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Effectiveness of Percutaneous Coronary Intervention Versus Coronary Artery Bypass Grafting in Patients With End-Stage Renal Disease

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ABSTRACT

Introduction: Coronary artery disease (CAD) is highly prevalent in patients with end-stage renal disease (ESRD), posing significant treatment challenges. Percutaneous Coronary Intervention (PCI) and Coronary Artery Bypass Grafting (CABG) are the main revascularization strategies, but their comparative effectiveness and safety in ESRD patients remain unclear. **Methods:** A comprehensive review of 13 studies, including randomized controlled trials, observational cohorts, and meta-analyses, was conducted. Studies were selected based on adult ESRD populations comparing PCI and CABG outcomes, focusing on mortality, major adverse cardiac events (MACE), repeat revascularization, quality of life, and complications. **Results:** Short-term mortality was consistently lower with PCI (e.g., 1.2% vs. 15.4% at 30 days in Wang et al., 2020). Acute renal failure incidence was also lower after PCI (2.3%) compared to CABG (7.7%) in CKD patients (Giustino et al., 2018). Long-term outcomes, including all-cause mortality and MACE, were generally comparable between PCI and CABG across multiple studies. However, in patients with diabetes and CKD, CABG showed superior 10-year survival (44.2% vs. 64.3% mortality; Gao et al., 2020). Repeat revascularization rates were often higher after PCI, though some studies reported similar complete revascularization success. Quality of life improvements were noted with PCI in early CKD stages but not in advanced stages. **Discussion:** PCI offers a safer short-term profile with fewer complications, while CABG may provide better long-term survival in select high-risk subgroups. Differences in complication profiles and patient comorbidities should guide treatment choice. **Conclusion:** Treatment decisions for ESRD patients with CAD should be individualized, balancing short-term safety and long-term benefits, ideally within a multidisciplinary framework.

Keywords: End-Stage Renal Disease, Percutaneous Coronary Intervention, Coronary Artery Bypass Grafting, Coronary Artery Disease, Revascularization, Mortality, Major Adverse Cardiac Events, Quality of Life.

INTRODUCTION

End-Stage Renal Disease (ESRD) is a critical condition characterized by irreversible loss of kidney function, necessitating renal replacement therapy such as dialysis or transplantation. Cardiovascular disease remains the leading cause of morbidity and mortality in ESRD patients, with coronary artery disease (CAD) being highly prevalent in this population (Wang et al., 2020). The management of CAD in ESRD patients poses unique challenges due to their complex comorbidities and increased procedural risks. Coronary revascularization is a cornerstone in the treatment of significant CAD, with Percutaneous Coronary Intervention (PCI) and Coronary Artery Bypass Grafting (CABG) being the two primary modalities. However, the optimal revascularization strategy for ESRD patients remains controversial due to limited randomized data and the high-risk nature of this group (Dokollari et al., 2022).

PCI offers a less invasive approach with shorter recovery times and lower immediate procedural risks. Studies have demonstrated that PCI in ESRD patients is associated with lower short-term mortality and fewer acute complications compared to CABG (Wang et al., 2020; Giustino et al., 2018). For example, Wang et al. (2020) reported a 30-day mortality of 1.2% for PCI versus 15.4% for CABG, highlighting the potential short-term safety advantage of PCI.Conversely, CABG has traditionally been considered the gold standard for complex multivessel CAD, offering more complete revascularization and potentially better long-term outcomes. Several studies have shown that CABG is associated with lower rates of repeat revascularization and may confer survival benefits in certain subgroups, such as patients with diabetes and chronic kidney disease (Gao et al., 2020).

Long-term comparative outcomes between PCI and CABG in ESRD patients are less definitive. Meta-analyses and observational cohorts have reported comparable all-cause mortality and major adverse cardiac events (MACE) over follow-up periods ranging from 3 to 10 years (Li et al., 2023; Charytan et al., 2016). However, the SYNTAXES trial subgroup analysis revealed significantly lower 10-year mortality with CABG in patients with both diabetes and CKD (44.2% vs. 64.3% for PCI; adjusted HR 0.52, p=0.047) (Gao et al., 2020). Complication profiles differ between the two procedures. PCI is associated with lower rates of acute renal failure and procedural myocardial infarction but carries risks such as coronary perforation and stent thrombosis (Giustino et al., 2018; Barrett et al., 2018). CABG, while more invasive, may lead to higher rates of acute kidney injury and longer hospital stays (Wang et al., 2020).

Repeat revascularization rates tend to be higher after PCI, reflecting the less durable nature of stenting in this population. Several studies have documented significantly lower repeat revascularization with CABG, although some report similar complete revascularization rates between the two modalities (Su et al., 2019; Kumada et al., 2018). Quality of life (QoL) outcomes have been less frequently studied but are important considerations. Bangalore et al. (2022) found that PCI improved angina-related QoL in patients with early-stage CKD (stages 1-3), but no significant QoL improvement was observed in advanced stages (4-5), underscoring the complexity of treatment decisions in ESRD.

The heterogeneity of study designs, patient populations, and follow-up durations complicates direct comparisons. Most available data derive from retrospective observational studies and meta-analyses, with few randomized controlled trials specifically targeting ESRD patients (Dokollari et al., 2022). Technical aspects of the procedures also influence outcomes. PCI techniques have evolved with drug-eluting stents and adjunctive pharmacotherapy improving success rates, while CABG approaches vary between on-pump and off-pump surgeries, each with distinct risk profiles (Esteves et al., 2020).

