250–4.
 - 7 Moncrief JW. Telemedicine in the care of the end-stage renal disease patient. *Adv Ren Replace Ther* 1998; 5:286–91.
 - 8 Winchester JF. Telecommunications and dialysis patient. *Am J Kidney Dis* 1999; 34:XXXVI–XXXVIII.
 - 9 Agroyannis B, Fourtounas C, Romagnoli G, *et al.* Telemedicine technology and applications for home hemodialysis. *Int J Artif Organs* 1999; 22:679–83.

Corresponding author:

Hiromichi Suzuki, MD, Department of Nephrology, Saitama Medical School, 38 Morohongo, Moroyamamachi, Iruma-gun, Saitama 350-0495 Japan.

Complications of Peritoneal Dialysis Related to Increased Intra-abdominal Pressure

Adit S. Mahale, Atul Katyal, Ramesh Khanna

Peritoneal dialysis (PD) is associated with a number of complications, some of which can be attributed to raised intra-abdominal pressure. Intra-abdominal pressure is highest during coughing or straining—activities which, fortunately, are transient. High pressure, primarily due to high volumes of PD solution, can predispose patients to hernias, dialysate leaks, and back pain; it can also cause altered mechanics of breathing. This article reviews those various complications and their management.

Key words

High intra-abdominal pressure, hernia, dialysate leak, back pain, pulmonary function test

Introduction

Peritoneal dialysis (PD) is associated with unique set of infectious and noninfectious complications. Amongst the noninfectious complications, a significant number relate to the consequences of raised intra-abdominal pressure, which is seen with the infusion of peritoneal dialysate.

Discussion

The empty peritoneal cavity has a pressure of approximately 0.5 – 2.2 cm H₂O. With the infusion of dialysate, the intra-abdominal pressure increases linearly to about 2 – 10 cm H₂O (1). Furthermore, day-to-day activities can raise intra-abdominal pressure. In a study done by Twardowski *et al.* (2), intra-abdominal pressures were measured with various intraperitoneal fluid volumes in 6 patients during natural activities. The maximum rise in pressure was seen with coughing or straining. During those two activities, intra-abdominal pressures reached as high as 120 – 150 mmHg, but fortunately were transient.

From: Division of Nephrology, University of Missouri, Columbia, Missouri, U.S.A.

Hernia

According to the Laplace law, higher intra-abdominal pressure and volume can both increase tension on the abdominal wall, which might lead to hernias and dialysate leaks.

Hernias occur in about 10% – 15% of PD patients (3,4; Table I), and the risk increases by 20% for each year on continuous ambulatory peritoneal dialysis (CAPD) (6). Patients with polycystic disease have a higher incidence of hernias and leaks. That finding may be related either to a larger kidney size in relation to higher intra-abdominal pressure, or to a manifestation of a generalized collagen disorder (7,8).

Surgical technique is also an important factor. A predisposition to incisional hernia occurs when the incision is in the midline position as compared with the paramedian approach (9).

Another important area of weakness is the processus vaginalis. After migration of the testes through the processus vaginalis to the scrotum, the processus vaginalis obliterates. Obliteration may fail to occur in a large segment of the population, but the condition is inapparent. A patent processus vaginalis has been found in 90% of infants of both sexes at birth and, at autopsy, in up to 37% of adults without hernias. However, under the influence of raised intra-abdominal

TABLE I Hernias reported in peritoneal dialysis patients (5)

Inguinal	23%
Catheter exit site	19.1%
Umbilical	18.6%
Other incisional sites	9.8%
Ventral	8.3%
Epigastric	2.9%
Diaphragmatic	2.0%
Pelvic	1.0%
Femoral	1.0%
Spigelian	0.5%
Unclassified	13.7%

pressure, PD fluid or bowel (or both) may escape through a patent processus vaginalis and may present as an indirect hernia.

Most of the time, a hernia presents as a painless swelling. However, the serious complications of hernia include intestinal strangulation and incarceration. These complications are usually seen with smaller hernias. They can mimic peritonitis and can be associated with bowel perforation. Hernias can also present as recurrent gram-negative peritonitis (3,10,11).

Several measures can be taken to prevent development of hernia:

- Detection and repair of pre-existing hernias
- Detection of a patent processus vaginalis during catheter insertion
- Paramedian catheter placement (9)
- Prevention of constipation and coughing in the early postoperative period
- Catheter break-in period of at least 2 weeks
- No dialysis in the vertical position in the immediate postoperative period
- Strenuous exercises only on an empty abdomen
- Use of a peritoneoscope to insert the dialysis catheter
- Initiation of CAPD with low dialysate volumes if dialysis is needed immediately

Patients who develop hernias after initiation of PD should undergo surgical repair. Hernioplasty may be reinforced with a polypropylene mesh (12). However, mesh repair may be inadequate in some patients with malnutrition (13).

Hernia recurrences are uncommon after surgery. In the case of a recurrence, the patient's intra-abdominal pressure may need to be lowered by a change either to nighttime cycler dialysis or to more frequent exchanges with a lower dialysate volume.

Dialysate leakage

Dialysate leakage is a rarer, but more distressing, complication of PD. Leaks can present as edema of the abdominal or genital walls. The complication is seen in fewer than 10% of PD patients. Men experience a higher incidence of genital edema than do women, probably because the processus vaginalis is more often patent in men (14,15). In women, dialysate can travel through the pouch of Douglas, the vaginal vault, or even through the fallopian tubes and present as a vagi-

nal leak (16,17). Women with vaginal leaks may have a higher incidence of fungal peritonitis (18).

Dialysate leaks can occur either early or late. Early leaks occur less than 30 days after PD catheter insertion (33%). They are usually related to catheter placement technique, and they present as external leakage, either at the exit site or at the median or paramedian surgical wound. Late leaks usually occur beyond 30 days (66%). They are related to mechanical or surgical tears in the peritoneal membrane and present as internal leakage in the pleural cavity, abdominal wall, and external genitalia (19).

Patients with leaks may present with a diminished effluent return. They may have ultrafiltration failure but a normal peritoneal equilibration test. They may also have increased abdominal girth, abdominal asymmetry, and waistband or clothing imprints that seem deeper than usual. The abdominal wall can look pale and boggy.

Diagnosis of a dialysate leak can be made by nuclear scintigraphy or another radiologic procedure such as computed tomography (CT) scan or magnetic resonance imaging. Those procedures involve instillation of dialysate mixed with a radiologic marker (⁹⁹Tc-based colloid, iodinated contrast, or gadolinium) into the abdominal cavity.

In peritoneal scintigraphy, the dialysate containing the ⁹⁹Tc-based colloid is rapidly infused with the patient in the supine position. Measures to increase intra-abdominal pressure are then undertaken (20,21). Images (anterior, posterior, lateral, and oblique views) are usually taken every 15 minutes over 2 hours. Delayed images (24 – 48 hours) are taken for small leaks (22).

