

# Survival Rate of Chronic Kidney Disease (CKD) Patients Undergoing Continuous Ambulatory Peritoneal Dialysis (CAPD): A Meta-Analysis

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Chronic kidney disease (CKD) is defined as kidney damage, structurally and/or functionally, that persists for more than three months. Continuous ambulatory peritoneal dialysis (CAPD) has several benefits compared to other renal replacement therapies (RRT), although the results are inconclusive. The objective of this review and meta-analysis was to evaluate the survival rate of CKD patients undergoing CAPD. A systematic search according to PRISMA 2020 guidelines was carried out through online databases for relevant studies evaluating the survival rate of CKD patients undergoing CAPD. The articles obtained were observational studies that had been adjusted to the inclusion and exclusion criteria. Newcastle Ottawa Scale (NOS) was used to assess the study quality. Analysis was carried out with Review Manager software v.5.4. 11 studies were obtained, most of which were retrospective cohort studies from China, with 3700 aged 7.6 to 74.1 years and follow-up durations ranging from 5 months to 18 months. Based on the analysis, the pooled survival rate in 1, 2, 3, 5, and 10 years was 91% (95% CI 82–96%), 73% (95% CI 60–83%), 63% (95% CI 44–78%), 63% (95% CI 40–82), and 73% (95% CI 38–92%) respectively. Heterogeneity was high across time points (I<sup>2</sup> 96%–99%). Egger's 2-year survival rate analysis test showed a significant publication bias risk ( $p=0.046$ ). CKD patients who underwent CAPD had a survival rate of 91%, 73%, 63%, and 73% at 1, 2, 3, 5, and 10 years, respectively.

**Keywords:** Chronic Kidney Disease (CKD); Clinical Epidemiology; Continuous Ambulatory Peritoneal Dialysis (CAPD); Survival Rate.

Chronic kidney disease (CKD) is defined as kidney damage, structurally and/or functionally, that persists for more than three months. The functional disorder referred to is a decrease in the glomerular filtration rate (GFR) reaching  $<60 \text{ mL}/\text{minute}/1.73 \text{ m}^2$  or albuminuria reaching  $\geq 30 \text{ mg}$  in 24 hours.<sup>1</sup> Based on its etiology, CKD can be caused by various conditions. In most cases, CKD itself is a complication that occurs due to other

health problems. Some of these etiologies include diabetes mellitus (around 30%–50 % of all CKD cases are generally caused by DM), hypertension, kidney infections, congenital abnormalities, and others.<sup>2</sup> However, the main mechanism of CKD can be explained in general as chronic dysfunction of microvascularization in the nephron, which ultimately causes kidney functional and structural disorders.<sup>1</sup>

When viewed from an epidemiological perspective, the exact incidence rate of CKD throughout the world is difficult to ascertain because the majority of CKD cases are asymptomatic, where the majority of patients who are finally diagnosed with CKD come for examination at an advanced stage.<sup>3</sup> According to Centers for Disease Control and Prevention (CDC) data, the incidence of CKD elevated from 11.8% in 1988-1994 to 14.2% in 2015-2016.<sup>4</sup> However, several recent studies have stated that the incidence of advanced-stage CKD has decreased. In a meta-analysis by Hill et al.,<sup>5</sup> it was found that the prevalence of CKD was dominated by CKD stages 1, 2, and 3. On the other hand, the prevalence of CKD stages 4 and 5 only reached 0.4% and 0.1%, respectively.<sup>5</sup>

Renal replacement therapy (RRT) is one of the treatment choices for functional and structural damage to the kidney patients, both in acute and chronic conditions. This therapy substitutes for the function of impaired kidneys to carry out functions in fluid and electrolyte regulation, excretion of metabolic waste, and other harmful substances.<sup>6</sup> This substitution can take the form of a kidney transplant (which is the most recommended type of RRT) or by using dialysis, either hemodialysis (HD) or peritoneal dialysis (PD).<sup>7</sup>

Peritoneal dialysis is one of the modalities used in dialysis and has several advantages compared to HD. Compared with HD, patients undergoing PD do not need to come regularly to the hospital for dialysis procedures because the procedures can be done at home.<sup>8</sup> One of the developments in PD today is continuous ambulatory peritoneal dialysis (CAPD). CAPD is a development of PD, which is part of continuous renal replacement therapy (CRRT). Based on various studies, RRT using CAPD is known to have various advantages, such as having a risk of patients experiencing hypotension when compared to HD because CAPD has a slower filtration rate and has a greater collective filtration capacity when compared to HD, so it can provide efficacy in better elimination of toxins and metabolic waste.<sup>9</sup>

