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## Research article

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## Analysis of risk factors of postoperative mortality in peritoneal dialysis patients with developed peritonitis

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**Abstract.** Peritoneal dialysis (PD)-associated peritonitis can lead to dysfunction in PD delivery as a result of thickening of the peritoneal membrane, usually due to recurrent peritonitis, and result in peritonitis with ileus or intestinal perforation. This study sought to investigate the risk factors that lead to mortality in patients receiving PD who underwent surgery for peritonitis.

**Methods.** The study was designed as a retrospective observational study and included 36 patients who received PD and underwent surgical treatment for peritonitis between 2011 and 2020. Data on patient demographics, comorbid diseases, duration of PD application, number of peritonitis episodes due to PD, surgical procedures performed due to peritonitis, and postsurgical morbidity and mortality rates were collected.

**Results.** It was found that mortality increased with advancing age in patients with coronary artery disease (CAD) compared to those without CAD, and this increase was statistically significant ( $p = 0.002$ ). In addition, it was determined that the accompanying cirrhosis significantly increased mortality in elderly patients ( $p = 0.043$ ). In considering the surgical procedures performed, it was found that segmental small-bowel resection ( $n = 16$ ) was mostly performed due to ileus or intestinal perforation, and no additional pathological findings other than peritonitis were encountered in 12 patients. Mortality occurred in eight patients in the advanced-age group and one patient in the other group among patients operated on for peritonitis. No difference in mortality rate was found according to the surgical procedure ( $p = 0.512$ ). Binary logistic regression analysis was applied and age, coroner artery diseases (CAD), and dialysis time for risk of mortality. Respectively, age (odds ratio [OR]= 1.09; 95% CI [1.013-1.193];  $p=0.024$ ), CAD [OR] = 43.7; 95% CI [5.191-368.755];  $p < .001$  and dialysis time [OR] = 1.786; 95% [1.060-3.010];  $p=0.029$  was calculated.

**Conclusions.** Mortality increased by 1.09 times for each one-year increase in age after 52.5 years of age and also CAD increased the mortality rate by 43.7 times. Prolonged PD duration increased the mortality rate especially after 11.5 months, increased the peritonitis-related mortality rate by 1.7 times. We propose that since surgical interventions may be performed in peritonitis due to PD; and do not increase peritonitis-related mortality, an appropriate surgical procedure can be performed safely in experienced centers before it is too late.

**Key words:** peritoneal dialysis -associated peritonitis, surgical treatment, risk factors, postoperative mortality.

**Conflict of interest statement.** The authors declare no competing interest.

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## Аналіз факторів ризику післяопераційної смертності у хворих, які лікуються методом перитонеального діалізу з перитонітом

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**Резюме.** Перитоніт, асоційований з перитонеальним діалізом (ПД) може призвести до втрати техніки методу в результаті потовщення перитонеальної мембрани та перитоніту з клубовою непрохідністю або перфорацією кишківника. Це дослідження спрямоване на вивчення факторів ризику смертності ПД пацієнтів, які перенесли хірургічне втручання з приводу перитоніту.

**Методи.** Дослідження було розроблено як ретроспективне обсерваційне дослідження та включало 36 пацієнтів, які лікувались методом ПД та перенесли хірургічне лікування перитоніту в період з 2011 по 2020 рр. Дані про демографічні показники пацієнтів, супутні захворювання, тривалість лікування ПД, кількість епізодів перитоніту, хірургічні процедури, а також показники захворюваності та смертності після операції були проаналізовані.