In CT peritoneography (see Figure 1), iodinated contrast (iopamidol, diatrizoate) is mixed with dialysate (approximately 50 mL contrast per liter of dialysate) and instilled into the abdominal cavity. The patient is then asked to walk about or to roll from side to side. The CT scan can be done with or without oral or intravenous contrast. Thin slices (5 – 8 mm) are better for detecting small leaks (23). The process of CT peritoneography yields images that are more distinctive for fluid distributions, adhesions, loculations, abscess, small leaks, and catheter localizations than are the images produced by a CT scan.

Recently, magnetic resonance peritoneography has been used to detect dialysate leaks (24). Gadolinium DTPA (approximately 10 mL contrast per liter of dialysate) is used. The contrast can be mixed with ei-

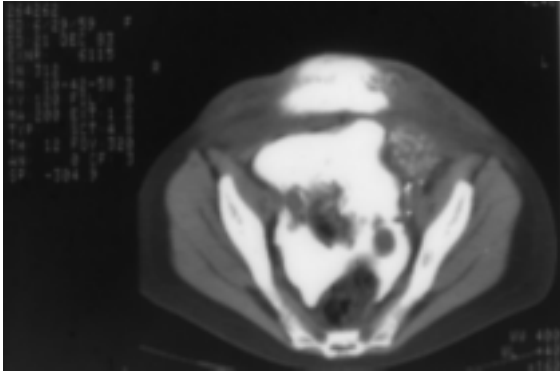


FIGURE 1 Computed tomography (CT) scan of abdomen with contrast. Dye can be seen leaking into the soft tissue in the anterior abdominal wall.

ther saline or dialysate (25). Gadolinium is well tolerated in patients with renal failure. No serious side effects have been reported.

Treatment of leaks involves reduction of intra-abdominal pressure. The patient can dialyze either by using more frequent exchanges with lower volumes of dialysate, by using a cyclor while in the supine position, or, rarely, by temporary conversion to hemodialysis (usually 2 – 3 weeks). Early leaks are usually managed by temporary hemodialysis or by surgical repair. In a study by Leblanc *et al.* (19), late leaks were treated by temporary hemodialysis (29%), surgery (27%), transfer to automated peritoneal dialysis (16%), or transfer to hemodialysis (25%). Those treatment categories showed leak recurrence rates of 65%, 25%, 14%, and 0% respectively.

In cases of recurrence, patients may need a prolonged transfer (4 – 6 weeks) to hemodialysis. If the processus vaginalis is patent, and it is responsible for the leak, surgical correction is required. If, however, the leak is attributable to fluid migrating from the anterior abdominal wall, surgery is rarely successful.

Hydrothorax

Hydrothorax is associated with abnormal communication between the peritoneal and abdominal cavities (26). The true incidence is not known; however, judging from various case series, the incidence ranges between 1.6% and 10% (27–29).

Autopsies have shown discontinuities in the tendinous portions of the hemidiaphragms and an absence

of muscle fibers, which are replaced by a weak collagen network (30,31). That mechanism usually explains a massive hydrothorax that develops soon after initiating PD.

More commonly, patients develop late onset of hydrothorax, which may be an acquired defect attributable to a sustained rise in intra-abdominal pressure. The pressure gives rise to small “bubbles” within the weakened tissue, which can then rupture and produce a hydrothorax (27,31,32). Sometimes the fluid persists despite emptying of the abdomen. That situation may result from a “stop valve” effect that causes one-way passage of fluid from the peritoneal space to the pleural space. The effect may be due either to a valve-like defect in the diaphragm or to the action of the hepatic capsule in tamponing the backflow (33).

In rare cases, a pericardial effusion may be seen if communication between the pleural and pericardial spaces exists, as in patients with previous pericardiocentesis (34,35).

Hydrothorax is seen predominantly in female patients. The cause of that sexual predominance is not known, but may be due to prior pregnancies. The effusion occurs exclusively on the right side. The location may be related to the heart and pericardium, which prevent flux across the left hemidiaphragm. Patients with polycystic kidney disease also have a higher incidence of hydrothorax (36).

Small effusions are usually asymptomatic. Larger effusions may present as shortness of breath. Patients may mistake a hydrothorax for fluid overload and may use a hypertonic solution. But increased ultrafiltration may further raise intra-abdominal pressure and thus worsen the hydrothorax and the dyspnea. Patients may also present with apparent ultrafiltration failure combined with diminished effluent return but a normal peritoneal equilibration test.

A chest radiograph is usually diagnostic. If the cause is uncertain, a thoracocentesis may be helpful. The pleural fluid usually shows very high glucose, low protein, and presence of D-lactate. Assays for D-lactate are not easily available commercially, and they may be difficult to perform. Methylene blue dye can be instilled into the peritoneal cavity before the thoracocentesis, turning the pleural fluid blue. However, methylene blue causes chemical peritonitis, and the blue staining may be so faint as to produce false negative results (37).

Nuclear scans using ^{99}Tc -based colloids can be used to detect leaks across the peritoneal cavity. Contrast peritoneography using nonionic media and a CT scan may also be useful. Recently, magnetic resonance peritoneography has been used with good success (38).

In patients with a large, symptomatic hydrothorax, therapeutic thoracocentesis is usually needed. The subsequent approach in most patients is typically conservative: temporary transfer to hemodialysis (usually for 3–4 weeks). Alternatively, low-volume exchanges in a semi-sitting position, or daytime exchanges with nighttime rest, can be performed. Those conservative approaches usually result in closure in about 40% of cases (39).

If conservative approaches fail, then intervention can be undertaken. Commonly, chemical pleurodesis is used. Various sclerosing agents have been tried, including talc (40); tetracyclines (41); fibrin derivatives, such as fibrin glue with two components, fibrinogen and factor XIII, plus an aprotinin–thrombin solution (42); autologous blood (43,44); and *Nocardia rubra* cell-wall skeleton (45). The procedure may require VATS (video-assisted thoracoscopy) (46). Talc and tetracycline can reach the peritoneal cavity and cause peritoneal fibrosis. Peritoneal dialysis is usually stopped for 4 weeks for fibrosis to occur. Unfortunately, failure rates are high with pleurodesis (up to 50%).

Lastly, in recurrent cases, surgical repair with thoracotomy can be performed. The procedure requires general anesthesia (47). The defects are located, sutured, and reinforced with prosthetic material such as Teflon (39).

Altered mechanics of breathing

Stable patients on PD with 2-L dialysate exchanges have been demonstrated to have reductions in most lung volumes, including functional residual capacity (FRC) (48,49). An FRC below closing volume has been suggested to lead to small-airway collapse, which in turn causes a ventilation–perfusion mismatch and, subsequently, arterial hypoxemia (50,51). Arterial hypoxemia is usually transient, but the fall in FRC persists.

In a study by Bush and Gabriel (52), CAPD patients had a mean diffusing capacity for carbon monoxide just under 70% of the predicted value. The cause was not known, but the hypothesis was that the patients probably had subclinical pulmonary edema re-

lated to low albumin, stemming from PD losses (52). Another explanation was that raised intra-abdominal pressure led to reflux and chronic aspiration and, subsequently, to interstitial fibrosis (53).