However, data regarding CAPD is still limited, both in clinical applications and research data regarding its efficacy. The literature states that only about 7% of patients receiving RRT in the United States undergo PD procedures.<sup>8</sup> A study conducted by Gunawan and Sakti<sup>10</sup> found a one-

year survival rate of 80%. In addition, excellent results were found by Yi et al.,<sup>11</sup> which found the one-year survival rate of patients undergoing CAPD at 99.6%. Based on other studies that discuss the efficacy and safety of CAPD, the results are inconclusive because there are inconsistent results ranges between studies. Apart from that, there are comorbid conditions and complications that play a role in the mortality rate of CKD patients undergoing CAPD, such as the incidence of peritonitis, comorbid hypertension, diabetes mellitus, and others. Thus, this systematic review and meta-analysis aims to assess the survival rate of patients undergoing CAPD.

## MATERIALS AND METHODS

All findings pertaining to the study topic were identified, evaluated, and interpreted in this meta-analysis study. To find all pertinent papers, the PICOS (Population, Intervention, Comparison, Outcome, Studies) approach was employed. The 2020 Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) standards became the basis of the systematic search technique.

### Study selection

All of the study articles included in this review are studies that report and assess the survival rate of chronic renal disease patients receiving CAPD. All the studies were identified from PubMed, ScienceDirect, Google Scholar, and the Cochrane Library online databases. The survival rate referred to in this study is the percentage of patients in the research group who are still alive for a certain period after undergoing a procedure in the form of CAPD, expressed in the period 1 to 10 years after the procedure. The study's population were CKD patients who had performed CAPD. Studies were excluded if (1) the populations underwent dialysis therapy other than using the CAPD method, (2) the follow-up time was less than one year, (3) no clear statement regarding the survival rate, (4) non-specific study designs.

### Literature searching

To maximize search results, several keywords relevant to the PICOs were used to look for pertinent literature. Initially, the author used medical subject headings (MeSH) to determine

keywords for the study search. Following MeSH keyword selection, Boolean operators (AND, OR, and NOT) were used to group the keywords in accordance with the research topic. Advanced search and bibliographic search were used to search for the studies. Survival rate AND chronic renal disease AND (peritoneal dialysis) OR (continuous ambulatory peritoneal dialysis) were the search keywords used.

#### Data extraction and study quality evaluation

This study evaluated the quality of papers to be using critical appraisal. Data extraction was done independently by each author. The New Castle and Ottawa Scale (NOS) for Cohort and Cross-Sectional Studies, which has three assessment components: findings, comparability, and selection, was utilized to assess the study quality. The article was deemed to fit the requirements and included in the inclusion criteria if the overall interpretation reached was rather good, and vice versa.

#### Data analysis

To analyse the data and draw conclusions, all data was systematically integrated and characterized. The information included population demographic characteristics, measuring techniques, measurement parameters, primary research findings, and research features (such as the last name of first author, the publication year, and the research site). To make analysis easier, data was supplied in tabular form (synthesis matrix). Review Manager software v.5.4 and single proportion analysis were used to quantitatively calculate overall patient survival rate. I-squared and

t-squared tests were used to assess heterogeneity. Random effect model was indicated if there was significant heterogeneity value. A quantitative Egger's test and a qualitative funnel plot method were utilized to assess the publication bias risk. A p-value of <0.05 was determined to be significant.

## RESULTS

#### Literature searching

3688 publications from four online databases (PubMed, ScienceDirect, Google Scholar, and Cochrane) were found during the study search process. Using computer software (Citation Manager), duplicates were eliminated, yielding 2408 papers. 37 publications that could be accessed and subsequently evaluated for eligibility were found through the title and abstract screening process. Additionally, 11 included papers were used for both qualitative (systematic review) and quantitative (meta-analysis) analysis after 26 articles were eliminated due to incomplete or irrelevant data. The following is a description of the PRISMA guideline-based study search flow (Figure 1).