**Результати.** Встановлено, що смертність ПД пацієнтів збільшувалась з віком у пацієнтів з ішемічною хворобою серця (ІХС) порівняно з пацієнтами без ІХС ( $p = 0,002$ ). Крім того, встановлено, що супутній цироз достовірно підвищував смертність у пацієнтів літнього віку ( $p = 0,043$ ). Аналіз проведених хірургічних втручань визначив, що сегментарна резекція тонкої кишки ( $n = 16$ ) здебільшого була виконана через кишкову непрохідність або перфорацію кишки, у 12 пацієнтів не було виявлено додаткових патологічних ознак, крім перитоніту. Летальний випадок констатовано у 8 пацієнтів старшої вікової групи та одного пацієнта середнього віку. За хірургічним втручанням різниці в смертності не виявлено ( $p = 0,512$ ). Бінарний логістичний регресійний аналіз продемонстрував, що вік, ІХС та тривалість діалізу були факторами ризику післяопераційної смертності у ПД пацієнтів: відношення шансів [OR] = 1,09; 95% CI [1,013-1,193];  $p=0,024$ , САД [OR] = 43,7; 95% CI [5,191-368,755];  $p < ,001$  та [OR] = 1,786; 95% CI [1,060-3,010];  $p=0,029$ , відповідно.

**Висновки.** За даними нашого дослідження, смертність від ПД-асоційованого перитоніту збільшувалась в 1,09 рази з кожним роком після досягнення пацієнтами віку 52,5 років. Наявність ІХС підвищувала післяопераційну летальність у 43,7 рази. Тривалість ПД збільшувала понад 11,5 місяців підвищувала смертність від перитоніту у 1,7 рази. Оскільки оперативні втручання не збільшують смертність від ПД-асоційованого перитоніту, відповідну хірургічну процедуру можна безпечно виконувати в умовах досвідчених центрів.

**Ключові слова:** перитонеальний діаліз, перитоніт, хірургічне лікування, фактори ризику, післяопераційна летальність.

**Introduction.** Although peritoneal dialysis (PD) is a widely used dialysis modality for patients with end-stage renal disease (ESRD) but it can lead to a variety of complications; among those known, peritonitis is one such common and serious example [1]. It has been reported that the rate of peritonitis should be below 0.5 episodes per patient-year in patients undergoing PD, but episodes have been documented to occur at different rates by different centers [2]. PD-associated peritonitis can lead to dysfunction in PD delivery as a result of thickening of the peritoneal membrane, usually due to recurrent peritonitis, and result in perito-

nititis with ileus or intestinal perforation. This explains the polymicrobial pathology that grows in the peritoneal fluid in PD-related peritonitis and the associated mortality rate (> 15%) [3, 4]. The present study aimed to investigate the risk factors that lead to mortality in patients receiving PD who underwent surgery for peritonitis.

**Materials and Methods.** The study was designed as a retrospective observational study and was approved by the Baskent University Institutional Review Board (project no. KA21/322) and supported by the Baskent University Research Fund. Patients who underwent PD and surgical treatment for peritonitis between 2011 and 2020 were screened retrospectively using the hospital automation system, and data on patient demographics, comorbid diseases, duration of PD application, number of peritonitis episodes due to PD, surgical procedures performed due to peritonitis, and postsurgical morbidity and mortality rates were collected. A total of 36 patients were finally included in this study.

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Patients with information that could not be fully sourced from the hospital automation system, those under the age of 18 years, and those whose postoperative follow-up could not be performed at our center were excluded from this study. Patients mainly included in the study; Patients who apply peritoneal dialysis and apply it alone in their own home, but who have been given the necessary sterile use training and followed up

in our center, are patients who apply peritoneal dialysis and were operated on for peritonitis, and the cause of secondary peritonitis cannot be determined during the operation. Patients who underwent hemodialysis, were diagnosed with secondary peritonitis and were followed up for primary peritonitis but were not operated on were excluded from the study (Fig. 1).