Resource utilization and cost-effectiveness analyses remain sparse but are critical for guiding clinical decision-making, especially given the high healthcare burden of ESRD and CAD

(Koop et al., 2024). In summary, PCI tends to offer lower short-term mortality and complication rates, whereas CABG may provide superior long-term survival and reduced need for repeat interventions in selected ESRD patients. Individualized treatment decisions should consider patient comorbidities, anatomical complexity, and patient preferences.

Further high-quality randomized trials are needed to clarify the optimal revascularization strategy in this vulnerable population. Meanwhile, multidisciplinary collaboration between nephrologists, cardiologists, and cardiac surgeons is essential to optimize outcomes. This review aims to synthesize current evidence comparing PCI and CABG in ESRD patients, highlighting clinical outcomes, complications, and quality of life to inform clinical practice and future research directions.

METHODS

Protocol

The study strictly adhered to the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020 guidelines to ensure methodological rigor and accuracy. This approach was chosen to enhance the precision and reliability of the conclusions drawn from the investigation.

Criteria for Eligibility

This systematic review aims to evaluate effectiveness of percutaneous coronary intervention versus coro- nary artery bypass grafting in patients with end-stage renal disease

Screening

We screened in papers that met these criteria:

- **Adult ESRD Population**: Does the study include adult patients (18 years) with documented end- stage renal disease (ESRD)?
- **Intervention Comparison**: Does the study directly compare outcomes between PCI and CABG as primary coronary revascularization methods?
- **Clinical Outcomes**: Does the study report at least one of the following outcomes: mortality, major adverse cardiac events (MACE), repeat revascularization rates, quality of life measures, or procedure- related complications?
- **Study Design**: Is the study design either a randomized controlled trial, prospective/retrospective cohort study, or systematic review/meta-analysis?
- **Population Analysis**: If the study includes mixed populations (ESRD and non-ESRD), does it present separate analysis for ESRD patients?
- **Clinical Context**: Does the study examine stable coronary artery disease rather than focusing solely on acute coronary syndromes?
- **Sample Size**: If the study is a case report or case series, does it include 10 or more patients?

We considered all screening questions together and made a holistic judgement about whether to screen in each paper.

Data extraction

We asked a large language model to extract each data column below from each paper. We gave the model the extraction instructions shown below for each column.

- **Study Design**:

  Identify the type of study design. Specify:

- Randomized controlled trial (RCT)
- Observational study (cohort, case-control)

- Single-center or multi-center study
- Prospective or retrospective design

If multiple design elements are present, list all. If unclear, note ”design not clearly specified”. Look in the methods section for this information.

- **Patient Characteristics**:

  Extract key patient demographic and clinical characteristics:

- Mean/median age
- Gender distribution
- Specific renal disease stage (e.g., eGFR < 30 ml/min/1.73 m2)
- Comorbidities
- Number of patients in each intervention group

Use exact numbers/percentages from the study. If ranges are provided, include both. If data is incomplete, note ”partial information available”.

- **Intervention Details**:
  Specify the exact
  interventions:
- Percutaneous Coronary Intervention (PCI) technique
- Coronary Artery Bypass Grafting (CABG) type (on-pump/off-pump)
- Any specific modifications or additional treatments

Capture precise details about the procedure from methods section. If multiple variants exist, list all. If technique is not fully described, note ”incomplete intervention details”.

- **Primary and Secondary Outcomes**:

  List all outcomes measured:

- Primary outcomes (e.g., all-cause mortality)
- Secondary outcomes (e.g., Major Adverse Cardiac and Cerebrovascular Events)
- Specific metrics used (hazard ratios, confidence intervals)

Extract exact outcome measurements and statistical significance. If multiple time points are reported (30 days, 1 year, 5 years), capture all. Use verbatim quotes from results section where possible.

- **Follow-up**
  Duration: Record:
- Total follow-up period
- Specific follow-up time points (30 days, 1 year, 5 years)
- Completeness of follow-up (percentage of patients followed)

Extract exact duration from methods or results section. If follow-up is incomplete, note the percentage of patients lost to follow-up.

- **Study Setting and Sample**
  Size: Capture:
- Geographic location
- Total number of patients
- Number of patients in each intervention group
- Inclusion/exclusion criteria

Use exact numbers from the study. If multiple cohorts exist, list all. Verify numbers match across methods and results sections.

Search Strategy

The keywords used for this research based PICO :

Element	Keyword 1	Keyword 2	Keyword 3	Keyword 4
opulation (P)	End-Stage Renal Disease	Chronic Kidney Disease	Dialysis-dependent	Coronary Artery Disease
Intervention (I)	Percutaneous Coronary Intervention (PCI)	Drug-Eluting Stents	Minimally Invasive	Percutaneous Revascularization
Comparison (C)	Coronary Artery Bypass Grafting (CABG)	On-pump CABG	Off-pump CABG	Surgical Revascularization
Outcome (O)	Mortality	Major Adverse Cardiac Events (MACE)	Repeat Revascularization	Quality of Life (QoL)

The Boolean MeSH keywords inputted on databases for this research are: *("End-Stage Renal Disease" OR "Chronic Kidney Disease" OR "Dialysis-dependent" OR "Coronary Artery Disease") AND ("Percutaneous Coronary Intervention" OR "Drug-Eluting Stents" OR "Minimally Invasive Revascularization" OR "Percutaneous Revascularization") AND ("Coronary Artery Bypass Grafting" OR "On-pump CABG" OR "Off-pump CABG" OR "Surgical Revascularization") AND ("Mortality" OR "Major Adverse Cardiac Events" OR "Repeat Revascularization" OR "Quality of Life")*

Data retrieval

Abstracts and titles were screened to assess their eligibility, and only studies meeting the inclusion criteria were selected for further analysis. Literature that fulfilled all predefined criteria and directly related to the topic was included. Studies that did not meet these criteria were excluded. Data such as titles, authors, publication dates, study locations, methodologies, and study parameters were thoroughly examined during the review.