#### Study characteristics

A total of 11 studies were obtained in this review. A total of 9 studies were retrospective cohort studies, 1 study was a cross-sectional study, and 1 was case-control study. Most of the studies came from China with the total population involved in all inclusion studies being 3700 CKD patients undergoing CAPD therapy. The duration of study

**Table 1.** Study characteristic

Author, year	Study design	Country	Population	Duration of follow-up (Months)	Mean of age (year)
Ataei et al. <sup>12</sup>	Cross-sectional	Iran	182	18	7.69±4.72
Gunawan and Sakti. <sup>10</sup>	Retrospective cohort	Indonesia	674	5	N/A
Isla et al. <sup>13</sup>	Retrospective cohort	South Africa	152	5	36.8±11.4
Joshi et al. <sup>14</sup>	Retrospective cohort	China	805	5	71.3±4.3
Kit-Chung et al. <sup>15</sup>	Case-control	China	133	10	74.1±5.9
Prasad et al. <sup>16</sup>	Retrospective cohort	India	66	12	12.3±3.91
Sakaci et al. <sup>17</sup>	Retrospective cohort	Turki	58	13	71.8±4.9
Vikrant <sup>18</sup>	Retrospective cohort	India	60	10	60.2±9.2
Wen et al. <sup>19</sup>	Retrospective cohort	China	716	5	51±15
Yi et al. <sup>11</sup>	Retrospective cohort	China	433	6	51.3±15.7
Zhang et al. <sup>20</sup>	Retrospective cohort	China	421	10	57.9±14.8

follow-up ranged from 5 months to 18 months, with patient averages ranging from 7.6 years to 74.1 years. Table 1 presents the study characteristics.

#### Study outcome

Most studies report that patients with CAPD have a higher survival rate or lower mortality than patients who do not undergo CAPD, especially in end-stage renal disease (ESRD) patients. A number of studies also report that increasing age has an effect on survival rates regardless of the use of CAPD therapy. On the other hand, 9 studies had good study quality, and 2 others had moderate study quality, so all studies could be

used in quantitative analysis. All study outcomes are described in Table 2.

#### Quantitative analysis

To determine the overall survival rate from all included studies, a quantitative analysis was carried out. According to data obtained from the inclusion study, the analysis was carried out using a number of time durations, including 1, 2, 3, 5, and 10 years.

The analysis of survival rates at 1 year included 10 studies, where the overall survival rate was 91% (random effect; 95% CI 82 – 96%; heterogeneity;  $5\text{O}\beta^2 < 0.01$ ;  $I^2 = 96\%$ ) (Figure 2).

