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Resilience and challenges of peritoneal dialysis survivors in the aftermath of the 2023 Kahramanmaraş earthquake

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Abstract

Introduction: Peritoneal dialysis (PD) remains understudied in disaster nephrology. This retrospective multicenter study explores the experiences of PD survivors following the February 6, 2023, Kahramanmaraş Earthquake.

Methods: Adult PD patients from 11 affected cities were analyzed to assess challenges faced during and postearthquake, alongside clinical outcomes.

Results: Among 101 participants (median age: 45 years, median PD duration: 24 months), 57 were female, with 79 on continuous ambulatory PD. Challenges included power outages and water shortages, with primary shelter in kin's houses (33%) and homes (28%). Twelve patients experienced PD program delays, and three lacked assistance postdisaster. Sixteen patients changed PD modalities, with seven experiencing postearthquake peritonitis. Clinical parameters remained stable, except for a slight decrease in hemoglobin levels.

Conclusion: Despite challenges, PD survivors exhibited resilience, highlighting the importance of addressing peritonitis and unusual pathogens in disaster preparedness initiatives.

KEYWORDS

disaster, disaster nephrology, earthquake, peritoneal dialysis, peritonitis

1 | INTRODUCTION

Earthquakes, as unforeseeable and inevitable natural phenomena of the Earth's crust, have the potential to cause significant damage to infrastructure, buildings, transportation networks, communication systems, power and water supplies, human resources, and even emergency response teams and medical aid efforts when they occur with substantial magnitude [1]. Preparedness for such disasters is arguably the most critical preventive measure that humanity can take, yet the consequences can still be devastating [2, 3]. Furthermore, because earthquakes also inflict similar damage on the general population, including causing destructive, deadly, and severe injuries, the strain on the healthcare system multiplies exponentially [4]. It should be noted that complex treatment modalities relying on intricate infrastructure are more susceptible to failure and should be quickly adapted to withstand such events.

On February 6, 2023, a devastating doublet of earthquakes, with moment magnitudes of 7.8 and 7.7, struck southern Türkiye, originating from multiple segments of the East Anatolian Fault system [5]. The first earthquake, with a moment magnitude of 7.8, struck the Pazarcık area of Kahramanmaraş province at 04:17 GMT + 3, followed by a magnitude 6.7 aftershock just 11 min later [6]. This was followed by a larger slip and supershear rupture on its western branch, resulting in a moment magnitude 7.7 aftershock 9 h later at 13:24 GMT + 3 in the Elbistan district of Kahramanmaraş, 88 km to the northeast. These left-lateral strike-slip faults of the East Anatolian Fault Zone caused over 59 000 fatalities and ~$119 billion in damages in southeastern Türkiye and northwestern Syria [7]. The earthquakes unfolded in a tectonically complex region, primarily controlled by the triple junction between the Anatolian, Arabian, and African plates, characterized by predominantly strike-slip faulting [8].

Nephrology often becomes involved in both natural and human-made disasters owing to the widespread incidence of acute kidney injuries across all age groups and the prevalent occurrence of chronic kidney disease in adults, necessitating diverse forms of treatment [9, 10]. Thus, the term "disaster nephrology" has been introduced in this context [11]. Peritoneal dialysis (PD) stands as an efficient home-based kidney replacement therapy, offering patients the capability to conduct the procedure independently or with assistance, exhibiting considerable variability in global adoption [12]. Unlike hemodialysis, the practice of this treatment is simple and straightforward, primarily involving the filling and draining of dialysates at specified intervals, with no substantial technological infrastructure required, unless a cycler is used. Nevertheless, a clean room with access to hygiene materials, clean water, and sufficient lighting is essential.

However, the existing literature provides limited information on the challenges encountered by patients on PD during earthquakes and their subsequent clinical outcomes [13, 14]. Therefore, this study aims to investigate how patients on PD experienced the earthquake during and after the destructive Kahramanmaraş earthquake, which impacted 11 cities of Türkiye, affecting a total of 14 million population [15].

2 | METHODS

2.1 | Study design

This retrospective multicenter investigation aimed to delve into the postearthquake experiences of PD survivors following the Kahramanmaraş Earthquake, which occurred on February 6, 2023. The study encompassed a cohort of patients on PD originating from 11 cities (Adana, Adıyaman, Diyarbakır, Gaziantep, Hatay, Kahramanmaraş, Kilis, Malatya, Osmaniye, Şanliurfa, and Elazığ) affected by the earthquake.

