—Case Reports—

Closed Fracture Diagnosed by Bedside Ultrasonography During Hemodialysis: A Report of Seven Cases and Relevant Clinical Characteristics

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Background: Patients undergoing dialysis have a high incidence of fracture, and early diagnosis is important. We report seven cases of closed rib or upper-limb fractures diagnosed by bedside ultrasonography during maintenance hemodialysis sessions and describe relevant clinical characteristics.

Case presentation: We identified seven patients who were injured by falls in their homes. No injuries occurred on the day of dialysis. Five of the 7 patients did not visit the emergency room. All patients complained of persistent unexplained pain during a regular hemodialysis session. Ultrasonography (US) was performed during dialysis sessions, without any reports of pain. Before US evaluation, the sensitivity of radiography for diagnosis of fracture was 25%, while the sensitivity of US was 100%. Compared with other patients in our clinic, these patients were significantly older and had lower serum albumin concentrations and lower hemodialysis efficiency as determined by Kt/V. They also had a higher incidence of diabetes and a greater need for vasopressors during dialysis. These findings were consistent with the results of previous studies of the characteristics of fractures in dialysis patients. However, blood levels of creatinine, corrected calcium, phosphate, intact parathyroid hormone, and hemoglobin, as well as bone density and blood pressure, after the previous dialysis session were not different.

Conclusions: To our knowledge, this is the first report of closed fracture of superficial bone diagnosed by bedside ultrasonography during a hemodialysis session. Ultrasonography is especially useful for diagnosis in these cases because it is noninvasive and highly accurate. Doctors should determine the differential diagnosis for closed fracture in patients undergoing dialysis, especially in those who are older, have diabetes, and are malnourished, and in those with recent contusions and persistent pain. (J Nippon Med Sch 2019; 86: 230–235)

Key words: bedside ultrasound, closed fractures, hemodialysis, chronic kidney disease

Background

Compared with the general population, patients undergoing dialysis have a higher incidence of fracture[1]. This is attributable to the higher incidence of bone diseases in patients with chronic kidney disease (CKD), such as secondary hyperparathyroidism and conditions resulting from chronic dialysis, such as low muscle strength and malnutrition, which can increase the risk of falls. Furthermore, fractures are significantly related to morbidity and mortality in patients with renal failure[2,3]. Thus, early diagnosis and treatment of fracture is particularly important in patients undergoing dialysis[1]. Patients on hemodialysis attend dialysis clinics frequently and may thus choose not to visit a hospital emergency department immediately after an accident-related injury that they consider relatively mild. They are more likely to report such

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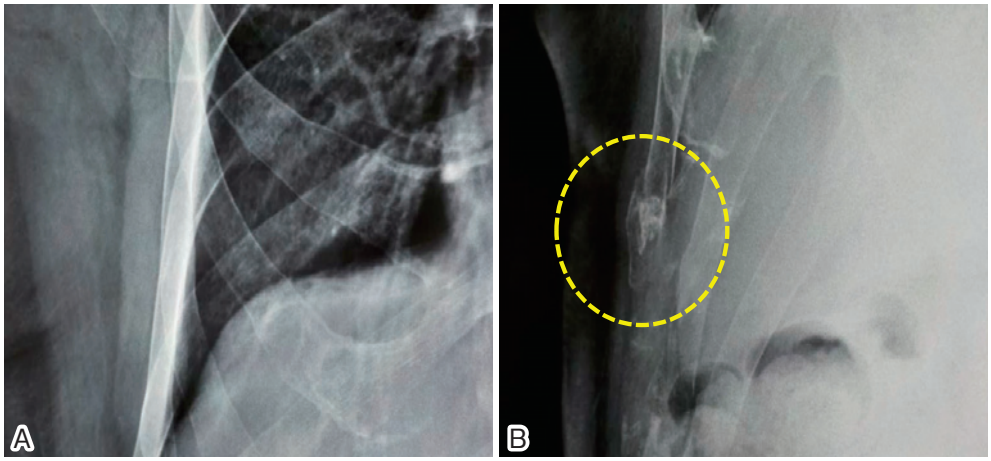

Fig. 1 Radiographic findings in Case 1. No fracture was detected in an emergency clinic evaluation on the day after injury (A). Ultrasonographic findings of fracture were confirmed on a second radiograph, obtained after ultrasonography (B).

events to a dialysis nurse at their next dialysis session. Furthermore, drugs that increase fracture risk, such as heparin, are commonly used during routine hemodialysis sessions. The bleeding risk associated with heparin could cause a delay in potential surgical treatment, thereby worsening fracture outcomes.