Quality Assessment and Data Synthesis

Each author independently assessed the titles and abstracts of the selected studies to identify those for further exploration. Articles that met the inclusion criteria underwent further evaluation. Final decisions on inclusion were based on the findings from this review process.

Table 1. Article Search Strategy

Database	Keywords	Hits
Pubmed	*("End-Stage Renal Disease" OR "Chronic Kidney Disease" OR "Dialysis-dependent" OR "Coronary Artery Disease") AND ("Percutaneous Coronary Intervention" OR "Drug-Eluting Stents" OR "Minimally Invasive Revascularization" OR "Percutaneous Revascularization") AND ("Coronary Artery Bypass Grafting" OR "On-pump CABG" OR "Off-pump CABG" OR "Surgical Revascularization") AND ("Mortality" OR "Major Adverse Cardiac Events" OR "Repeat Revascularization" OR "Quality of Life")*	1,538
Semantic Scholar	*("End-Stage Renal Disease" OR "Chronic Kidney Disease" OR "Dialysis-dependent" OR "Coronary Artery Disease") AND ("Percutaneous Coronary Intervention" OR "Drug-Eluting Stents" OR "Minimally Invasive Revascularization" OR "Percutaneous Revascularization") AND ("Coronary Artery Bypass Grafting" OR "On-pump CABG" OR "Off-pump CABG" OR "Surgical Revascularization") AND ("Mortality" OR "Major Adverse Cardiac Events" OR "Repeat Revascularization" OR "Quality of Life")*	253
Sagepub	*("End-Stage Renal Disease" OR "Chronic Kidney Disease") AND ("Percutaneous Coronary Intervention") AND ("Coronary Artery*	7,661

	Bypass Grafting") AND ("Mortality" OR "Major Adverse Cardiac Events" OR "Repeat Revascularization" OR "Quality of Life")	
Google Scholar	*("End-Stage Renal Disease" OR "Chronic Kidney Disease") AND ("Percutaneous Coronary Intervention") AND ("Coronary Artery Bypass Grafting") AND ("Mortality" OR "Major Adverse Cardiac Events" OR "Repeat Revascularization" OR "Quality of Life")*	16,100