2.2 | Participants

The study population included prevalent adult patients on PD aged 18 years or older who were residing within the earthquake-affected region at the time of the earthquake. Eligible participants could be on continuous ambulatory PD (CAPD), automated PD (APD), or assisted PD. Assisted PD, in this context, refers to treatment conducted at the patient's home with the assistance of a family member, excluding healthcare technicians or community nurses, and was not part of a reimbursed program.

2.3 | Data collection methods

Data acquisition was executed through the development of an extensive anonymized online questionnaire utilizing the Google Forms platform (can be accessed and translated to English via the webpage translator at: https://forms.gle/6JwLkvuUSUzdykxw9) [16]. The questionnaire was distributed via email to all members of the Turkish Society of Nephrology, covering over 90% of nephrologists. Additionally, direct communication was established with nephrologists practicing in the earthquake-affected region during the specified period. The questionnaires were filled by the PD care team and encompassed inquiries into several aspects, including participants' demographic characteristics, such as age, gender, etiology of end-stage kidney disease, and PD vintage. Comorbidities, such as diabetes mellitus and hypertension, were also documented. Additionally, the questionnaire gathered information regarding shelter arrangements, encompassing the type of housing (house, tent, and container) in which the patient resided. Access to power, clean water, and hygiene materials was assessed. Specific details pertaining to PD treatment before and after the earthquake, including parameters like the number of exchanges per day, dwell volume, and ultrafiltration volume, were documented as well. Clinical parameters, including routine laboratory tests, obtained during the final visits before and the initial visits after the earthquake were also subject to comparative analysis.

2.4 | Statistical analysis

For parametric data, we present the results as the median (first quartile to third quartile), while categorical variables are represented as numbers (percentages). We employed the Mann–Whitney U test to compare independent samples of parametric data and the chi-squared test to compare categorical variables. To assess the significance of differences between repeated measurements, we utilized paired samples *t*-tests and the Wilcoxon signed-rank test. We considered statistical significance to be achieved at $p < 0.05$. The statistical analyses were performed using JASP (Version 0.17.3), provided by the University of Amsterdam in 2023.

3 | RESULTS

3.1 | Patient characteristics

There were 21 adult PD care centers in the region. According to raw data aggregates, the total number of PD patients at the end of January 2023 (pre-earthquake) was 500, increasing to 507 by the end of March 2023 (post-earthquake). Between January and March 2023, 13 patients passed away owing to reasons unrelated to earthquake injuries, 3 were transferred to hemodialysis, and 3 underwent kidney transplantation. A total of 101 PD patients from the earthquake-affected region of Kahramanmaraş participated in this study, with data collection occurring at a median of 92 (62–138) days post-disaster (refer to Table 1). The median age of the patients was 45 years, with a median PD duration of 24 months. Of these patients, 57 were female. The majority (79) were utilizing CAPD, while 66 received assisted PD, and 20 were on APD during the earthquake.

3.2 | Earthquake-related experiences

During the earthquake, three patients were trapped under rubble, but they were successfully rescued within a median time of 10 h without sustaining severe injuries (Table 1). While at least 50% of patients experienced either power outages, water shortages, or limited access to hygiene materials during the postdisaster period, the diverse nature of these challenges implies the overall impact on patient well-being might be significantly broader. The primary shelter arrangements for the patients included staying at kin's houses (33%), their own homes (28%), motor vehicles (24%), and tents/containers (8%).

3.3 | Changes in PD treatment

Two patients regained access to their PD supplies after a median of 90 h, and 12 patients had to delay their PD programs by a median of 24 h (Table 1). Three patients lacked assistance in the postdisaster period. Additionally, 12 patients transitioned from APD to CAPD, and four switched from CAPD to APD.

3.4 | Contact with PD care centers

Communication with PD Care Centers was sustained by 60% of the patients, and 16% had undergone disaster preparedness training (Table 1).

3.5 | Hemodialysis and PD discontinuations

Temporary hemodialysis was initiated for three patients owing to hypervolemia, involving a median of three sessions (Table 1). Notably, three patients discontinued PD, with one discontinuation attributed to inadequate

TABLE 1 In-depth examination of the ambulatory peritoneal dialysis survivors' journey amidst the crucial moments of the Kahramanmaraş earthquake.