Those observed changes in pulmonary function tests are no more severe in patients with chronic obstructive pulmonary disease (COPD) than they are in patients without that condition (49). Thus, COPD should not be a contraindication for PD. Presence of dialysate in the abdomen can actually improve pulmonary function in some COPD patients. To generate the same tension, the diaphragm must generate more pressure when the radius is smaller. Thus, contractility of the diaphragm may increase in response to the presence of PD fluid. However, the relationship has an upper limit, after which the diaphragm loses efficiency and ventilatory compromise occurs (54).

Back pain

Increased intra-abdominal fluid in CAPD may pull the spine to a more lordotic position (51). Some patients may also have poor abdominal muscle tone owing to previous surgeries or poor physical conditioning. The increased mechanical stress on the lumbar spine can cause back pain or sciatica. Moreover, patients may have underlying degenerative disk disease or osteoporosis that may further exacerbate the back pain (55).

Treatment of low back pain in CAPD patients may include a reduction in the dialysate fill volume or a change to continuous cycling peritoneal dialysis (CCPD) or nightly intermittent peritoneal dialysis (NIPD). For patients with severe back pain, transfer to hemodialysis may be necessary if adequate clearance on CCPD cannot be achieved.

References

- 1 Gotloib L, Mines M, Garmizo L, Varma I. Hemodynamic effects of increasing intra-abdominal pressure in peritoneal dialysis. *Perit Dial Bull* 1981; 1:41–3.
- 2 Twardowski ZJ, Khanna R, Nolph KDA, *et al.* Intraabdominal pressures during natural activities in patients treated with continuous ambulatory peritoneal dialysis. *Nephron* 1986; 44:129–35.
- 3 Digenis G, Khanna R, Matthews R, Oreopoulos DG. Abdominal hernias in patients undergoing continuous ambulatory peritoneal dialysis. *Perit Dial Bull* 1982; 2:115–17.
- 4 Suh H, Wadhwa NK, Cabralda T, Sokunbi D, Pinard B. Abdominal wall hernias in ESRD patients receiv-

- ing peritoneal dialysis. *Adv Perit Dial* 1989; 5:84–6.
- 5 Rocco M, Stone W. Abdominal hernias in chronic peritoneal dialysis patients: a review. *Perit Dial Bull* 1985; 5:171–4.
 - 6 O'Connor J, Rigby R, Hardie L. Abdominal hernias complicating continuous ambulatory peritoneal dialysis. *Am J Nephrol* 1986; 6:271–4.
 - 7 Modi KB, Grant AC, Garret A, Rodger RSC. Indirect inguinal hernia in CAPD patients with polycystic kidney disease. *Adv Perit Dial* 1989; 5:84–6.
 - 8 Sorenson VR, Joffe P. Subcutaneous swelling during CAPD. *Perit Dial Int* 1998; 18:232–5.
 - 9 Spence P, Matthews R, Khanna R, Oreopoulos DG. Improved results with a paramedian technique for the insertion of peritoneal dialysis catheters. *Surg Gynecol Obstet* 1985; 161:585–7.
 - 10 Shohat J, Shapira Z, Shumeli D, Boner G. Intestinal incarceration in occult abdominal wall herniae in continuous ambulatory peritoneal dialysis. *Isr J Med Sci* 1985; 21:985–7.
 - 11 Steiner RW, Halasz NA. Abdominal catastrophes and other unusual events in continuous ambulatory peritoneal dialysis patients. *Am J Kidney Dis* 1990; 15:1–7.
 - 12 Imvrios G, Tsakiris D, Gakis D, *et al.* Prosthetic mesh repair of multiple recurrent and large abdominal hernias in continuous ambulatory peritoneal dialysis patients. *Perit Dial Int* 1994; 14:338–43.
 - 13 Abraham G, Nallathambi MN, Bhaskaran S, Srinivasan L. Recurrence of abdominal wall hernias due to failure of mesh repair in a peritoneal dialysis patient. *Perit Dial Int* 1997; 17:89–91.
 - 14 Tzamaloukas AH, Gibel LJ, Eisenberg B, *et al.* Scrotal edema in patients on CAPD: causes, differential diagnosis and management. *Dialysis and Transplantation* 1990; 21:581–90.
 - 15 Abraham G, Blake PG, Mathews RE, Bargman JM, Izatt S, Oreopoulos DG. Genital swelling as a surgical complication of continuous ambulatory peritoneal dialysis. *Surg Gynecol Obstet* 1990; 170:306–8.
 - 16 Caporale N, Perez D, Alegre S. Vaginal leak of peritoneal dialysate fluid. *Perit Dial Int* 1991; 11:284–5.
 - 17 Ogunc G, Oygur N. Vaginal fistula: a new complication of CAPD [Letter]. *Perit Dial Int* 1995; 15:84–5.
 - 18 Wright CA, Moran J, Silk D. Is peritoneal–vaginal fistula the main cause of fungal peritonitis in female CAPD patients? [Letter]. *Perit Dial Bull* 1984; 4:51.
 - 19 Leblanc M, Ouimet D, Pichette V. Dialysate leaks in peritoneal dialysis. *Semin Dial* 2001; 14:50–4.
 - 20 Dubin L, Froelich J. Evaluation of scrotal edema in patients on peritoneal dialysis. *Clin Nucl Med* 1985; 10:173–4.
 - 21 Johnson BF, Segasby CA, Holroyd AM, Brown CB, Cohen GL, Raftery AT. A method of demonstrating subclinical inguinal herniae in patients undergoing peritoneal dialysis: the isotope “peritoneoscrotogram”. *Nephrol Dial Transplant* 1987; 2:254–7.
 - 22 Berman C, Velchik MG, Shusterman N, Alave A. A clinical utility of the Tc-99m SC intraperitoneal scan in CAPD patients. *Clin Nucl Med* 1989; 14:405–9.
 - 23 Twardowski ZJ, Tully RJ, Ersoy FF, Dedhia NM. Computerized tomography with and without intraperitoneal contrast for determination of intraabdominal fluid distribution and diagnosis of complications in peritoneal dialysis patients. *ASAIO Trans* 1990; 36:95–103.
 - 24 Prokesch RW, Schima W, Schober E, Vychytil A, Fabrizii V, Bader TR. Complications of continuous ambulatory peritoneal dialysis: findings on MR peritoneography. *Am J Roentgenol* 2000; 174:987–91.
 - 25 Magre GR, Terk M, Colletti P, Muggia F, Boswell W. Saline MR peritoneography. *Am J Roentgenol* 1996; 167:749–51.
 - 26 Ramon RC, Carrasco AM. Hydrothorax in peritoneal dialysis. *Perit Dial Int* 1998; 18:5–10.
 - 27 Nomoto Y, Suga T, Nakajima K, *et al.* Acute hydrothorax in continuous ambulatory peritoneal dialysis—a collaborative study of 161 centers. *Am J Nephrol* 1989; 9:363–7.
 - 28 Shemin D, Clark DD, Chazan JA. Unexplained pleural effusion in peritoneal dialysis population. *Perit Dial Int* 1989; 9:143–4.
 - 29 Chow CC, Sung JY, Cheung CK, Hamilton–Wood C, Lai KN. Massive hydrothorax in continuous ambulatory peritoneal dialysis. *Nephron* 1983; 34:130–4.
 - 30 Johnston RF, Loo RV. Hepatic hydrothorax: studies to determine the source of the fluid and report of thirteen cases. *Ann Intern Med* 1964; 61:385–401.
 - 31 Lieberman F, Hidemura R, Peters R, Reynolds T. Pathogenesis and treatment of hydrothorax complicating cirrhosis with ascites. *Ann Intern Med* 1966; 64:341–51.
 - 32 Bargman JM. Non-infectious complications of peritoneal dialysis. In: Gokal R, Khanna R, Krediet R, Nolph KDA, eds. *Textbook of peritoneal dialysis*. Boston: Kluwer Academic Publishers; 2000: 609–46.
 - 33 Green A, Logan M, Medawar W, *et al.* The management of hydrothorax in continuous ambulatory peritoneal dialysis. *Perit Dial Int* 1990; 10:271–4.
 - 34 Hou CH, Tsai TJ, Hsu KL. Peritoneopericardial communication after pericardiocentesis in a patient on continuous ambulatory peritoneal dialysis with dialysis pericarditis. *Nephron* 1994; 68:125–7.
 - 35 Nather S, Anger H, Koall W, *et al.* Peritoneal leak and chronic pericardial effusion in a CAPD patient. *Nephrol Dial Transplant* 1996; 11:1155–8.