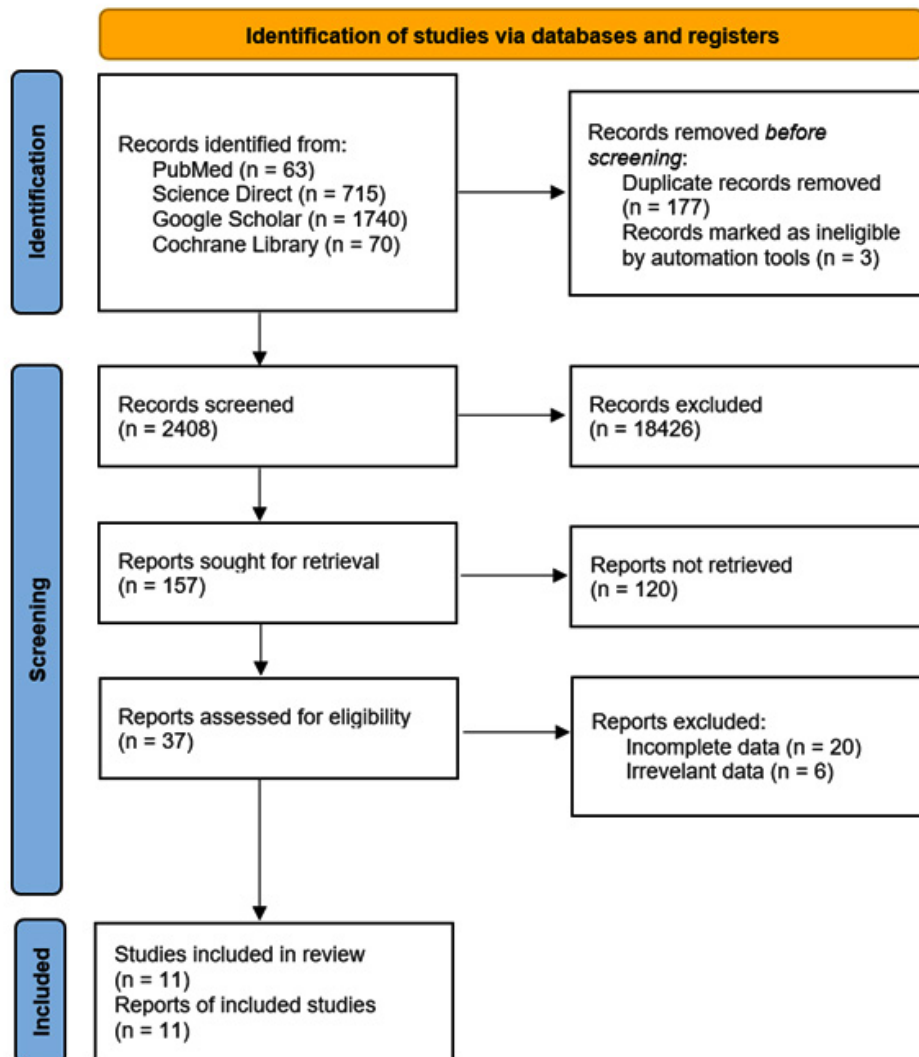


Fig. 1. PRISMA Flowchart

6 studies were included for the survival rates at 2 years analysis, which resulted in 73% of overall survival rate (random effect; 95% CI 60 – 83%; heterogeneity;  $50\beta^2 < 0.01$ ;  $I^2 = 95\%$ ) (Figure 3).

Survival rates at 3 years analysis encompassed 8 studies and the overall survival rate result was 63% (random effect; 95% CI 44 – 78%; heterogeneity;  $50\beta^2 < 0.01$ ;  $I^2 = 97\%$ ) (Figure 4).

7 studies were pooled and analyzed for the 5-year survival rates, which resulted in a 63% of overall survival rate (random effect; 95% CI 40 – 82%; heterogeneity;  $50\beta^2 < 0.01$ ;  $I^2 = 98\%$ ) (Figure 5).

For the 10-year survival rates, 2 studies were analyzed, which resulted in an overall survival rate of 73% (random effect; 95% CI 38 – 92%; heterogeneity;  $50\beta^2 < 0.01$ ;  $I^2 = 99\%$ ) (Figure 6).

#### Publication bias

Next, publication bias analysis was carried out using Egger's test; quantitative analysis showed an insignificant p-value in the survival rate analysis

for 1, 3, 5, and 10 years, reflecting a low risk of publication bias. Meanwhile, a p-value  $< 0.05$  in the 2-year survival rate analysis reflects a significant risk of publication bias. The Egger's test analysis results are presented in Table 3.

## DISCUSSION

This meta-analysis aimed to estimate survival rates among CKD patients undergoing continuous ambulatory peritoneal dialysis (CAPD) using 11 included observational studies. CAPD is a home-based dialysis modality that may reduce the need for frequent hospital visits and support quality of life compared with facility-based hemodialysis.

The pooled 1-year survival rate was 91% (95% CI 82–96%), consistent with several included cohorts reporting  $>90\%$  1-year survival among CAPD-treated patients, namely by Ataei et al.,<sup>12</sup> Joshi et al.,<sup>14</sup> Wen et al.,<sup>19</sup> Yi et al.,<sup>11</sup> and Zhang et al.<sup>20</sup> who found high levels of Survival in ESRD patients undergoing CAPD reaches more than 90%.

**Table 2.** Study outcome

Author, year	Study outcome	Quality of study (NOS)
Ataei et al. <sup>12</sup>	The long-term survival rate in this study was higher than data in previous studies reported in Europe.	Good
Gunawan and Sakti. <sup>10</sup>	End Stage Renal Disease (ESRD) patients who received CAPD in this study had good 5-year survival rates.	Good
Isla et al. <sup>13</sup>	Management of comorbidities that accompany ESRD patients receiving CAPD can prevent morbidity and mortality in patients	Good
Joshi et al. <sup>14</sup>	Elderly patients have lower survival rates than younger patients.	Moderate
Kit-Chung et al. <sup>15</sup>	Patients who underwent Helper-Assisted CAPD had worse survival rates	Moderate
Prasad et al., 2019 <sup>16</sup>	CAPD is a possible option for ESRD patients in pediatric patients in developing countries considering aspects of limited resources.	Good
Sakaci et al. <sup>17</sup>	The mortality rate is higher in elderly patients. This is influenced by advanced age and the presence of comorbid conditions that worsen the patient's condition.	Good
Vikrant, <sup>18</sup>	The study results showed higher mortality in elderly patients, especially elderly people with a burden of comorbid conditions.	Good
Wen et al. <sup>19</sup>	High peritoneal dialysate glucose concentrations are associated with mortality rates in patients receiving CAPD	Moderate
Yi et al. <sup>11</sup>	Doctor-patient contact of no more than two months was independently associated with greater survival rates in patients undergoing CAPD.	Good
Zhang et al. <sup>20</sup>	The survival rate of patients who received CAPD was found to be better	Good