Recent advances in ultrasonography have increased its utility for diagnosing fractures in the fields of trauma and orthopedic surgery[4–6]. In hemodialysis clinics, bedside ultrasonography is often used to evaluate the patency of vascular access sites and to determine dry weight[7]. In a recent study evaluating the median nerve within the carpal tunnel we showed the utility of bedside ultrasonography for early detection of dialysis-related carpal tunnel syndrome[8]. However, to our knowledge, no studies have used ultrasonography to diagnose fracture in patients undergoing hemodialysis.

In September 2016, we experienced our first case of bedside ultrasound-detected rib fracture in a hemodialysis patient. This patient did not seek treatment at an emergency clinic immediately after being injured at home but instead reported the accident to the dialysis nurse or technician during a regularly scheduled hemodialysis maintenance visit. Through August 2017, we experienced six more cases of rib/upper limb fracture diagnosed by bedside ultrasound. In this report, we describe the clinical characteristics of these patients and identify factors associated with fracture requiring ultrasonographic evaluation.

Case Presentation

Case 1: A 68-year-old man complained of right-sided chest pain of 1 day's duration to the dialysis nurse during a maintenance hemodialysis session at our hospital. One day after his previous dialysis session, after waking up, he fell and hit his chest on the floor in his house. He visited the emergency department, but a radiograph of his ribs showed no evidence of fracture (**Fig. 1A**). The emergency room physician diagnosed chest contusion and advised him to apply a compress to the affected chest area; however, the pain had not subsided by the next day.

Ultrasonography (Toshiba Viamo TM, 12-MHz probe[8]) of the affected area of the chest was performed during his dialysis session. A line of discontinuity in his 9th rib was detected (**Fig. 2A**), and closed fracture was diagnosed. The patient did not report any increase in pain during the procedure. An X-ray examination after the dialysis session confirmed the location of the fracture indicated by ultrasonography. The fracture was detected on the X-ray (**Fig. 1B**), and the patient's medication was subsequently modified. Ultrasonographic reevaluation of the rib during a dialysis session 1 week later revealed partial bone union of the affected rib (**Fig. 2B**).

Case 2: A 91-year-old woman complained of right-sided chest pain of 1 day's duration to the dialysis nurse during her maintenance hemodialysis session at our hospital. One day after the previous dialysis session, she fell and hit her chest against a table in her home. She decided it was just a contusion, stayed at home, and applied a cold compress. However, the pain did not subside until the next day. Ultrasonography during the dialysis session revealed a "step sign" on her right 6th rib (**Fig. 3A**) and a local low-intensity area, possibly from a local hematoma. The fracture was diagnosed by ultrasonography, and X-ray evaluation of the affected area af-

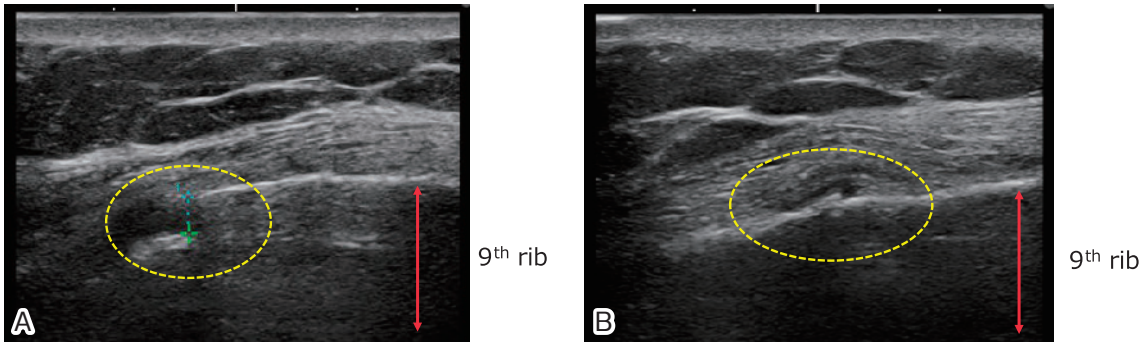

Fig. 2 Ultrasonographic findings for the fracture in Case 1. (A) A discontinuity in the curve of the bone surface was seen at a scheduled dialysis visit, 3 days after injury (oval area). (B) The bone had partially fused at 2 days after injury (oval area).