- 36 Fletcher S, Turney JH, Brownjohn AM. Increased incidence of hydrothorax complicating peritoneal dialysis in patients with adult polycystic kidney disease. *Nephrol Dial Transplant* 1995; 9:832–3.
- 37 Macia M, Gallego E, Garcia-Cobaleda I, Chahin J, Garcia J. Methylene blue as a cause of chemical peritonitis in a patient on peritoneal dialysis [Letter]. *Clin Nephrol* 1995; 43:136.
- 38 Prischl FC, Muhr T, Seiringer EM, *et al.* Magnetic resonance imaging of the peritoneal cavity among peritoneal dialysis patients, using the dialysate as “contrast medium.” *Am Soc Nephrol* 2002; 13: 197–203.
- 39 Allen SM, Matthew HR. Surgical treatment of massive hydrothorax complicating continuous ambulatory peritoneal dialysis. *Clin Nephrol* 1991; 36: 299–301.
- 40 Kennedy L, Shan SA. Talc pleurodesis for treatment of pneumothorax and pleural effusion. *Chest* 1994; 106:1215–22.
- 41 Benz RL, Scheifer CR. Hydrothorax in continuous ambulatory peritoneal dialysis: successful treatment with intrapleural tetracycline and a review of the literature. *Am J Kidney Dis* 1985; 5:136–40.
- 42 Vlachojannis J, Boettcher I, Brandt L, Schoeppe W. A new treatment for unilateral recurrent hydrothorax during CAPD. *Perit Dial Bull* 1985; 5:136–40.
- 43 Hidai H, Takatsu S, Chiba T. Intrathoracic instillation of autologous blood in treating massive hydrothorax following CAPD. *Perit Dial Int* 1989; 9:221–3.
- 44 Okada K, Takahashi S, Kinoshita Y. Effect of pleurodesis with autoblood on hydrothorax due to continuous ambulatory peritoneal dialysis-induced diaphragmatic communication. *Nephron* 1993; 65: 163–4.
- 45 Shirai D, Sakaguchi K, Kajimoto Y, Ochi S, Okada A. *Nocardia rubra* cell wall skeleton pleurodesis for massive hydrothorax during CAPD. *Perit Dial Bull* 1985; 5:180–1.
- 46 Jagasia MH, Cole FH, Stegamn MH, Deaton P, Kennedy L. Video-assisted talc pleurodesis in the management of pleural effusion secondary to continuous ambulatory peritoneal dialysis: a report of three cases. *Am J Kidney Dis* 1996; 28:772–4.
- 47 Pattison C, Rodger R, Adu D. Surgical treatment of hydrothorax complicating continuous ambulatory peritoneal dialysis. *Clin Nephrol* 1984; 21:191–3.
- 48 Ahluwalia M, Ishikawa S, Gellman M, *et al.* Pulmonary function during peritoneal dialysis. *Clin Nephrol* 1982; 18:251–6.
- 49 Singh S, Dale A, Morgan B, Sahebajami H. Serial studies of pulmonary function in continuous ambulatory peritoneal dialysis. *Chest* 1984; 24:79–83.
- 50 Freedman S, Maberly D. Gas exchange in renal failure [Letter]. *Br Med J* 1971; 3:43.
- 51 Bargman JM. Complications of peritoneal dialysis related to increased intraabdominal pressure. *Kidney Int* 1993; 43(Suppl 40):S75–80.
- 52 Bush A, Gabriel R. Pulmonary function in chronic renal failure: effects of dialysis and transplantation. *Thorax* 1991; 46:424–8.
- 53 Smith S, Goldberg M. Pulmonary insufficiency as a result of chronic aspiration secondary to CAPD therapy. *Am J Kidney Dis* 1985; 6:131–42.
- 54 Rebeck A. Peritoneal dialysis and the mechanics of the diaphragm [Editorial]. *Perit Dial Bull* 1982; 2:109–10.
- 55 Homodraka-Malis A. Pathogenesis and treatment of back pain in peritoneal dialysis patients. *Perit Dial Bull* 1983; (Suppl 3):S41–3.

Corresponding author:

Atul Katyal, MD, Division of Nephrology, Room MA436, University of Missouri, Columbia, Missouri 65212 U.S.A.

Gastric Angiodysplasia in Patients Undergoing Maintenance Dialysis

Koji Tomori, Hidetomo Nakamoto, Syuhei Kotaki, Yuji Ishida, Hiroshi Takane, Hironori Nemoto, Yoshihiko Kanno, Soichi Sugahara, Hirokazu Okada, Hiromichi Suzuki

We successfully used argon plasma coagulation (APC) to treat two cases of dialysis patients with hemorrhagic gastric angiodysplasia. Gastric angiodysplasia is recognized as an important cause of gastrointestinal bleeding. Angiodysplastic lesion confined to the gastric antrum was first described in 1953 and named gastric antral vascular ectasia (GAVE). The condition is characterized as submucosal capillary dilatation and fibromuscular hyperplasia. The typical finding of GAVE is the so-called watermelon stomach, attributable to vasodilatation.

In case 1, a 69-year-old man was introduced continuous ambulatory peritoneal dialysis (CAPD) in July 1997 because of chronic renal failure due to nephrosclerosis. He was hospitalized for severe anemia in December 1997. Gastrointestinal fiberoscopy (GIF) showed oozing in the antrum, and gastritis and esophagitis with sliding hernia. Famotidine was started and recombinant human erythropoietin (rHuEPO) was used for anemia. However, the severe anemia did not improve. The patient was hospitalized again for severe anemia and hematemesis. Another GIF showed typical watermelon stomach, which corresponded with GAVE. An APC was performed without complications. Three months later, the anemia was improved, and the dose of rHuEPO was reduced.