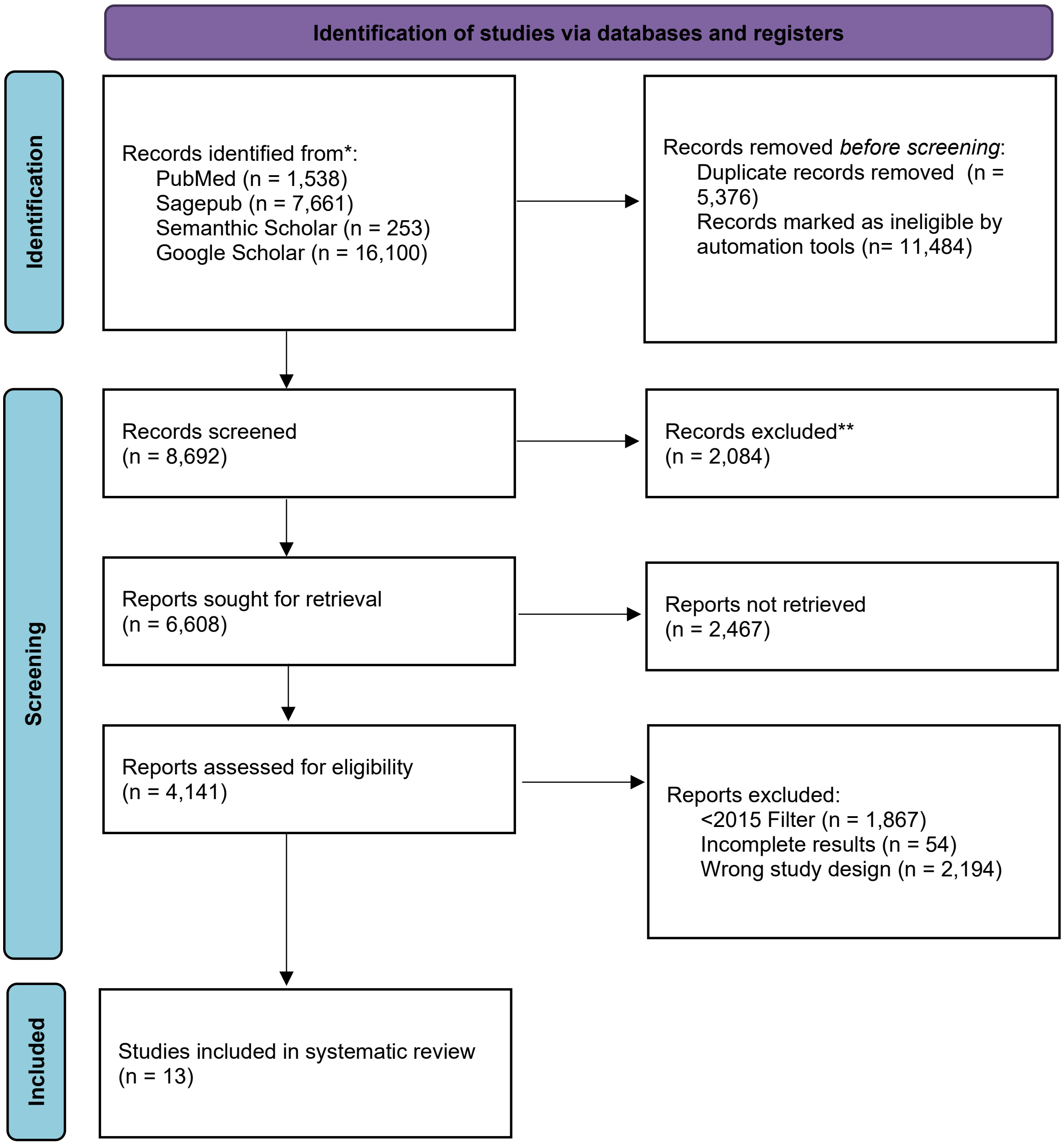

Figure 1. Article search flowchart

JBI Critical Appraisal													
PARAMETER	**Wang et al., 2020**	**Kumada et al., 2018**	**Li et al., 2023**	**Dokollari et al., 2022**	**Charytan et al., 2016**	**Gao et al., "SYNTAXES trial"**	**Esteves et al., 2020**	**Giustino et al., 2018**	**Bangalore et al., 2022**	**Koop et al., 2024**	**Su et al., 2019**	**Jain et al., 2019**	**Barrett et al., "REAL-TIME VOLUME ASSESSMENT"**
1. Bias related to temporal precedence Is it clear in the study what is the "cause" and what is the "effect" (ie, there is no confusion about which variable comes first)?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2. Bias related to selection and allocation Was there a control group?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3. Bias related to confounding factors Were participants included in any comparisons similar?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4. Bias related to administration of intervention/exposure Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	No	No	No	No	No	No	No	No	No	No	No	No	No
5. Bias related to assessment, detection, and measurement of the outcome													
Were there multiple measurements of the outcome, both pre	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

and post the intervention/exposure?													
Were the outcomes of participants included in any comparisons measured in the same way?	**No**	**No**	**No**	**No**	**No**	**No**	**No**	**No**	**No**	**No**	**No**	**No**	**No**
Were outcomes measured in a reliable way?	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
6. **Bias related to participant retention** Was follow-up complete and, if not, were differences between groups in terms of their follow-up adequately described and analyzed?	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
7. Statistical conclusion validity Was appropriate statistical analysis used?	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**

Results

Characteristics of Included Studies

Study	Study Design	Sample Size	Population Characteristics	Follow-up Duration	Full text retrieved
Wang et al., 2020	Retrospective observational cohort study	112	Dialysis-dependent End-Stage Renal Disease (ESRD) patients	1-8 years (median 1-3.6 years)	Yes
Kumada et al., 2018	Observational cohort study	325	Chronic hemodialysis patients	43 months	No

Study	Study Design	Sample Size	Characteristics	Duration	retrieved
Li et al., 2023	Retrospective observational cohort study	823	Coronary Artery Disease (CAD) patients with advanced Chronic Kidney Disease (CKD) (estimated Glomerular Filtration Rate (eGFR) < 30 ml/min/1.73	Up to 5 years	Yes
Dokollari et al., 2022	Meta-analysis of observational studies	No mention found	Dialysis-dependent patients	Up to 8.5 months	No
Charytan et al., 2016	Meta-analysis of randomized controlled trials	3993 (526 with stage 3-5 CKD)	Patients with stage 3-5 CKD	5 years	No
Gao et al., "SYNTAXES trial"	Randomized controlled trial	1,638	Patients with complex coronary artery disease, subgrouped by Diabetes Mellitus (DM) and CKD status	10 years	No
Esteves et al., 2020	Randomized controlled trial	No mention found	No mention found	No mention found	No
Giustino et al., 2018	Randomized controlled trial	1,869 (361 with CKD)	Patients with left main coronary artery disease and CKD	3 years	No
Bangalore et al., 2022	Randomized controlled trial	5956	Patients categorized by CKD stage	Median 3.1 years	No
Koop et al., 2024	Randomized controlled trial	No mention found	No mention found	20 years	No

Study	Study Design	Sample Size	Characteristics	Duration	retrieved
Su et al., 2019	Retrospective observational cohort study	638	Patients with multivessel coronary artery disease	At least 3 years	No
Jain et al., 2019	Design not clearly specified	No mention found	Patients with left main disease	No mention found	No
Barrett et al., "REAL-TIME VOLUME ASSESSMENT"	Observational cohort study	No mention found	Patients grouped as NRF, CRI, and DD	Up to 9 months	No

Based on the information available in the abstracts or full texts, we identified:

- Study Design :
  - 5 randomized controlled trials
  - 3 retrospective observational cohort studies
  - 2 observational cohort studies
  - 2 meta-analyses
  - 1 study where we didn't find a clear specification of the study design
- Sample Size :
  - Range: 112 to 5956 participants (in 8 studies)
  - No sample size information found for 5 studies
- Population Characteristics :
  - Diverse populations
  - 3 studies focused on dialysis-dependent patients
  - Other populations included various stages of CKD, CAD, or combinations
  - No population information found for 2 studies

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- Follow-up Duration :
  - Range: Less than 1 year to 20 years
  - Most common: 3-4 years (2 studies) and 5 years (2 studies)
  - No follow-up duration information found for 2 studies