However, the study run by Prasad et al.,<sup>16</sup> reported the lowest 1-year survival, which may relate to a high peritonitis burden in pediatric CAPD patients (45/66 cases) and potential loss to follow-up. Peritonitis is a major CAPD complication associated with mortality and technique failure, and outcomes may be worse with virulent or antibiotic-resistant organisms.<sup>21,22</sup> Accordingly, prompt pathogen identification, timely antibiotic treatment, and prevention strategies (aseptic technique, early detection, and patient education) are central to improving outcomes.<sup>23</sup>

When viewed from the 2-year survival rate, the 2-year pooled survival rate was 73% (random effect; CI 95% 60 – 83%). The results of this analysis are consistent with the included studies in this meta-analysis, such as Isla et al.,<sup>13</sup> Joshi et al.,<sup>14</sup> and Wen et al.,<sup>19</sup> which found a 2-year survival rate of more than 70%. However, if we look back at the included studies, those

conducted by Vikrant, 2014<sup>18</sup> and Kit-Cheung et al.<sup>15</sup> had the lowest survival rates (53% and 56%, respectively). Based on research conducted by Vikrant, 2014,<sup>18</sup> similar results were obtained by Prasad et al.,<sup>16</sup> where the percentage of peritonitis incidents reached more than 50% of the entire research sample. Furthermore, research by Kit-Cheung et al.<sup>15</sup> found the involvement of other comorbid conditions, such as diabetes mellitus and hypertension. Furthermore, in the analysis of patient survival rates at 3, 5, and 10 years, each pooled survival rate was found to be 63% (95% CI 44 – 78%); 63% (95% CI 40 – 82%); and 73% (95% CI 38 – 92%).

A non-linear trend was observed across survival time points, with survival declining from 1 to 3 years, remaining similar at 5 years, and appearing higher at 10 years. This pattern should be interpreted cautiously, as the 10-year pooled estimate was derived from only two studies,