In case 2, a 57-year-old woman was introduced to hemodialysis in 1998 for uremia due to nephrosclerosis. In October 2000, she was hospitalized for rHuEPO-resistant anemia. A GIF showed oozing in the antrum with diffuse vasodilation in the antrum; GAVE was diagnosed. An APC was carried out without complications. Three months later, anemia was improved.

Recently, gastric angiodysplasia was reported to be an important complication in dialysis patients and was recognized as an important cause of

rHuEPO-resistant anemia. Argon plasma coagulation is an effective treatment for gastric angiodysplasia in patients on dialysis.

Key words

Continuous ambulatory peritoneal dialysis, gastric antral vascular ectasia (GAVE), argon plasma coagulation (APC)

Introduction

Angiodysplasia is characterized by small vascular lesions in the gastrointestinal submucosa and mucosa (1–3). Angiodysplastic lesion confined to the gastric antrum was first described in 1953 by Rider *et al.* (4), who named the condition gastric antral vascular ectasia (GAVE). Angiodysplasia is one of many terms used to describe a disease in which mucosal and submucosal vascular lesions are associated with gastrointestinal bleeding (1–4). The term “watermelon stomach” was reported in 1984 by Jabbari *et al.*, who were struck by the endoscopic features of the condition: longitudinal gastric folds containing visible vessels, radiating from the pylorus and resembling the skin of a watermelon (5). Angiodysplasia may occur as single lesion or as multiple lesions in one or more locations in the gut. The main clinical finding of angiodysplasia is either acute or chronic gastrointestinal hemorrhage.

Gastrointestinal bleeding is a common complication in chronic renal insufficiency. Although the incidence of anemia may be decreasing owing to the development of human recombinant erythropoietin (rHuEPO), erythropoietin-resistant anemia remains an important problem in patients with chronic renal insufficiency. Gastric angiodysplasia has been shown to be an important cause of gastrointestinal bleeding (1–5). Recently, we successfully used argon plasma coagulation (APC) to treat two cases of hemorrhagic gastric angiodysplasia in dialysis patients.

Patients and methods

Case 1

On July 15, 1997, at the age of 65, a man was started on continuous ambulatory peritoneal dialysis (CAPD) because of chronic renal failure attributable to nephrosclerosis. He was discharged from hospital on August 20, 1997. One month later, relapsing hiccup and epigastralgia developed. On December 1997, the man was readmitted to our hospital for clinical evaluation of those symptoms.

At that time, laboratory findings showed a white blood cell count of $9,900/\mu\text{L}$, a red blood cell count of $341 \times 10^4/\mu\text{L}$, hemoglobin 8.3 g/dL, hematocrit 26.0%, and platelet count $13.6 \times 10^4/\mu\text{L}$. An upper gastrointestinal fiberscope (GIF) exam revealed gastritis and esophagitis with sliding hernia. Daily oral administration of 20 mg famotidine and weekly subcutaneous injection of 6000 IU rHuEPO were started. The epigastralgia improved, and the man was discharged from hospital.

Starting in March 1999, laboratory findings revealed gradual progression of anemia. A 6,000 IU weekly dose of rHuEPO by subcutaneous injection was prescribed. In August 2000, the man experienced tarry stools and shortness of breath on exertion. On September 9, 2000, this now 69-year-old man came to our hospital complaining of relapsing hiccup and general fatigue in addition to the former symptoms.

Laboratory findings showed a white blood cell count of $3,680/\mu\text{L}$, a red blood cell count of $160 \times 10^4/\mu\text{L}$, hemoglobin 4.8 g/dL, hematocrit 15.5%, platelet count $14.7 \times 10^4/\mu\text{L}$, serum glutamic oxaloacetic transaminase (AST) 11 IU/L, glutamic-pyruvic transaminase (GPT) 11 IU/L, lactic dehydrogenase (LDH) 176 IU/L, total protein 5.8 g/dL, albumin 3.6 g/dL, blood urea nitrogen (BUN) 52 mg/dL, creatinine 10.6 mg/dL, sodium 137 mEq/L, potassium 4.9 mEq/L, calcium 8.5 mg/dL, serum Fe 24 $\mu\text{g}/\text{dL}$, and ferritin 11 ng/mL. On clinical examination, blood pressure was 116/76 mmHg. A GIF exam showed red stripes and diffuse erythematous spots, including dilated vascular vessels. Those findings looked like watermelon stripes at the gastric antrum (Figure 1).

The severe anemia was caused by chronic blood loss from the abnormally dilated mucosal and submucosal capillary veins in the gastric antrum. The patient was diagnosed with gastric antral vascular ectasia (GAVE). Endoscopic APC therapy was carried out

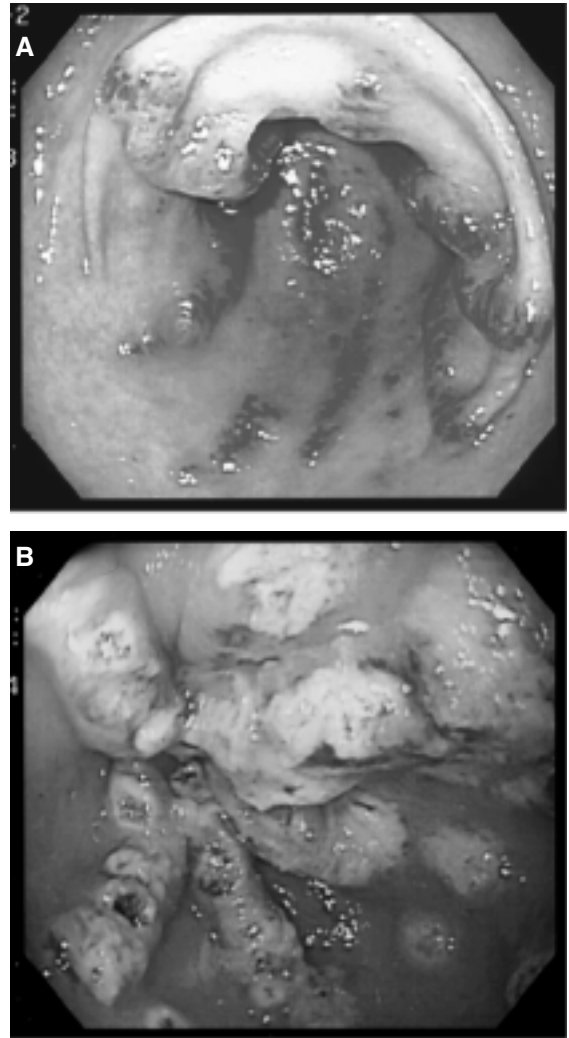


FIGURE 1 Findings of gastrointestinal fiberscope in case 1. (A) Before argon plasma coagulation (APC). (B) After APC.

twice, and lansoprasol (30 mg daily) was started. After the APC therapy, capillary dilatation disappeared, and the severe anemia gradually improved. After one month, the patient was discharged from our hospital. He attended outpatient clinic every two weeks.

On December 4, 2001 (one year later), he was admitted again to our hospital complaining of relapsing hiccup, tarry stool, general fatigue, and marked anemia. Gastroendoscopic findings showed recurrence of GAVE. Endoscopic APC therapy was performed three times, and lansoprasol was started. One month

later, the patient was discharged from hospital. In December 2002, two years after APC, he was in a good condition without any evidence of recurrence of anemia due to GAVE (Figure 2).