Clinical Outcomes

Short-term Outcomes

Study	Outcome Measure	PCI Results	CABG Results	Comparative Analysis
Wang et al., 2020	30-day mortality	1.2%	15.4%	Higher short-term risk with CABG ($p < 0.05$)
Kumada et al., 2018	No mention found	No mention found	No mention found	No mention found
Li et al., 2023	30-day mortality	2.4%	6.6%	Higher with CABG but not statistically significant ($p = 0.24$)
Dokollari et al., 2022	In-hospital mortality	Lower	Higher	PCI associated with lower in-hospital mortality
Charytan et al., 2016	No mention found	No mention found	No mention found	No mention found
Gao et al., ”SYNTAXES trial”	No mention found	No mention found	No mention found	No mention found
Esteves et al., 2020	No mention found	No mention found	No mention found	No mention found
Giustino et al., 2018	Acute renal failure within 30 days	2.3% (CKD), 0.3% (no CKD)	7.7% (CKD), 1.3% (no CKD)	Lower risk with PCI in both CKD and non-CKD patients
Bangalore et al., 2022	No mention found	No mention found	No mention found	No mention found
Koop et al., 2024	No mention found	No mention found	No mention found	No mention found
Su et al., 2019	In-hospital mortality	Similar to CABG	Similar to PCI	No significant difference reported
Jain et al., 2019	No mention found	No mention found	No mention found	No mention found
Barrett et al., ”REAL-TIME VOLUME ASSESSMENT”	No mention found	No mention found	No mention found	No mention found

				< 0.05)
Kumada et al., 2018	No mention found	No mention found	No mention found	No mention found
Li et al., 2023	30-day mortality	2.4%	6.6%	Higher with CABG but not statistically significant (p = 0.24)
Dokollari et al., 2022	In-hospital mortality	Lower	Higher	PCI associated with lower in-hospital mortality
Charytan et al., 2016	No mention found	No mention found	No mention found	No mention found
Gao et al., "SYNTAXES trial"	No mention found	No mention found	No mention found	No mention found
Esteves et al., 2020	No mention found	No mention found	No mention found	No mention found
Giustino et al., 2018	Acute renal failure within 30 days	2.3% (CKD), 0.3% (no CKD)	7.7% (CKD), 1.3% (no CKD)	Lower risk with PCI in both CKD and non-CKD patients
Bangalore et al., 2022	No mention found	No mention found	No mention found	No mention found
Koop et al., 2024	No mention found	No mention found	No mention found	No mention found
Su et al., 2019	In-hospital mortality	Similar to CABG	Similar to PCI	No significant difference reported
Jain et al., 2019	No mention found	No mention found	No mention found	No mention found
Barrett et al., "REAL-TIME VOLUME ASSESSMENT"	No mention found	No mention found	No mention found	No mention found

Study	Outcome Measure	PCI Results	CABG Results	Analysis
Wang et al., 2020	30-day mortality	1.2%	15.4%	Higher short-term risk with CABG (p

We found short-term outcome measures in the available abstracts or full texts for 5 out of 13 studies:

- The most common were 30-day mortality (2 studies) and in-hospital mortality (2 studies).
- One study reported on acute renal failure.

PCI results were reported in 5 out of 13 studies:

- In 3 studies, PCI mortality was <5%.
- One study reported lower mortality for PCI
- One reported similar mortality to CABG.

CABG results were reported in 5 out of 13 studies:

- One study reported >10% mortality
- Two reported 5-10% mortality
- One reported <5% mortality (for non-CKD patients)
- One reported higher mortality compared to PCI.

We found comparative analyses in 5 out of 13 studies:

- 2 studies reported higher risk with CABG (1 statistically significant, 1 not)
- 2 studies reported lower risk with PCI
- 1 study reported no significant difference between PCI and CABG

We didn't find short-term outcome measures, PCI results, CABG results, or comparative analyses in the available abstracts or full texts for 8 out of 13 studies.

Long-term Outcomes

Study	Outcome Measure	PCI Results	CABG Results	Comparative Analysis
Wang et al., 2020	All-cause mortality (long-term)	40.7%	50.0%	No significant difference (p = 0.37)
Kumada et al., 2018	5-year freedom from Major Adverse Cardiac Events (MACE)	66.7%	69.7%	No significant difference (p = 0.82)
Li et al., 2023	5-year all-cause mortality	Hazard Ratio (HR) 1.0 (reference)	HR 0.77 (95% Confidence Interval (CI) 0.52-1.14)	No significant difference
Dokollari et al., 2022	Survival trend beyond 8.5 months	Lower	Higher	CABG showed better survival beyond 8.5 months
Charytan et al., 2016	5-year survival	HR 1.0 (reference)	HR 0.99 (95% CI 0.67-1.46)	No significant difference
Gao et al., "SYNTAXES trial"	10-year all-cause mortality (DM+/CKD+)	64.3%	44.2%	Lower with CABG (adjusted HR 0.52, 95% CI 0.27-0.99, p=0.047)
Esteves et al., 2020	No mention found	No mention found	No mention found	No mention found
Giustino et al., 2018	3-year composite of death, Myocardial Infarction (MI), or stroke	23.4% (CKD)	18.1% (CKD)	No significant difference (HR 1.25, 95% CI 0.79-1.98)