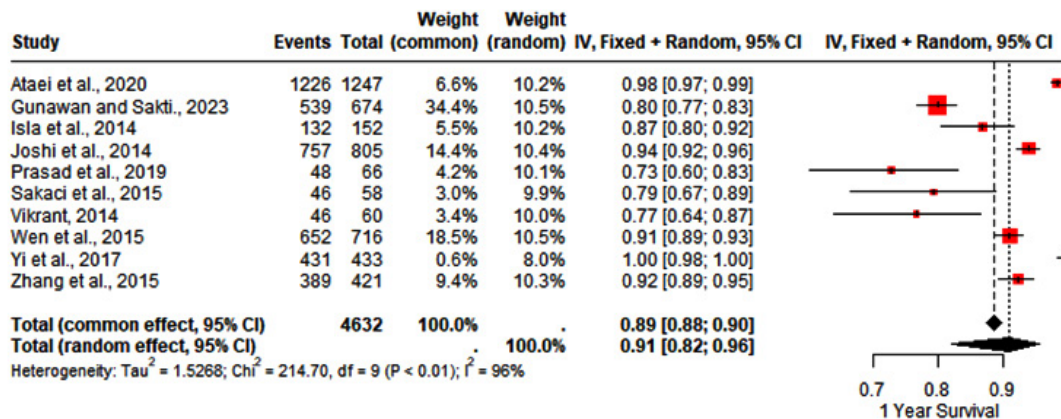


Fig. 2. One-year survival rate analysis

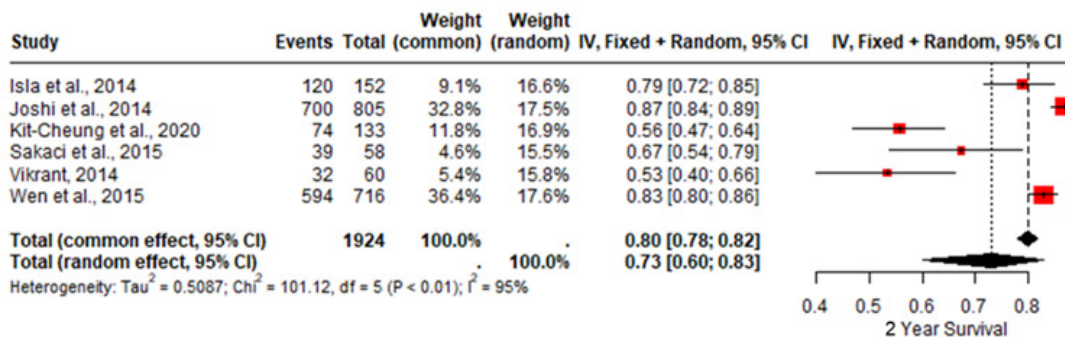


Fig. 3. Two-year survival rate analysis

reporting survival rates of 84.8% in the study performed by Ataei et al.<sup>12</sup> and 55.7% in the study performed by Zhang et al.<sup>20</sup> A non-linear trend was observed across survival time points, with survival declining from 1 to 3 years, remaining similar at 5 years, and appearing higher at 10 years. This pattern should be interpreted cautiously, as the 10-year pooled estimate was derived from only two studies, reporting survival rates, such as the study conducted by Prasad et al.,<sup>16</sup> which in their study found a three-year survival rate of only 30%. Conversely, large-scale studies with moderate survival outcomes, including a study conducted by Gunawan and Sakti<sup>10</sup> (3- and 5-year survival of 60% and 52% in 647 patients), exerted substantial weight on the pooled estimates.

Mortality in CKD patients undergoing CAPD is multifactorial and influenced by patient-

related, treatment-related, and socioeconomic factors. Established predictors include advanced age, comorbidities such as diabetes and cardiovascular disease, nutritional status, and dialysis adequacy. In a study run by Kit-Cheung et al.,<sup>15</sup> it was found that the average blood pressure of patients was more than 140mmHg. This study's results align with other inclusion studies, such as Gunawan and Sakti<sup>10</sup> which also found that CKD patients had comorbid hypertension. CKD is a chronic condition that can affect or be influenced by the function of other organ systems in the body, especially the cardiovascular system, or what is often referred to as cardio-renal syndrome (CRS), a bidirectional interaction in which dysfunction of the heart and kidneys mutually exacerbates disease progression.<sup>24</sup> Hemodynamic impairment, neurohormonal activation (RAAS and sympathetic pathways), and endothelial dysfunction contribute