Case 2

In October 1998, at the age of 57, a woman was admitted to our hospital and started on hemodialysis for chronic renal failure due to nephrosclerosis. The patient had a long history of severe hypertension. Soon after the start of hemodialysis, she developed severe anemia resistant to rHuEPO and iron supplements. On October 15, 2000, she presented complaining of tarry stools and general fatigue, and was hospitalized for rHuEPO-resistant anemia. Laboratory findings showed a white blood cell count of 3,680/ μ L, a red blood cell count of $159 \times 10^4/\mu$ L, hemoglobin 4.4 g/dL, hematocrit 14.2%, platelet count $17.8 \times 10^4/\mu$ L, AST 19 IU/L, GPT 11 IU/L, LDH 186 IU/L, total protein 4.8 g/dL, albumin 2.6 g/dL, BUN 70 mg/dL, creati-

nine 11.7 mg/dL, sodium 141 mEq/L, potassium 3.5 mEq/L, calcium 8.1 mg/dL, serum Fe 37 μ g/dL, and ferritin 99 ng/mL. A GIF exam showed oozing in the antrum with diffuse vasodilation. The diagnosis was GAVE (Figure 3). Oral administration of lansoprasol (30 mg daily) was started, and APC was carried out four times without any complications.

One month later, the woman was discharged from our hospital. She continued to visit the outpatient dialysis center. Three months later, the anemia had improved. In December 2002, two years after APC, she was in a good condition and continuing to undergo hemodialysis with no evidence of recurrence of GAVE (Figure 4).

Discussion

We successfully used APC to treat two cases of hemorrhagic gastric angiodysplasia in dialysis patients. A 69-old-man undergoing CAPD and a 59-old-woman undergoing hemodialysis were admitted to our hospi-

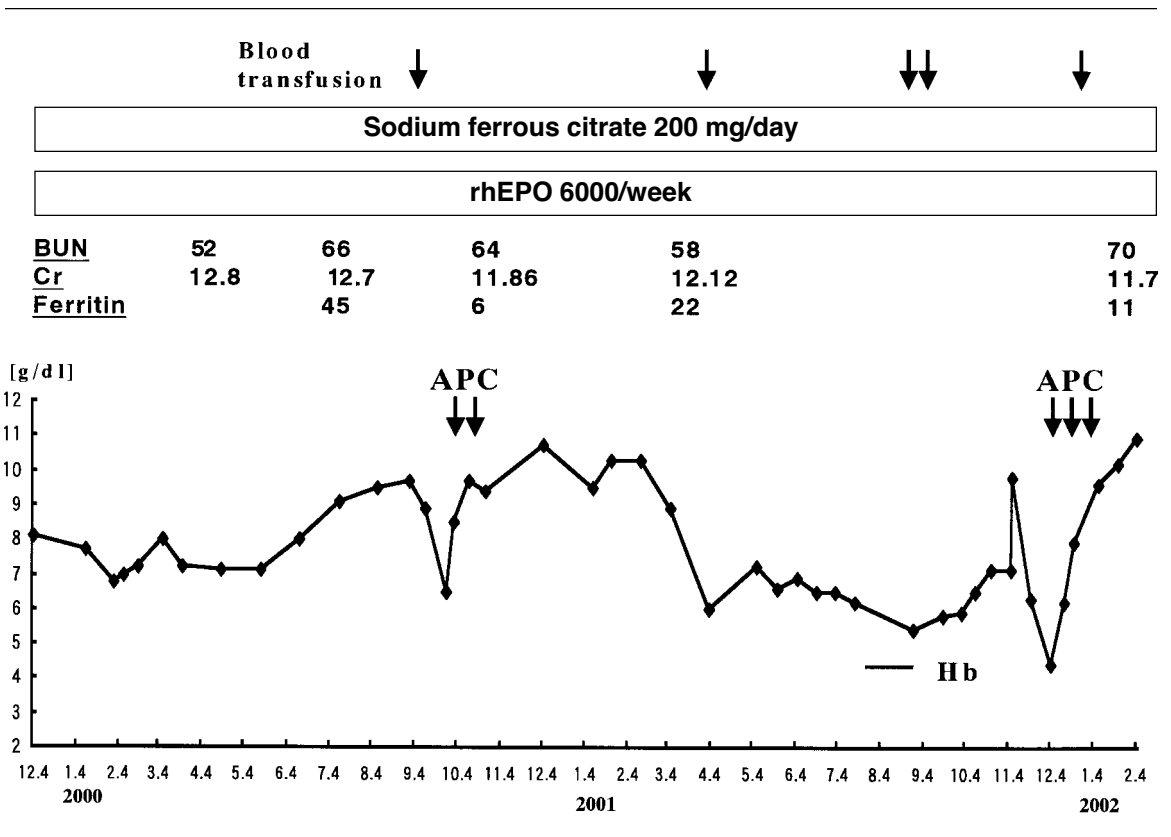


FIGURE 2 Clinical course of case 1. APC = argon plasma coagulation; Hb = hemoglobin.

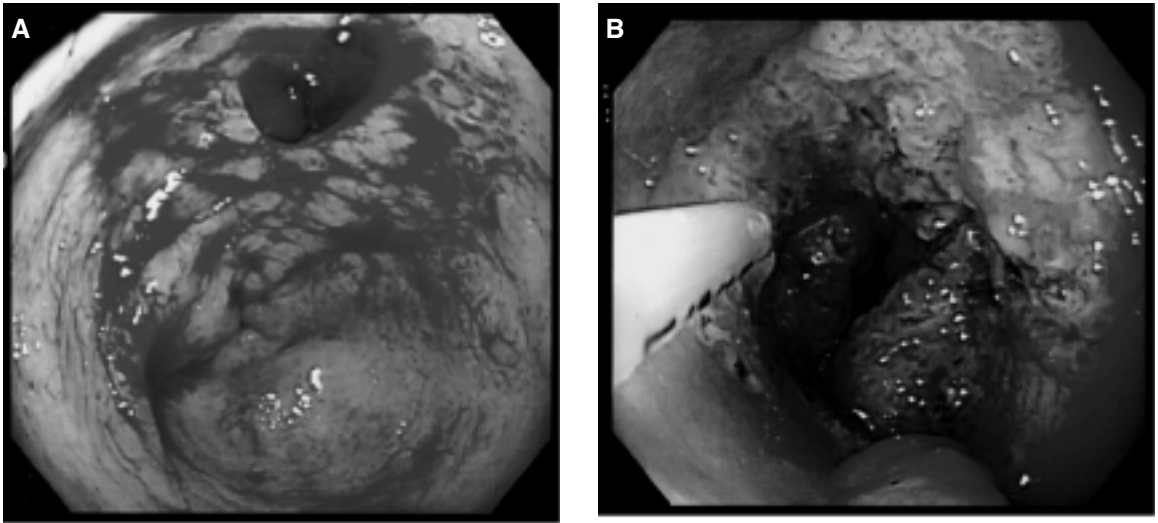


FIGURE 3 Findings of gastrointestinal fiberscope in case 2. (A) Before argon plasma coagulation (APC). (B) After APC.