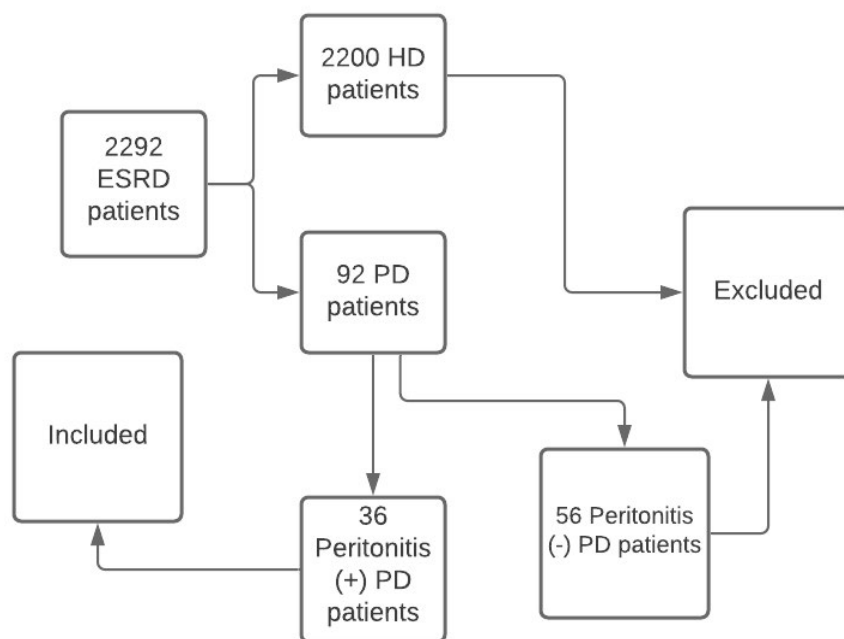


Fig. 1. Flowchart documenting inclusion and exclusion of study participants. (Abbreviations: ESRD, end-stage renal disease; HD, hemodialysis; PD, peritoneal dialysis).

As a result, the parameters that we think may have an effect on mortality in patients undergoing PD and having peritonitis attacks due to it were revealed, and we predicted that mortality rates could be reduced by taking necessary precautions in a timely manner in such patients.

**Statistical Analysis.** The Statistical Package for the Social Sciences for Windows version 24 software program (IBM Corporation, Armonk, NY, USA) was used for statistical analysis purposes during the evaluation of the study results.

Descriptive statistics were expressed as numbers and percentages for categorical variables and mean  $\pm$  standard deviation values for quantitative variables if the data were suitable for normal distribution or median values if they were not suitable for normal distribution, respectively (age and dialysis time). The normality distribution of the data was evaluated using the Shapiro–Wilk test. In comparing quantitative measurements according to sociodemographic characteristics and study groups, the student's t-test was used for evaluating two independent groups with data suit-

able for normal distribution. The comparison of proportions according to study group and the evaluation of correlations were conducted using the chi-squared test or Fisher's exact test.

Receiver-operating characteristic (ROC) curve analysis was performed to determine cutoff values for age and dialysis time according to mortality. Binary logistic regression analysis was performed to evaluate risk factors that may result in Peritoneal Dialysis-Related peritonitis. During analysis,  $P < .05$  was considered to be statistically significant.

**Results.** The mean age of 36 patients included in the study was calculated as  $50.86 \pm 12.867$ . There was no statistically significant difference between the gender distribution of the patients (47.7% Female / 52.3% Male;  $p = 0.101$ ). ROC analysis was performed for age and duration of dialysis. The cut-off value for age was calculated as 52.5 years, and the cut-off value for dialysis duration was calculated as 11.5 months.

Demographic data and clinical results of the 36 patients included in the study are summarized in Table 1.

Table 1

## Demographic data of the study groups

		Age < 52.5 years (n = 20)	Age ≥ 52.5 years (n = 16)	P-value
Sex	F	35% (7)	58.8% (10)	0.101*
	M	65% (13)	31.6% (6)	
Diseases	HT	60% (12)	40% (8)	0.549*
	DM	50% (2)	50% (2)	0.813*
	CAD	22.2% (2)	77.8% (7)	0.002*
	COPD	0	100% (1)	0.257*
	Cirrhosis	0	100% (3)	0.043*
	Other	66.7% (4)	33.3% (2)	0.650*
Surgery	No pathology	35% (7)	31.3% (5)	0.512*
	Primary repair	10% (2)	6.3% (1)	
	Adhesiolysis	20% (4)	6.3% (1)	
	Segmental small bowel resection	35% (7)	56.3% (9)	
Peritoneal dialysis time		9.85 ± 2.183	12.94 ± 1.237	0.001†
Mortality		5% (1)	50% (8)	0.002*

Footnotes: \* Chi-squared test; † Student's t-test.

Abbreviations: F: Female, M: Male, HT: Hypertension, DM: Diabetes Mellitus, CAD: Coronary Artery Disease, COPD: Chronic Obstructive Pulmonary Disease.