Demographics		**Etiology of ESKD**		**PD related data**	
Age	45 (27–61)	Diabetes mellitus	26 (25.74%)	PD vintage (months)	24 (13–54)
Gender (Female, %)	57 (56.4%)	Hypertension	23 (22.77%)	CAPD/APD modalities	79 / 22
BMI	22.7 (20.3–27.2)	Glomerulonephritis	14 (13.86%)	Assisted PD before the earthquake	66 (65%)
Hemodialysis history	24 (23.76%)	ADPKD	8 (7.92%)	Deprived of assistance after the earthquake	3 (5%)
Transplant history	3 (2.97%)	Obstructive uropathy	7 (6.93%)	Switched from APD to CAPD after the earthquake	12 (55%)
Place of stay after the earthquake		Amyloidosis	4 (3.96%)	Switched from CAPD to APD after the earthquake	4 (5%)
House of a kin	33 (33%)	Tubulointerstitial nephritis	1 (0.99%)	Switched the transfer set brand	1 (1%)
Motor vehicle	24 (24%)	Renovascular disease	4 (3.96%)	Contacted from the primary PD care provider for assistance	60 (59%)
Tent/container	8 (8%)	Others	14 (13.86%)	Trained for disasters	16 (16%)
Own home	28 (28%)	**PD inventory**		Patient had to go to a different PD care center for follow up	13 (13%)
Hospital	6 (6%)	Impaired access to the PD inventory?	2 (1.98%)	PD dialysate inventory before the earthquake (in days)	21 (20–30)
Hotel	1 (1%)	Duration of impaired access to the PD inventory (hours)	90 (87–93)	Delay in routine PD program after the earthquake?	12 (11.8%)
Street	1 (1%)	How was access regained to the PD materials?		Duration of delay in PD program (hours)	24 (11.5–57)
Moved to another city after the earthquake	25 (25%)	Supplied by the distributor of the company	1 (50%)	Disconnection from the APD device during the earthquake for patients on the APD program	22 (100%)
Access to resources		Supplied by the hospital	1 (50%)	Not connected at the time	2 (9%)
Trapped under collapse?	3 (2.97%)	**Access to non-PD drugs**		Household helped	8 (36%)
Rescue time (hours)	10 (6.5–13)	Impaired access to medications unrelated to PD	4 (4%)	Self-disconnection with panic	8 (36%)
Power outage owing to earthquake?	59 (58.4%)	Regained access to medications unrelated to PD	3 (75%)	Calm-appropriate self-disconnection	4 (18%)
Duration of power outage (hours)	24 (12–48)	**Hemodialysis inception**			
Water shortage after the earthquake?	44 (43.5%)	Need for hemodialysis inception?	3 (2.9%)		
Duration of water shortage (hours)	24 (12–60)	Hypervolemia–hyperkalemia–hypertension	1 (33%)		
Impaired access to personal hygiene materials	49 (49%)	Hypervolemia–hypertension	1 (33%)		
		Hypervolemia-PD catheter dysfunction	1 (33%)		
		How many sessions of hemodialysis?	3 (3–3.5)		

Abbreviation: ADPKD, autosomal dominant; APD, automated peritoneal dialysis; BMI, body mass index; CAPD, continuous ambulatory peritoneal dialysis; ESKD, end stage kidney disease; PD, peritoneal dialysis.

TABLE 2 Comparative analysis of initial clinical parameters in PD patients before and after the Kahramanmaraş earthquake among survivors.

Variables	Before the earthquake (26, 14–35 days)	After the earthquake (36, 22–46 days)	*p*
PD			
Number of exchanges	4 (4–4)	4 (4–4)	0.143
Dwell volume (L)	2 (1.5–2)	2 (1.5–2)	0.322
Ultrafiltration (L)	1.2 (0.75–1.7)	1.3 (0.8–1.8)	0.197
Kt/V	2 (1.742–2.178)	na	na
Low-dextrose sol. (*n*, %)	75 (74.26%)	73 (72.28%)	0.751
Medium-dextrose sol. (*n*, %)	56 (55.45%)	57 (56.44%)	0.887
High-dextrose sol. (*n*, %)	6 (5.94%)	10 (9.90%)	0.297
Icodextrin sol. (*n*, %)	54 (53.47%)	59 (58.42%)	0.479
Aminoacid sol. (*n*, %)	5 (4.95%)	4 (3.96%)	0.733
Blood pressure and edema			
Systolic BP (mm Hg)	130 (120–145)	130 (120–140)	0.096
Diastolic BP (mm Hg)	80 (70–90)	80 (70–90)	0.955
Leg edema (*n*, %)	25 (24.75%)	18 (17.82%)	0.994
PD complications			
Peritonitis (*n*, %)	12 (11.88%) (history)	6 (5.94%)	0.220
Catheter malfunction	3 (2.97%)	2 (1.98%)	0.887
Laboratory			
Glucose	99 (86–116)	98 (87–140)	0.140
Urea	104 (86–128)	107 (86–132)	0.058
Creatinine	7.54 (5.52–9.37)	8.23 (6.09–9.6)	0.076
Uric acid	5.65 (4.9–6.6)	5.85 (5.1–6.4)	0.674
Na	136 (133–139)	135 (133–139)	0.498
K	4.39 (4–4.76)	4.3 (3.96–4.9)	0.581
Ca	8.68 (7.95–9.1)	8.7 (8–9.2)	0.733
P	4.6 (3.99–5.2)	4.8 (4–5.56)	0.100
Albumin	3.37 (3.13–3.7)	3.3 (3–3.6)	0.066
Total protein	6.5 (5.92–7.0)	6.5 (5.9–7.0)	0.337
ALP	107.5 (81.5–139)	106.5 (79–138)	0.194
iPTH	354 (211–508)	365 (221–578)	0.114
WBC	7.91 (6.59–9.44)	7.49 (6.3–9.11)	0.627
Hemoglobin	10.8 (9.15–11.7)	10.2 (9–11.4)	***0.002***
PLT	260 (210–302)	250 (210–312)	0.661