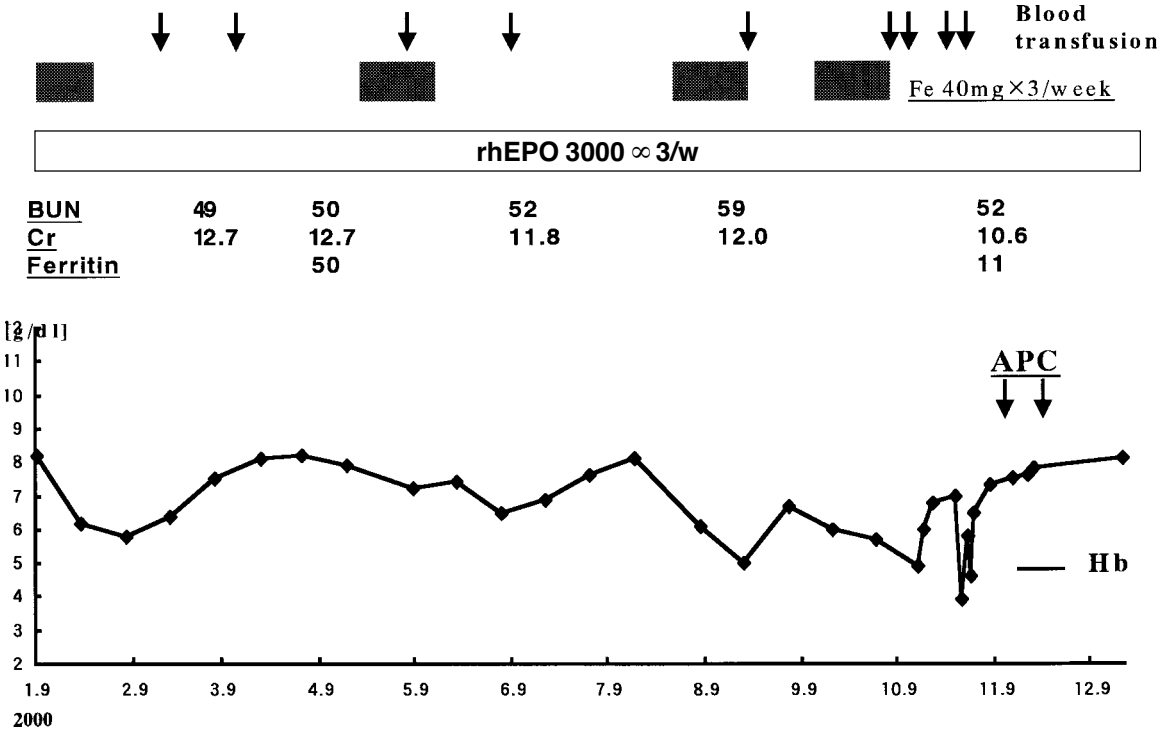


FIGURE 4 Clinical course of case 2. APC = argon plasma coagulation; Hb = hemoglobin.

tal for severe erythropoietin-resistant anemia. In each case, a GIF exam showed typical watermelon stomach, corresponding to GAVE. In both cases, APC therapy was carried out without complications. Recently, GAVE has been reported as an important complication of dialysis patients and has been recognized as an important cause of erythropoietin-resistant anemia.

Gastric angiodysplasia is rare upper gastrointestinal disease characterized by abnormal veno-capillary ectasia and fibromuscular hyperplasia in the mucosal and submucosal layers of the gastric antrum. "Angiodysplasia" is one of many terms used to describe the disease characterized by mucosal vascular lesions associated with gastrointestinal bleeding (6). The diagnosis of angiodysplasia depends on endoscopic imaging: red lesions, flat or slightly raised above the mucosal surface, usually 2 – 10 mm in size, corresponding on microscopic examination to dilated submucosal veins, vessels, and overlying mucosal capillaries (7). Histopathology findings also help to diagnose GAVE. Histopathology characteristics include hyperplastic antral mucosa, dilated capillaries in the submucosa and the lamina propria (some of them with fibrin thrombi), and fibrinomuscular hyperplasia of the muscularis mucosa in the lamina propria (5). If physicians are not familiar with those findings, a diagnosis of GAVE may be missed. An absence of signs of gastric inflammation rule out hemorrhagic gastritis, which is a frequent misdiagnosis (8,9).

Angiodysplasia has occasionally been reported as a cause of digestive bleeding in uremic patients (10–13). Those reports refer to a localized form of angiodysplasia confined to the gastric antrum. Although angiodysplastic lesions are incriminated in 1.25% – 8% of episodes of gastrointestinal tract bleeding in patients with normal renal function (11), several retrospective reports suggest that angiodysplastic lesions are responsible for 19% – 32% of episodes of gastrointestinal tract bleeding observed in patients with chronic renal insufficiency (10–13).

Recently, Navab *et al.* (14) reported a high incidence of angiodysplasia in patients with chronic renal failure. That study looked at 65 patients with angiodysplasia. Of the 65 patients, 42 (64.6%) had normal renal function and 23 (35.4%) had renal insufficiency (defined as serum creatinine consistently above 1.5 mg/dL). The cause of angiodysplasia in patients with chronic renal insufficiency is not known.

Quintero *et al.* (15) reported that gastric angiodysplasia in patients with cirrhosis has been related to hypergastrinemia and low serum pepsinogen I. Patients with chronic renal insufficiency would be expected to have elevated levels of serum gastrin and serum pepsinogen I because of low levels of renal excretion. Gastrin has been reported to have a gastric vasodilator effect; it would therefore be of interest to determine gastrin levels in patients with renal failure who have angiodysplasia (16).

Many cases of end-stage renal disease (ESRD) with angiodysplasia have been reported. Other causative factors that have been considered include portal hypertensive mucosal vasculopathy (17), degenerative lesions related to age (18), antral prolapse (5), and achlorhydria with hypergastrinemia (19). An acquired platelet dysfunction and coagulation abnormality were observed in patients on hemodialysis. Zuckerman *et al.* (13) reported a 39% occurrence of clotting abnormalities in patients with renal failure. Patients on hemodialysis may have increased risk of bleeding from angiodysplasia because of heparin use (17).

Ingestion of aspirin or anti-inflammatory agents causes a disproportionate rise in bleeding time. Patients with renal insufficiency and angiodysplasia should avoid using such drugs. For those reasons, CAPD is more comfortable for ESRD patients with angiodysplasia. Yorioka *et al.* (20) reported a case of ESRD with angiodysplasia. In that case, bleeding from angiodysplasia improved after the dialysis method was changed from hemodialysis to CAPD. Reduction of serum gastrin by CAPD was suspected to have contributed to the improvement of the patient's angiodysplasia and anemia.