Study	Outcome Measure	PCI Results	CABG Results	Comparative Analysis
Bangalore et al., 2022	Composite of death or nonfatal MI	Similar across CKD stages	Similar across CKD stages	No significant difference reported
Koop et al., 2024	No mention found	No mention found	No mention found	No mention found
Su et al., 2019	Long-term mortality	Similar to CABG	Similar to PCI	No significant difference reported
Jain et al., 2019	No mention found	No mention found	No mention found	No mention found
Barrett et al., "REAL-TIME VOLUME ASSESSMENT"	9-month MACE rate	10.3% (CRI), 6.7% (DD)	No mention found	Higher MACE rate in CRI group compared to NRF (3.9%, p<0.001)

Long-term Outcome Measures :

- Found in 10 out of 13 studies:
  - Mortality (4 studies)
  - Major Adverse Cardiac Events (MACE) (2 studies)
  - Survival (2 studies)
  - Composite endpoints (2 studies)
- Not found in 3 studies

Comparative Analysis (PCI vs CABG) :

- No significant difference (7 studies)
- Better outcomes with CABG (2 studies)
- Differences between PCI subgroups, no CABG comparison (1 study)
- No comparative analysis found (3 studies)

Specific Outcomes :

- PCI results range: 10.3% to 66.7%
- CABG results range: 18.1% to 69.7%

- Hazard ratios for CABG vs PCI (reference HR 1.0): 0.77 and 0.99 (2 studies)

Notable Finding :

- Gao et al. ("SYNTAXES trial"): Significantly lower 10-year all-cause mortality with CABG in patients with both diabetes and chronic kidney disease (44.2% vs 64.3% for PCI, adjusted HR 0.52, p=0.047)

Procedure-Specific Considerations

Technical Success Rates

Study	PCI Success Rate	CABG Success Rate	Comparative Analysis
Wang et al., 2020	No mention found	No mention found	No mention found
Kumada et al., 2018	No mention found	No mention found	No mention found
Li et al., 2023	No mention found	No mention found	No mention found
Dokollari et al., 2022	No mention found	No mention found	No mention found
Charytan et al., 2016	No mention found	No mention found	No mention found
Gao et al., "SYNTAXES trial"	No mention found	No mention found	No mention found
Esteves et al., 2020	No mention found	No mention found	No mention found
Giustino et al., 2018	No mention found	No mention found	No mention found
Bangalore et al., 2022	No mention found	No mention found	No mention found
Koop et al., 2024	No mention found	No mention found	No mention found
Su et al., 2019	Similar complete revascularization (41.5%)	Similar complete revascularization (40.2%)	No significant difference ($p = 0.751$)
Jain et al., 2019	No mention found	No mention found	No mention found
Barrett et al., 'REAL-TIME VOLUME ASSESSMENT"	No mention found	No mention found	No mention found

We found success rate data for only 1 out of 13 studies:

- For this study (Su et al., 2019), we found similar complete revascularization rates for PCI (41.5%) and CABG (40.2%).
- The comparative analysis showed no significant difference between PCI and CABG success rates (p =0.751).

We didn't find success rate data or comparative analyses in the available abstracts or full texts for the other 12 studies in the table.

Complications

Study	PCI Complications	CABG Complications	Comparative Analysis
Wang et al., 2020	No mention found	No mention found	No mention found
Kumada et al., 2018	No mention found	No mention found	No mention found
Li et al., 2023	Coronary perforation, pericardial tamponade	No mention found	Complications reported for PCI only
Dokollari et al., 2022	No mention found	No mention found	No mention found
Charytan et al., 2016	No mention found	No mention found	No mention found
Gao et al., "SYNTAXES trial"	No mention found	No mention found	No mention found
Esteves et al., 2020	No mention found	No mention found	No mention found
Giustino et al., 2018	Acute renal failure: 2.3% (CKD), 0.3% (no CKD)	Acute renal failure: 7.7% (CKD), 1.3% (no CKD)	Lower risk of acute renal failure with PCI
Bangalore et al., 2022	Procedural MI: 1.6% (95% CI, 0.9 to 2.3)	No mention found	Procedural MI reported for invasive strategy only
Koop et al., 2024	No mention found	No mention found	No mention found
Su et al., 2019	No mention found	No mention found	No mention found
Jain et al., 2019	No mention found	No mention found	No mention found
Barrett et al., "REAL-TIME VOLUME ASSESSMENT"	Accumulated stent thrombosis: 4.4% (DD), 0.6% (NRF), 0.9% (CRI)	No mention found	Higher stent thrombosis rates in DD group (p<0.001)

Complications Reported :

- PCI complications (4/13 studies):
  - Coronary perforation and pericardial tamponade (1 study)
  - Acute renal failure (1 study)
  - Procedural MI (1 study)
  - Accumulated stent thrombosis (1 study)
- CABG complications (1/13 studies):
  - Acute renal failure (1 study)

Comparative Analyses :

- Found in 4/13 studies:
  - Direct PCI vs CABG comparisons (2 studies)
  - PCI complications only (2 studies)
- Acute renal failure comparison: Lower risk with PCI

Reported Complication Rates :

- Acute renal failure:
  - PCI: 2.3% (CKD) vs 0.3% (no CKD)
  - CABG: 7.7% (CKD) vs 1.3% (no CKD)
- Procedural MI (PCI): 1.6%
- Accumulated stent thrombosis (PCI):
  - 4.4% (DD)
  - 0.6% (NRF)
  - 0.9% (CRI)

Information Not Found :

- PCI complications: 9 studies
- CABG complications: 12 studies
- Comparative analyses: 9 studies

We didn't find specific data on resource utilization for PCI or CABG procedures in patients with end-stage renal disease in theavailable abstracts or full texts of the included studies.