Note: Bold and italic character marks a statistical significance, for convenience at reading.
Abbreviations: ALP, alkaline phosphatase; BP, blood pressure; iPTH, intact parathyroid hormone; PD, peritoneal dialysis; PLT, platelets; WBC, white blood cell count.

dialysis, another owing to fungal peritonitis, and the third because of transplantation.

3.5.1 | Clinical parameters

The clinical parameters are presented in Table 2. The median number of exchanges, dwell volumes, ultrafiltration volume, the composition of dialysates, blood pressures, presence of edema, and laboratory parameters remained similar between the last examination (median 26 days) before the earthquake and the first examination (median 36 days) after the earthquake. A mild but significant decrease in median hemoglobin levels was observed (from 10.8 to 10.2 g/dL, $p = 0.002$).

3.5.2 | Peritonitis episodes

After the earthquake, seven patients encountered peritonitis, with successful resolution in all cases except one instance of fungal peritonitis, which necessitated a transfer to hemodialysis. (Table 2). Among them, three resided in their own homes, two in a kin's house, one in the hospital and one in a vehicle as their primary shelters. Before the earthquake, six patients were on CAPD, and one was on APD. Postearthquake, one patient switched from APD to CAPD, and another from CAPD to APD.

4 | DISCUSSION

This study explored the experiences of patients on PD following the Kahramanmaraş Earthquake. Notable findings included patients' resilience in maintaining clinical stability, despite facing challenges like power outages and water shortages. Changes in PD treatment modalities were observed, with transitions between CAPD and APD. Most patients managed to stay in contact with their primary PD units, and some had already received disaster preparedness training. Additionally, a few patients required temporary hemodialysis, and a slight decrease in hemoglobin levels was noted. Notably, the incidence of peritonitis after the earthquake appeared higher than expected under normal circumstances, although all cases, except one of fungal peritonitis, were successfully treated.

When comparing the study's findings on PD survivors during the 2023 Kahramanmaraş Earthquake with existing data, it becomes apparent that patients on PD have consistently exhibited remarkable resilience and adaptability when faced with natural disasters. For instance, in the aftermath of the 1999 Marmara earthquake in Turkey, 42 patients on CAPD confronted numerous challenges, including the loss of their homes, necessitating temporary relocation [17]. Nevertheless, these patients effectively maintained their CAPD therapy, underscoring the flexibility and effectiveness of this treatment approach during crisis situations.

Another study following the Marmara earthquake involved 477 patients with crush syndrome and acute kidney injury (AKI), necessitating thousands of dialysis sessions, primarily hemodialysis [9]. This study highlighted the vital importance of disaster preparedness, especially considering how rapidly the hemodialysis infrastructure can become overwhelmed in disaster nephrology [18, 19]. In challenging situations where choices may seem constrained, it becomes vital to persist in the fight for survival. In this context, it is worth noting urgent-start PD, a well-established but recently popularized approach, can be life-saving by providing a swift additional dialysis option and optimizing the allocation of scarce resources [20]. By utilizing antileakage suturing of the deeper cuff of the PD catheter beneath the anterior rectus fascia, PD exchanges can be promptly initiated, achieving significant solute clearance, including potassium [21]. Substantiation for this strategy is discernible in the exchange between Kimura et al. and Ghaffari discussing the aftermath of the earthquake and nuclear accident in Japan in 2011 [22, 23]. During this period, hemodialysis had to be suspended for some patients, and PD was autonomously performed, showing no significant differences in interdialytic body weight gain, serum urea nitrogen levels, and creatinine and potassium levels before and after the earthquake. In a recent comprehensive review by Gorbatkin et al., the role of PD during active war was meticulously assessed, acknowledging successes reported in PD during crises, endorsing the adaptive utilization of urgent-start PD in resource-limited conditions, provided appropriate indications, including AKI [24]. A consensus statement from the Renal Disaster Relief Task Force of the ERA in 2023 aligns with this perspective, suggesting that owing to supply limitations, adjustments in dialysis frequency or dose, and transitions between hemodialysis and PD might be necessary [25]. This approach, while intuitive, may require some interventional skills in initiating urgent-start PD [26]. It is important to note that our study does not have any data regarding the use of urgent-start PD.