In considering factors affecting mortality, ROC analysis was performed for age and the duration of dialysis (Fig. 2).

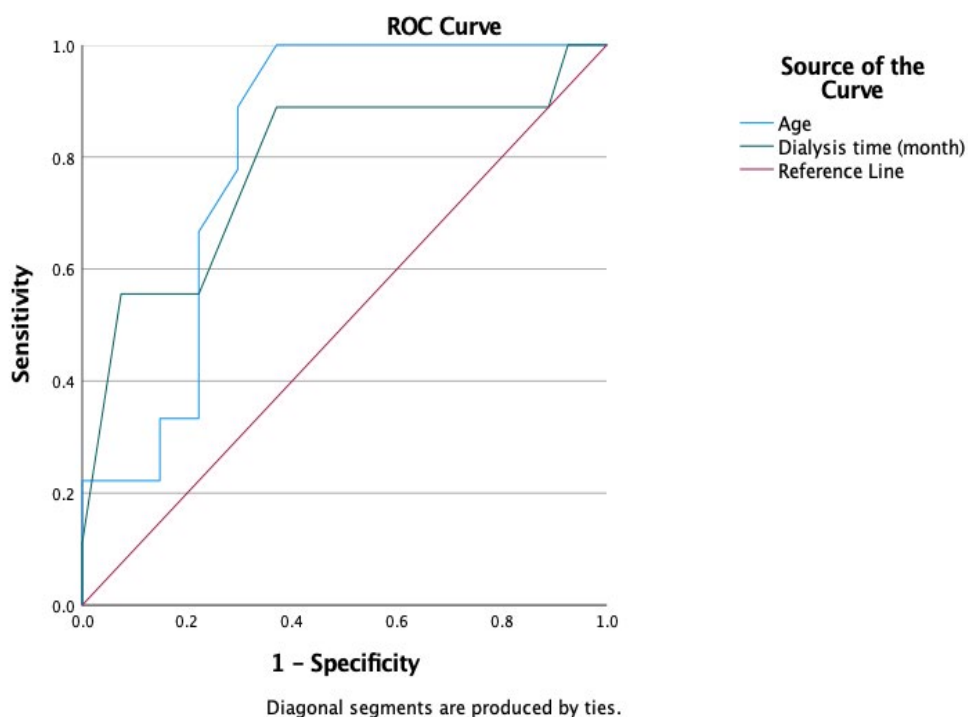


Fig. 2. ROC analysis of age and dialysis duration in PD patients.

As a result of the ROC analysis, the area under the ROC curve (AUC) value for age was found to be 0.811, which indicates a high level of discrimination ( $P = 0.006$ ), with a 95% confidence interval (CI) of 0.671 to 0.950. Accordingly, the cutoff value required to determine the age for mortality was 52.5%, the sensitivity was 88.9%, and the specificity was 59.3%. Patients older this age cutoff were considered to be those of advanced age. It was also found statistically significant that over 52.5 years of age increased mortality after peritonitis in PD patients ( $P = 0.02$ ).

Separately, in the ROC analysis for dialysis time, the AUC value was 0.784, which also indicates a high level of discrimination ( $P = 0.012$ ), and the accompanying 95% CI was 0.588 to 0.980. Accordingly, the cutoff value required to determine the duration of dialysis for mortality was found to be 11.5 months, the sensitivity was 88.9%, and the specificity was 51.9%.

In terms of comorbidities, it was found that mortality increased with advancing age in patients with coronary artery disease (CAD) compared to those with-

out CAD, and this increase was statistically significant ( $P = 0.002$ ). In addition, it was determined that the accompanying cirrhosis significantly increased mortality in elderly patients ( $P = 0.043$ ).

In considering the surgical procedures performed, it was found that segmental small-bowel resection ( $n = 16$ ) was mostly performed due to ileus or intestinal perforation, and no additional pathological findings other than peritonitis were encountered in 12 patients. As a result, mortality occurred in eight patients in the advanced-age group and one patient in the other group among patients operated on for peritonitis. Although this difference was statistically significant according to age group ( $P = 0.002$ ), it was not found to be statistically significant when the distribution of surgical procedures was evaluated ( $P = 0.512$ ) (see Table 1).