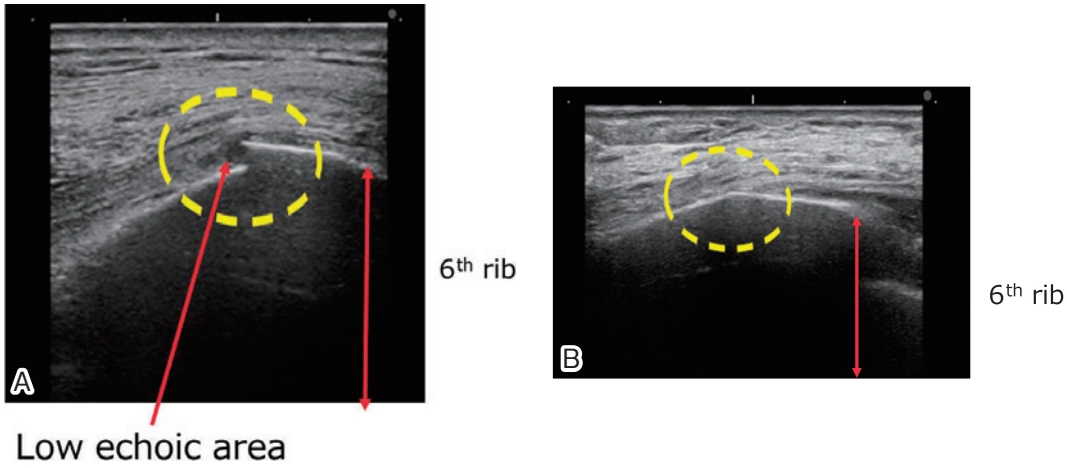

Fig. 3 Ultrasonographic findings for the fracture in Case 2. (A) On the day after injury, a break in the curve of the bone surface was noted (step sign). A hypoechoic area near the fracture indicated a small hematoma. (B) The bone had partially fused at 1 month after injury (oval area).

ter dialysis confirmed the diagnosis. Medication was started, and her pain resolved. One month later, ultrasonography revealed a union of the previous fracture (**Fig. 3B**).

Case Characteristics, Treatment, and Outcomes

After the first case (Case 1) in September 2016, we treated six more cases of closed fracture (four cases of rib fracture, one case of radial fracture, one case of a clavicular fracture, and one case of humeral fracture; n=7). Radiographic examination before US evaluation was performed in four of the seven patients, but fracture was detected by X-ray in only one of these four patients. The sensitivity and positive predictive value of radiography before US was 25% (1/4) and 100% (1/1), respectively, as compared with respective values of 100% (7/7) and 100% (7/7) for US. Radiographic evaluation before US was not performed in three patients because they reported pain after the start of hemodialysis. US during dialysis showed signs of fracture in all seven patients (**Table 1**).

After confirming signs of fracture by US, X-ray evaluation (with precise US information on the area of injury) was performed in six patients, and fracture was confirmed in all six. In one patient with a fracture detected by radiography before US, radiography was not repeated after US (**Table 1**). There were no false-positive or false-negative results on US. All seven cases that were recorded during the period from September 2016 through August 2017 were included in this study.

Using patient medical records, we retrospectively collected data on events related to the injury and information on renal disease and hemodialysis for all seven patients. Pain severity at the affected body area at the time of the first ultrasound and after complete healing were evaluated with a visual analogue scale (VAS). Dual Energy X-ray Absorptiometry (DEXA; Dichroma scan DCS-

Table 1 Clinical characteristics of the seven fracture patients and other dialysis outpatients

Patient No.	Sign of fracture			Sex	Age (years)	HD vintage (years)	Cause of renal failure	Location of fracture	Timing of injury after previous dialysis	No. of admissions to our hospital during past 3 years	VAS score	
	US	X-ray									After diagnosis	After cure
		Before US	After US									
1	Yes	No	Yes	M	68	5	DM	9th rib	Next day	0	4	0
2	Yes	NA	Yes	W	91	3	DM	6th rib	Two days	1	NA	NA
3	Yes	No	Yes	M	82	13	PCK	7th-9th rib	Next day	1	10	3
4	Yes	No	Yes	M	74	17	CGN	5th rib	Next day	1	6	0
5	Yes	NA	Yes	W	93	4	DM	Rt clavicular	Next day	1	NA	NA
6	Yes	Yes	NA	W	73	3	DM	Lt radius	Two days	1	8	4
7	Yes	NA	Yes	M	84	13	PCK	Lt humerus	Next day	0	10	5
Mean ± SE					80.9±3.9	8.3±2.0						
Value in other outpatients in our hospital					66.9±1.1	9.8±1.0						
P value					0.02*	0.53						