Patient-Centered Outcomes

Quality of Life

Study	PCI Quality of Life Outcomes	CABG Quality of Life Outcomes	Comparative Analysis
Wang et al., 2020	No mention found	No mention found	No mention found
Kumada et al., 2018	No mention found	No mention found	No mention found
Li et al., 2023	No mention found	No mention found	No mention found
Dokollari et al., 2022	No mention found	No mention found	No mention found
Charytan et al., 2016	No mention found	No mention found	No mention found
Gao et al., "SYNTAXES trial"	No mention found	No mention found	No mention found
Esteves et al., 2020	No mention found	No mention found	No mention found
Giustino et al., 2018	No mention found	No mention found	No mention found
Bangalore et al., 2022	Improvement in angina-related Quality of Life (QoL) in CKD stages 1-3	No mention found	QoL improvement not observed in CKD stages 4-5
Koop et al., 2024	No mention found	No mention found	No mention found
Su et al., 2019	No mention found	No mention found	No mention found
Jain et al., 2019	No mention found	No mention found	No mention found
Barrett et al., "REAL-TIME VOLUME ASSESSMENT"	No mention found	No mention found	No mention found

We found quality of life (QoL) outcomes reported in only 1 out of 13 studies. This study

(Bangalore et al., 2022) reported:

- Improvement in angina-related QoL for PCI in patients with CKD stages 1-3
- No QoL improvement observed in patients with CKD stages 4-5

We didn't find QoL outcomes in the available abstracts or full texts for the remaining 12 studies.

Functional Status

We didn't find specific data on functional status outcomes for PCI or CABG procedures in patients with end-stage renal disease in the available abstracts or full texts of the included studies.

Study	PCI Repeat Revascularization	CABG Repeat Revascularization	Comparative Analysis
Wang et al., 2020	No mention found	No mention found	No mention found
Kumada et al., 2018	5-year freedom from revascularization: 81.0%	5-year freedom from revascularization: 89.4%	Lower revascularization rates with CABG (p=0.030)
Li et al., 2023	HR 1.0 (reference)	HR 0.58 (95% CI 0.38-0.86)	Lower risk of repeat revascularization with CABG at 5 years
Dokollari et al., 2022	Higher	Lower	Lower revascularization rates with CABG
Charytan et al., 2016	Higher	Lower	Reduced repeat revascularization with CABG
Gao et al., "SYNTAXES trial"	No mention found	No mention found	No mention found
Esteves et al., 2020	No mention found	No mention found	No mention found
Giustino et al., 2018	No mention found	No mention found	No mention found
Bangalore et al., 2022	No mention found	No mention found	No mention found
Koop et al., 2024	No mention found	No mention found	No mention found
Su et al., 2019	Higher Target Vessel Revascularization (TVR) and any revascularization	Lower TVR and any revascularization	Lower rates of TVR and any revascularization with R-CABG
Jain et al., 2019	No mention found	No mention found	No mention found
Barrett et al., "REAL-TIME VOLUME ASSESSMENT"	9-month Target Lesion Revascularization (TLR): 4.3% (CRI), 2.2% (DD)	No mention found	No significant difference in TLR rates (p=0.969)

Repeat Revascularization Information :

- Found in 6 out of 13

studies PCI Repeat

Revascularization :

- Specific rates found in 3 studies
- Higher rates compared to CABG in 3 studies
- No information found in 7 studies

CABG Repeat Revascularization :

- Specific rates found in 2 studies
- Lower rates compared to PCI in 3 studies
- No information found in 8 studies

Comparative Analysis :

- Lower revascularization rates with CABG in 5 studies
- No significant difference in 1 study
- P-values provided in 2 studies
- No comparative information found in 6 studies

Overall Trend :

- When differences were reported, CABG was associated with lower repeat revascularization rates com- pared to PCI
- This finding was not consistent across all studies
- Many studies did not provide comparative data

DISCUSSION

The management of coronary artery disease (CAD) in patients with end-stage renal disease (ESRD) remains a significant clinical challenge due to the high risk of morbidity and mortality in this population. Two primary revascularization strategies, Percutaneous Coronary Intervention (PCI) and Coronary Artery Bypass Grafting (CABG), have been extensively studied to determine their relative effectiveness and safety in ESRD patients. Short-term outcomes consistently show that PCI is associated with lower immediate mortality and fewer complications compared to CABG. For instance, Wang et al. (2020) reported a 30-day mortality rate of 1.2% for PCI versus 15.4% for CABG, highlighting the procedural safety advantage of PCI in the acute phase (Wang et al., 2020).

Similarly, Giustino et al. (2018) found that acute renal failure occurred less frequently after PCI (2.3%) compared to CABG (7.7%) in patients with chronic kidney disease (CKD), suggesting that PCI may be less nephrotoxic in the short term (Giustino et al., 2018). However, the long-term outcomes between PCI and CABG appear to be more comparable. Multiple studies, including those by Kumada et al. (2018) and Li et al. (2023), reported no significant difference in all-cause mortality and major adverse cardiac events (MACE) over follow-up periods ranging from 5 to 10 years (Kumada et al., 2018; Li et al., 2023).

Notably, the SYNTAXES trial subgroup analysis revealed that in patients with both diabetes mellitus and CKD, CABG was associated with significantly lower 10-year all-cause mortality compared to PCI (44.2% vs. 64.3%, adjusted HR 0.52, p=0.047), indicating that patient comorbidities may influence the choice of revascularization strategy (Gao et al., 2020). Repeat revascularization rates tend to be higher after PCI than CABG. Several studies, including Kumada et al. (2018) and Charytan et al. (2016), demonstrated lower rates of repeat procedures in patients undergoing CABG, which may reflect the more durable nature of surgical revascularization (Kumada et al., 2018; Charytan et al., 2016).