In addition, binary logistic regression analysis was applied to investigate the impact of underlying risk factors on mortality rate in patients who developed PD-associated peritonitis (Table 2).

Table 2

**Binary logistic regression analysis of age, CAD and dialysis duration for mortality in peritoneal dialysis patients with developed peritonitis**

	B	S.E.	Wald	df	Sig.	Exp(B)	95 % C.I. for EXP (B)	
							Lower	Upper
Age	.094	.042	5.126	1	.024	1.099	1.013	1.193
CAD	3.778	1.088	12.070	1	.001	43.750	5.191	368.755
Dialysis time	.580	.266	4.747	1	.029	1.786	1.060	3.010

Abbreviations: CAD: coronary artery disease.

Age, CAD, and dialysis time were found to be statistically significant among the risk factors evaluated accordingly. Accordingly, respectively; age (odds ratio [OR]= 1.09; 95% CI [1.013-1.193];  $p=.024$ ), CAD [OR] = 43.7; 95% CI [5.191-368.755];  $p<.001$  and dialysis time [OR] = 1.786; 95% [1.060-3.010];  $p=.029$  was calculated.

**Discussion.** One of the most common problems that may arise in patients undergoing PD is peritonitis. If necessary precautions are taken, the possibility of peritonitis onset and related mortality can be reduced [5, 6]. Factors that may cause peritonitis have been documented in previous studies; accordingly, some known risk factors can or cannot be changed [2]. In our study, we examined the risk factors that increase the mortality rate after surgery in patients who developed peritonitis due to PD.

Our study offers several important results. Similar to existing studies [6, 7], the mortality rate due to peritonitis rose above 52.5 years (50%). In addition, we found that mortality increased by 1.09 times for each one-year increase in age after 52.5 years of age. However, we found that peritonitis-related mortality was greater in patients with comorbidities. In particu-

lar, we found in our study that accompanying CAD increased the mortality rate by 43.7 times. There are many studies in the literature reporting that CAD itself increases the mortality rate, but we documented an even higher risk in our study compared to previous reports [8-10]. Finally, in our study, we determined that prolonged PD duration increased the mortality rate; specifically, we found that the application of PD every month, especially after 11.5 months, increased the peritonitis-related mortality rate by 1.7 times. In contrast, other authors generally found the cutoff to be two years [1, 7, 11-13]. In addition, operative mortality in patients operated for peritonitis was observed only in those who underwent negative laparotomy and segmental small bowel resection. However, this result did not create a statistically significant difference compared to other surgeries.

It is very difficult to distinguish during peritonitis-related surgery between primary peritonitis, referring to a perforation that developed as a result of peritonitis, and secondary peritonitis, or that which occurs secondary to perforation [14-17]. However, the treatment in both cases can be surgical in nature. Localized pain and tenderness in only one area during

the abdominal examination can be evaluated in favor of secondary peritonitis findings [5]. Causes of secondary peritonitis include acute appendicitis, acute cholecystitis, intestinal perforation that may develop secondary to diverticulitis. However, it was stated that the priority in these cases should be surgical exploration [5, 18].

There are some limitations to our study. This is a retrospective and single-centered investigation. In addition, we considered our patients, whom we treated surgically, all as cases of primary peritonitis since no additional pathology was detected as a surgical finding, and we think that this decision adds some bias to our study. However, considering that it is clinically difficult to make this distinction in most cases, we think that the results of our study remain important.

**Conclusions.** We recommend that the decision for surgical intervention due to peritonitis be made early, regardless of whether it is primary or second-

ary. In addition, we think that coronary artery disease and advanced age may be risky in terms of mortality.

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**Authors contribution.**

**Murathan Erkent:** study design, data collection, statistical analysis, data interpretation, manuscript preparation, literature search;

**Emre Karakaya:** data collection, data interpretation, manuscript preparation, literature search;

**Tevfik Avci:** study design, data collection;

**Zeynep İlayda Bağcı:** data collection;

**Aydınca Akdur:** data interpretation, manuscript preparation, literature search.

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