US: ultrasound; Yes: fracture detected; No: no fracture detected; NA; not performed; VAS: visual analogue scale; DM: diabetes mellitus; PCK: polycystic kidney disease; CGN: chronic glomerulonephritis; HD: hemodialysis session; M: man; W: woman; SE: standard error; Rt: right; Lt: left.

600EXV, Hitachi Co. Ltd, Japan) data from patient medical records was used for routine bone densitometric evaluations for all patients. For statistical analysis, we obtained data on these variables from all outpatients in our dialysis center (N=137) and from controls and compared those data with the information for the present seven patients. Values are reported as mean ± S.E., and comparisons were performed by using the unpaired t-test or chi-square test, as appropriate. A P value of <0.05 indicated significance.

The clinical characteristics of the seven patients are shown in **Table 1**. The mean age and dialysis vintage were 80.9±3.9 and 8.3±2.0 years, respectively. The cause of renal disease was diabetic nephropathy in four cases, polycystic kidney disease in two cases, and chronic glomerulonephritis in one case. Five patients had been admitted to our hospital at least once during the most recent 3 years (for pneumonia in three cases, and cerebral infarction in two cases). Oral (amezinium) or intravenous (etilefrine) vasopressors were prescribed to four patients during their dialysis sessions. Antihypertensive drugs were prescribed to four patients (two patients received beta-blockers, two received nitrates, and one received a combined Ca^{2+} channel blocker/angiotensin receptor blocker) (**Table 2**).

The timing of the injuries is shown in **Table 1**. The injury occurred on the day after dialysis for five patients, and two days after dialysis for two patients. No injuries occurred on the day of dialysis, and all injuries occurred at patients' homes because of falling while rising to a standing position or slipping while walking alone. Immediately after injury, five of the patients believed they had contusions, stayed at home, and did not visit an emergency department. As indicated by the relatively high VAS pain scores, all patients informed dialysis nurses during regular dialysis that their pain was persistent or worsening, which was inconsistent with simple contusion.

Comparison of the Seven Patients and Other Dialysis Outpatients

Putative risk factors for fracture in the seven patients are shown in **Table 1, 2**. We retrospectively collected data for the same variables from all other outpatients at our dialysis center (Moka Hospital, Tochigi, Japan) and compared them with those of the seven injured patients. The seven injured patients were significantly older (80.9±3.9 years), had significantly lower serum albumin concentrations (3.6±0.1 g/dL), and had lower Kt/V (1.06±0.07). However, concentrations of corrected Ca^{2+}, phosphate, Cr, serum iPTH, and Hb, as well as bone density and blood pressure, immediately after the previous dialysis session, did not significantly differ between these two groups. The numbers of patients who had diabetic nephropathy, who used vasopressors during dialysis, and who were admitted to our hospital during the most recent 3-year period in the fracture group (vs. the remaining outpatients) were 4/7 vs. 40/130, 4/7 vs. 51/130, and 5/7 vs.

Table 2 Serum variables, bone density, Kt/V, and other characteristics of the seven fracture patients and other dialysis outpatients

Patient No.	Cr (mg/dL)	Corrected Ca^{2+} (mg/dL)	P (mg/dL)	Hb (g/dL)	Alb (g/dL)	Intact PTH (pg/mL)	Kt/V	Bone density (Young adult, mean %)	Blood pressure after previous dialysis session (mm Hg)	Vasoactive agents during dialysis	Antihypertensive drugs
1	11.61	8.5	5.5	10.5	3.5	245	0.83	62	179/100	—	Beta-blocker
2	12.39	8.6	6	8.1	3.3	213	0.97	71	149/74	Amezinium	Nitrate
3	6.41	7.6	5.9	9.7	3.9	21	1.33	54	114/69	—	—
4	6.85	8.6	6.1	11.5	3.4	132	1.22	77	144/84	Etilefrine	Beta-blocker
5	10.71	8.4	3.8	11.1	4.1	264	1.09	66	122/67	Amezinium	Nitrate
6	5.51	8.1	5.7	12.4	3.5	357	0.95	50	128/52	—	Ca^{2+}-blocker/ ARB
7	12.15	9.5	5	9.1	3.4	132	1.00	53	170/70	Amezinium	—
Mean ± SE	9.38±1.05	8.5±0.2	5.43±0.28	10.3±0.6	3.6±0.1	195±41	1.06±0.07	61.9±3.8	144±9/74±6		
Value in other outpatients in our hospital	10.84±0.28	8.7±0.1	5.42±0.14	11.2±0.1	3.8±0.0	289±23	1.39±0.03	69.1±2.0			
P value	0.25	0.35	0.99	0.17	0.04*	0.07	0.01*	0.11			