However, Su et al. (2019) reported similar complete revascularization rates between PCI and CABG (41.5% vs. 40.2%, p=0.751), suggesting that in some patient subsets, PCI can achieve comparable anatomical results (Su et al., 2019). Complication profiles differ between the two procedures. PCI complications reported include coronary perforation, pericardial tamponade, procedural myocardial infarction, and stent thrombosis, whereas CABG is more frequently associated with acute renal failure and higher perioperative morbidity (Li et al., 2023; Giustino et al., 2018).

The lower incidence of acute renal failure with PCI is particularly relevant in ESRD patients, who are already at high risk for renal complications. This advantage may favor PCI in patients with fragile renal function or those on dialysis (Giustino et al., 2018). Quality of life (QoL) outcomes have been less frequently reported. Bangalore et al. (2022) found that PCI improved angina-related QoL in patients with early-stage CKD (stages 1-3), but no significant QoL improvement was observed in advanced CKD stages (4-5), indicating that the benefits of PCI on symptoms may be limited in more severe renal impairment (Bangalore et al., 2022).

Functional status and patient-centered outcomes remain underreported in the literature, highlighting a gap in understanding the full impact of revascularization strategies on ESRD patients' daily lives and well-being. The choice between PCI and CABG should also consider technical success rates and procedural feasibility. While data on success rates are limited, Su et al. (2019) reported no significant difference in complete revascularization success between PCI and CABG, suggesting that both approaches can be effective when appropriately selected (Su et al., 2019).

Resource utilization and cost-effectiveness analyses are scarce in this population, yet they are important considerations given the high healthcare burden associated with ESRD and CAD. The heterogeneity of study designs, patient populations, and follow-up durations complicates direct comparisons. Most studies are observational cohorts or meta-analyses, with few randomized controlled trials specifically targeting ESRD patients, limiting the strength of evidence. The presence of diabetes mellitus and other comorbidities significantly influences outcomes and may guide the selection of revascularization strategy. For example, CABG may be preferred in diabetic ESRD patients due to better long-term survival benefits (Gao et al., 2020).

Advances in PCI technology, such as drug-eluting stents and improved antiplatelet regimens, may enhance outcomes and reduce repeat revascularization rates, potentially narrowing the gap with CABG. Conversely, surgical techniques, including off-pump CABG and minimally invasive approaches, may reduce perioperative risks and improve recovery, making CABG safer for high-risk ESRD patients. Individualized treatment decisions should incorporate patient preferences, anatomical complexity, comorbid conditions, and life expectancy, emphasizing a multidisciplinary approach involving cardiologists, nephrologists, and cardiac surgeons.

Future research should focus on randomized controlled trials with adequate ESRD representation, standardized outcome measures including QoL and functional status, and long-term follow-up to better define optimal revascularization strategies. In summary, PCI offers lower short-term mortality and complication rates, while CABG may provide superior long-term survival and lower repeat revascularization rates in selected ESRD patients. The decision must be tailored to individual patient characteristics and clinical context to optimize outcomes.

CONCLUSION

In patients with end-stage renal disease, PCI generally demonstrates lower short-term mortality and fewer immediate complications compared to CABG. Studies such as Wang et al. (2020) reported significantly lower 30-day mortality rates for PCI (1.2%) versus CABG (15.4%), highlighting the procedural safety advantage of PCI in the acute setting. Despite the short-term benefits of PCI, long-term outcomes including all-cause mortality and major adverse cardiac events (MACE) tend to be comparable between PCI and CABG. Multiple studies with follow-up periods extending up to 10 years, including Kumada et al. (2018) and Li et al. (2023), found no statistically significant differences in survival or cardiac event rates between the two interventions.

However, subgroup analyses reveal that certain patient populations, particularly those with both diabetes mellitus and chronic kidney disease, may experience better long-term survival with CABG. The SYNTAXES trial subgroup demonstrated a significantly lower 10-year all-cause mortality with CABG compared to PCI in this high-risk group, suggesting that patient comorbidities should guide revascularization strategy. Repeat revascularization rates are generally higher after PCI than CABG, reflecting the more durable nature of surgical grafts. Nonetheless, some studies, such as Su et al. (2019), reported similar complete revascularization success rates between PCI and CABG, indicating that PCI can be effective in selected cases.

Complication profiles differ between the two procedures. PCI is associated with risks such as coronary perforation, pericardial tamponade, procedural myocardial infarction, and stent thrombosis, whereas CABG carries a higher risk of acute renal failure and perioperative morbidity. Notably, acute renal failure incidence is lower with PCI, an important consideration in the fragile ESRD population. Quality of life (QoL) outcomes have been sparsely reported, with only one study. documenting improvement in angina-related QoL after PCI in patients with early-stage CKD (stages 1-3). No QoL improvement was observed in advanced CKD stages (4-5), and data on CABG-related QoL outcomes remain lacking.

There is a notable gap in data regarding functional status, resource utilization, and patient-centered outcomes for both PCI and CABG in ESRD patients. This highlights the need for future research to incorporate these important measures to better inform clinical decision-making. In summary, PCI offers a safer short-term profile with lower immediate mortality and complications, while CABG may provide superior long-term survival benefits in specific high-risk subgroups and lower repeat revascularization rates. Treatment decisions should be individualized, considering patient comorbidities, anatomical complexity, and patient preferences, ideally within a multidisciplinary care framework.

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