To our knowledge, only two other case reports describe angiodysplasia in patients undergoing CAPD (21,22). The 69-year-old man in the present report is the third case of a CAPD patient manifesting angiodysplasia. We treated the patient with APC; however, recurrence of bleeding from angiodysplasia was observed. Whenever bleeding recurred, the patient complained of relapsing hiccup. He had sliding hernia and ESRD. The possibility exists that the combination of those risk factors relates to the occurrence of angiodysplasia.

Various treatments for angiodysplasia have been reported, but the definitive method remains undetermined. Hormone therapy was successfully initiated

in severe uremic patients with bleeding gastrointestinal angiodysplastic lesions (23). Administration of oral glucocorticoid (24) or estrogen (25) is the common nonsurgical treatment for gastric angiodysplasia, but surgical treatment is also widely accepted (24,26).

Recently, APC therapy has been recognized as safe and effective for short-term treatment of gastric angiodysplasia (27–29). Yusoff *et al.* (28) reported that a mean of 2.6 treatment sessions were required in patients with normal renal function. However, the natural history of the condition is uncertain, and at medium-term follow-up, gastric angiodysplasia is found to recur in a substantial number of patients treated with APC. Intensive follow-up after APC is necessary, and re-treatment with APC is an option in ESRD patients.

Conclusions

We successfully used APC to treat two cases of hemorrhagic gastric angiodysplasia in dialysis patients. Recently, GAVE has been reported to be an important complication of dialysis patients and has been recognized as an important cause of rHuEPO-resistant anemia. Argon plasma coagulation was an effective treatment for GAVE in patients on dialysis.

References

- Meyer CT, Troncale FJ, Galloway S, Sheahan DG. Arteriovenous malformations of the bowel: an analysis of 22 cases and a review of the literature. *Medicine (Baltimore)* 1981; 60:36–48.
- Moore JD, Thompson NW, Appelman HD, Foley D. Arteriovenous malformations of the gastrointestinal tract. *Arch Surg* 1976; 111:381–9.
- Richardson JD, Max MH, Flint LM Jr, Schweisinger W, Howard M, Aust JB. Bleeding vascular malformations of the intestine. *Surgery* 1978; 84:430–6.
- Rider JA, Klotz AP, Kinsner JB. Gastritis with veno-capillary ectasia as a source of massive gastric hemorrhage. *Gastroenterology* 1953; 24:118–23.
- Jabbari M, Cherry R, Lough JO, Daly DS, Kinnear DG, Goresky CA. Gastric antral vascular ectasia: the watermelon stomach. *Gastroenterology* 1984; 87: 1165–70.
- Gilmore PR. Angiodysplasia of the upper gastrointestinal tract. *J Clin Gastroenterol* 1988; 10:386–94.
- Foutch PG. Angiodysplasia of the gastrointestinal tract. *Am J Gastroenterol* 1993; 88:807–18.
- Tovey FI. Gastric antral vascular ectasia: the watermelon stomach. *Gastroenterology* 1985; 88:1293.
- Park RH, Russell RI. Watermelon stomach. *Br J Surg* 1991; 78:395–6.
- Dave PB, Romeu J, Antonelli A, Eiser AR. Gastrointestinal telangiectasias. A source of bleeding in patients receiving hemodialysis. *Arch Intern Med* 1984; 144:1781–3.
- Marcuard SP, Weinstock JV. Gastrointestinal angiodysplasia in renal failure. *J Clin Gastroenterol* 1988; 10:482–4.
- Clouse RE, Costigan DJ, Mills BA, Zuckerman GR. Angiodysplasia as a cause upper gastrointestinal bleeding. *Arch Intern Med* 1985; 145:458–61.
- Zuckerman GR, Cornette GL, Clouse RE, Harter HR. Upper gastrointestinal bleeding in patients with chronic renal failure. *Ann Intern Med* 1985; 102: 588–92.
- Navab F, Masters P, Subramani R, Ortego TJ, Thompson CH. Angiodysplasia in patients with renal insufficiency. *Am J Gastroenterol* 1989; 84: 1297–301.
- Quintero E, Pique JM, Bombi JA, *et al.* Gastric mucosal vascular ectasias causing bleeding in cirrhosis. A distinct entity associated with hypergastrinemia and low serum levels of pepsinogen I. *Gastroenterology* 1987; 93:1054–61.
- Guth PH, Smith E. The effect of gastrointestinal hormones on the gastric microcirculation. *Gastroenterology* 1976; 71:435–8.
- Sarfeh IJ, Tarnawski A. Gastritis with mucosal vasculopathy in portal hypertension. *Gastroenterology* 1987; 93:1129–31.
- Wesenfelder LJ, Eugene CY. The “watermelon stomach.” A misunderstood syndrome [French]. *Gastroenterol Clin Biol* 1991; 15:823–7.
- Borsch G. Diffuse gastric antral vascular ectasia: the “watermelon stomach” revisited. *Am J Gastroenterol* 1987; 81:1333–4.
- Yorioka N, Hamaguchi N, Taniguchi Y, *et al.* Gastric antral vascular ectasia in a patient on hemodialysis improved with CAPD. *Perit Dial Int* 1996; 16:177–8.
- Moreiras Plaza M. Gastrointestinal angiodysplastic bleeding also occurs in CAPD. *Perit Dial Int* 1998; 18:655.
- Chang IT, Chen TW, Ng YY, Yang WC. Recurrent intestinal angiodysplastic bleeding in a patient on hemodialysis ceasing spontaneously with CAPD. *Perit Dial Int* 1998; 18:342–3.
- Bronner MH, Pate MB, Cunningham JT, Marsh WH. Estrogen–progesterone therapy for bleeding gastrointestinal telangiectasias in chronic renal failure. An uncontrolled trial. *Ann Intern Med* 1986; 105: 371–4.
- Gouldsbrough DR, Pell AC. Gastric antral vascular ectasia: a problem of recognition and diagnosis. *Gut*

- 1991; 32:954–5.
- 25 Hermans C, Goffin E, Horsmans Y, Laterre E, Van Ypersele de Strihou C. Watermelon stomach. An unusual cause of recurrent upper GI tract bleeding in the uraemic patient: efficient treatment with oestrogen–progesterone therapy. *Nephrol Dial Transplant* 1996; 11:871–4.
- 26 Kishi K, Kinoshita Y, Kitajima N, *et al.* Two cases of gastric antral vascular ectasia—response to medical treatment. *Gastroenterol Jpn* 1991; 26:757–62.
- 27 Sargeant IR, Loizou LA, Rampton D, Tulloch M, Bown SG. Laser ablation of upper gastrointestinal vascular ectasias: long term results. *Gut* 1993; 34:470–5.
- 28 Yusoff I, Brennan F, Ormonde D, Laurence B. Argon plasma coagulation for treatment of watermelon stomach. *Endoscopy* 2002; 34:407–10.
- 29 Probst A, Scheubel R, Wienbeck M. Treatment of watermelon stomach (GAVE syndrome) by means of endoscopic argon plasma coagulation (APC): long-term outcome. *Z Gastroenterol* 2001; 39:447–52.

Corresponding author:

Hiromichi Suzuki, MD, Department of Nephrology, Saitama Medical School, 38 Morohongo, Moroyamamachi, Iruma-gun, Saitama 350–0495 Japan.