Cr: creatinine; P: phosphate; Alb: albumin; PTH: parathyroid hormone; Kt/V: K-dialyzer: urea clearance, t: dialysis time, V: volume of urea distribution, equivalent to total body water

21/130, respectively. Thus, the prevalences of diabetic nephropathy and vasopressor use and the rate of relatively recent hospital admission were significantly higher in patients with fracture (**Table 2**).

Discussion

Here, we reported seven cases of closed fracture of superficial bone diagnosed by bedside ultrasonography during maintenance hemodialysis. Although radiography is the gold standard for diagnosing fracture, the usefulness of ultrasonography for diagnosing fracture has recently been studied in orthopedics. Ultrasound is useful because radiation exposure is low, repeated measurements can be performed at the bedside, and soft tissue around the wound can be evaluated simultaneously[4–6,9,10]. To our knowledge, this is the first report of detection of rib and upper limb fracture by bedside ultrasound performed during maintenance dialysis. This is one of the most important findings of this study.

Before we started our evaluation, we were concerned that placing the ultrasound probe on the injured body part might increase pain during evaluation. However, patients tolerated the procedure without difficulty, most likely because the ultrasound technician could ask patients about pain severity and modify the pressure of the probe during evaluation. Because patients with renal failure may experience fracture from less severe injuries, ultrasonography can be useful in detecting closed fractures in these patients. As shown in **Figure 2**, the presence of hematomas and edema in the soft tissue of the affected area can be identified simultaneously, and repeat diagnostic examinations are easy to perform. These are advantages of ultrasonography over radiography in detecting fracture of superficial bone in patients receiving dialysis.

The present seven patients were significantly older and had a higher incidence of diabetic nephropathy as the primary cause of renal failure. Additionally, vasopressor use during dialysis sessions and recent hospital admission (within the previous 3 years) were more common in patients with fracture. These patients had lower serum albumin concentrations and Kt/V values; however, serum Hb, iPTH, Ca^{2+}, and phosphate concentrations and bone density were not associated with fracture incidence, which is another important finding of this study. Age older than 40 years is a reported risk factor for fracture in dialysis patients[11], which is consistent with our results. Although secondary hyperparathyroidism and fracture are closely related, we observed no correlation with iPTH concentration, which is consistent with other reports[1].

Fracture is closely related to falls. The incidence of falls increased with the progression of muscular weakness,

neuromuscular diseases, and malnutrition[1]. Diabetic neuropathy can cause orthostatic hypotension, which increases fall risk. The high incidence of falls attributable to aging, malnutrition, and diabetes may be important in the incidence of fracture in our patients. The higher incidence of recent admissions to our hospital may be attributable to decreased muscle power, even after discharge. The present patients also had low Kt/V values, perhaps because of difficulties in increasing dialysis efficacy because of dialysis-related hypotension and malnutrition.

Another interesting finding of this study was that none of the observed injuries occurred on the day of a dialysis session, perhaps because patients walk more carefully after a dialysis session, to resolve any dialysis-related hypotension, and generally resume normal activity on the following day.

Conclusions

We reported seven cases of closed fracture of the ribs or upper limbs diagnosed by bedside ultrasonography in patients undergoing hemodialysis. Furthermore, we identified clinical characteristics shared by these patients. Most of these characteristics were consistent with those reported in previous studies of fracture in dialysis patients. Dialysis patients with unexpectedly severe pain after apparently mild fall injuries should undergo careful evaluation, including fracture assessment, as part of differential diagnosis, especially if they are older, have diabetes resulting in CKD and a low albumin concentration, and received vasoactive drugs during dialysis. Bedside ultrasonography may be an especially useful tool for differential diagnosis in these patients.

Conflict of Interest: The authors declare no conflict of interest.

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