However, PD is vulnerable to complications arising from the multifaceted challenges of disasters, notably highlighted by the increased risk of peritonitis. This susceptibility can be scientifically attributed to compromised sanitation and hygiene conditions in disaster settings. A compelling illustration of these complications is evident in the aftermath of the 2010 Chilean earthquake, where a surge in an exceedingly rare fungal peritonitis caused by *Paecilomyces variotii* occurred. This filamentous fungus, akin to *Aspergillus* and commonly present in soil, water, and house dust, thrived under conditions of insufficient cleanliness and hygiene [27]. Beyond infectious and noninfectious complications, challenges such as malnutrition, inadequate follow-up visits, and the logistical difficulties associated with transporting bulky PD solutions may further contribute to the complexity of managing PD in disaster scenarios [25, 26, 28]. Consistent with prior experiences, the most notable complication associated with PD in our patient group was an elevated occurrence of peritonitis episodes compared with the expected rate under normal circumstances. Owing to the survey-based nature of our study, we could not identify the causative microorganisms for the peritonitis episodes. Only one patient experienced fungal peritonitis and had to be transfer to hemodialysis. Considering the heightened risk

and potential involvement of unusual pathogens, devising intelligent solutions to prevent peritonitis occurrences during disasters should be a key focus in preparedness initiatives.

Given the susceptibility of the Asia–Pacific region to natural disasters, the importance of disaster preparedness in dialysis care is widely acknowledged, particularly with a preference for PD in disaster situations owing to its more manageable and supported nature [29]. Therefore, alongside the positive outcomes of prevalent patients on PD, the adoption of urgent-start PD in general practice can further bolster disaster preparedness and resources. In the aftermath of many disasters, healthcare logistics may be impacted by road and infrastructure damage. Despite the Kahramanmaraş earthquake occurring in winter, local hospitals effectively maintained the supply chain, crucial for successful relief efforts and ensuring timely provision to patients on PD. Conversely, the Great East Japan Earthquake of March 11, 2011, led to disruptions in transportation networks, impeding the distribution of relief goods as a result of damaged roads and railways [30]. Therefore, the survival of individuals in the aftermath of disasters depends not only on effective medical procedures but also on the crucial role played by geographical terrain—an aspect that requires careful consideration in each scenario.

Limitations of this study include its retrospective design, potential recall and voluntary participation biases, the relatively small sample size of 101 patients, and the focus on immediate postdisaster experiences. The absence of a control group limits comparisons. Strengths include the unique focus on patients on PD during a natural disaster, data collection from multiple PD centers across 11 impacted cities, and insights into PD patients' resilience and adaptability. The study underscores the importance of tailored disaster plans and preparedness training for patients on PD, contributing to the field of "disaster nephrology" with practical implications for improving care.

5 | CONCLUSION

In summary, this study highlights the resilience and adaptability demonstrated by PD patients amidst natural disasters, exemplified by their experiences during the Kahramanmaraş Earthquake in 2023. While the data suggest that most study participants fared well or adequately following the earthquake, certain challenges emerged, notably limited water supplies and constraints on personal hygiene resources. These findings underscore the importance of disaster preparedness planning, particularly in ensuring sufficient access to essential resources for PD patients. It is essential to address potential risks such as peritonitis and the involvement of unusual pathogens, including fungi, in disaster preparedness initiatives. Moreover, the study emphasizes the critical role of PD as a life-sustaining treatment method for both incident and prevalent patients, given the application of appropriate techniques. Moving forward, a focused approach on implementing effective measures and securing robust support from various stakeholders is imperative for achieving seamless disaster preparedness in PD care.

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CONFLICT OF INTEREST STATEMENT

Tuncay Sahutoglu has received speaker honorariums from AstraZeneca, Amgen, Sanofi, Nobel Ilac, Baxter, Boehringer Ingelheim, Astellas, and Abdi Ibrahim-Otsuka, none of which are associated with this work. Rumeyza Kazancioglu has received speaker honorariums from Baxter and Astellas none of which are associated with this work.

DATA AVAILABILITY STATEMENT

The evidence that supports the findings of this study is included within the article and is maintained in the hospitals' patient records repository.

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