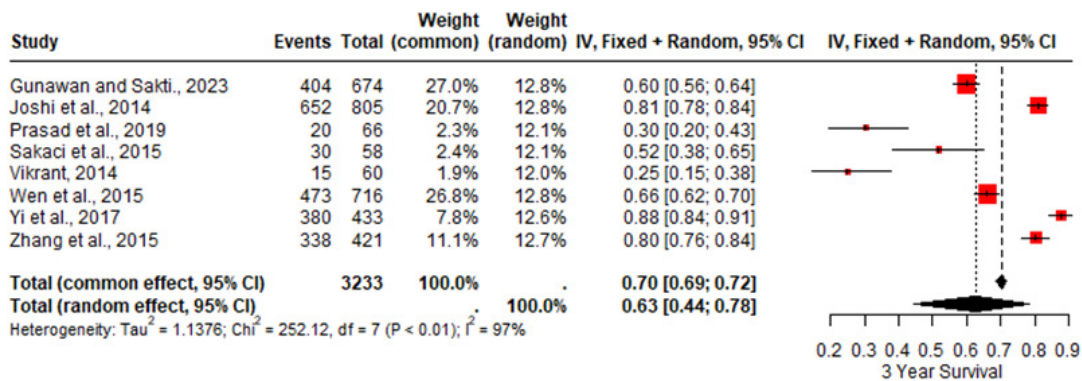


Fig. 4. Three-year survival rate analysis

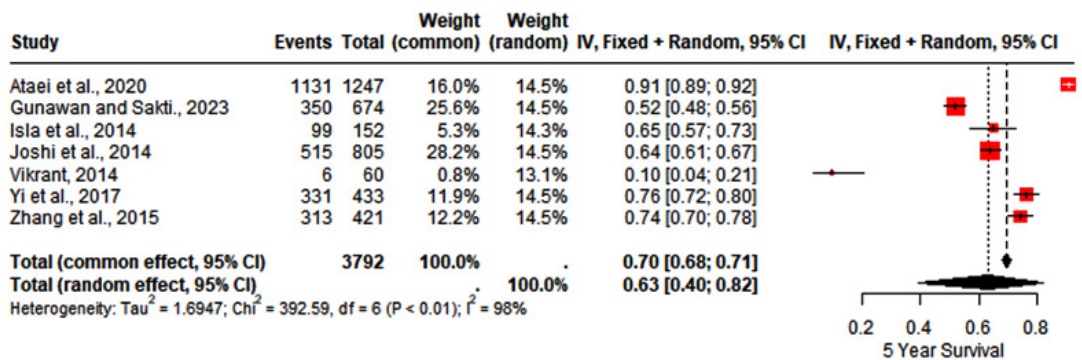


Fig. 5. Five-year survival rate analysis

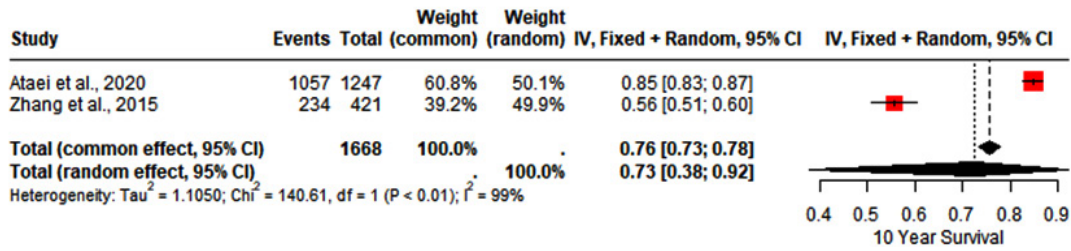


Fig. 6. Ten-year survival rate analysis

Table 3. Analysis of publication bias with Egger’s test

No	Survival rate	SE	p-value
1	1-year	57.96	0.251
2	2-years	35.55	0.046
3	3-years	60.26	0.167
4	5-years	175.97	0.423

to reduced renal perfusion, sodium retention, inflammation, and chronic renal ischemia, ultimately promoting renal fibrosis and progression of CKD.<sup>25,26</sup>

This meta-analysis has several limitations. This study only involved studies on the Asian and African continents, thereby limiting the generalization of data characteristics in the included studies. In addition, this study did not control for certain study characteristics that might play a role in the clinical outcomes of CAPD treatment because the number of studies discussing the survival rate of CAPD patients is quite rare. Importantly, heterogeneity was very high across all pooled time points (I<sup>2</sup> > 90%), indicating that the summary survival estimates should be interpreted as approximate averages across markedly different study populations and settings, rather than precise universal benchmarks. Potential sources of heterogeneity include regional differences, patient age distributions, comorbidity burden, peritonitis incidence, dialysis adequacy, and variations in clinical protocols and follow-up duration. Given this heterogeneity and the limited number of studies contributing to long-term outcomes, conclusions regarding 10-year survival should remain conservative.

**CONCLUSION**

Based on the findings of this meta-analysis, patients with chronic kidney disease undergoing continuous ambulatory peritoneal dialysis demonstrate favourable short- to mid-term survival outcomes. However, substantial variability across included studies indicates that survival estimates should be interpreted cautiously. Differences in patient characteristics, comorbid conditions, and CAPD-related complications may significantly influence survival outcomes.

Although pooled long-term survival appeared acceptable, interpretation of 10-year survival rates should remain conservative due to the limited number of studies contributing long-term data and the presence of substantial heterogeneity. Further large-scale, well-designed studies with standardized follow-up and comprehensive adjustment for clinical confounders are needed to better characterize long-term survival among CAPD patients and to improve the generalizability of these findings across different populations and healthcare settings.

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**Conflict of Interest**

The author(s) do not have any conflict of interest.

**Data Availability Statement**

This statement does not apply to this article.

**Ethics Statement**

This research did not involve human participants, animal subjects, or any material that requires ethical approval.

**Informed Consent Statement**

This study did not involve human participants, and therefore, informed consent was not required.

**Clinical Trial Registration**

This research does not involve any clinical trials

**Permission to reproduce material from other sources**

Not Applicable

**Author Contributions**

Yenny Kandarini: Conceptualization, Methodology, Writing; I Made Adi Narendranatha Komara: Data Collection, Analysis, Writing.

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