Published in final edited form as:

Urology. 2020 February ; 136: 75–81. doi:10.1016/j.urology.2019.10.009.

Kidney stone history and adverse outcomes after percutaneous coronary intervention

Chao-Han Lai, MD, PhD^{1,2,3}, Li-Ching Huang, PhD^{2,3}, S. Neil Holby, MD⁴, Ying-Ju Lai, MS⁵,
Pei-Fang Su, PhD⁵, Yu-Sheng Cheng, MD, PhD⁶, Yu Shyr, PhD^{2,3,*}, Ryan S. Hsi, MD^{7,*}

¹Department of Surgery, National Cheng Kung University Hospital, College of Medicine, National Cheng Kung University, Tainan, Taiwan

²Department of Biostatistics, Vanderbilt University Medical Center, Nashville, Tennessee, USA

³Center for Quantitative Sciences, Vanderbilt University Medical Center, Nashville, Tennessee, USA

⁴Department of Medicine, Vanderbilt University Medical Center, Nashville, Tennessee, USA

⁵Department of Statistics, National Cheng Kung University, Tainan, Taiwan

⁶Department of Urology, National Cheng Kung University Hospital, College of Medicine, National Cheng Kung University, Tainan, Taiwan

⁷Department of Urology, Vanderbilt University Medical Center, Nashville, Tennessee, USA

Abstract

OBJECTIVE—To determine whether kidney stone history is associated with adverse outcomes after percutaneous coronary intervention (PCI). Kidney stone formers have an increased risk of developing coronary artery disease; however, whether these patients have worse cardiac outcomes is unknown.

MATERIALS AND METHODS—We identified adult patients who underwent first-time PCI in Vanderbilt University Medical Center (VUMC) Synthetic Derivative from 2008 to 2016 (n=11,289) and in a nationwide database of Taiwan (NHIRD) from 2005 to 2012 (n=155,762). Odds ratios (ORs) of 30-day in-hospital mortality and hazard ratios (HRs) of 1-year and 3-year adverse outcomes associated with kidney stone history were estimated using a propensity score approach.

RESULTS—Overall, 294 and 12,286 stone formers undergoing PCI were identified in the VUMC and NHIRD, respectively. After matching, stone formers at VUMC were at higher risks of 30-day in-hospital mortality (OR 2.79, 95% CI 1.15–6.69) and 1-year (HR 1.59, 95% CI 1.13–2.24) and

Correspondence for reprints: Ryan S. Hsi, MD, Department of Urology, Vanderbilt University Medical Center, Nashville, Tennessee 37212, USA, Tel: 615-343-2036, Fax: 615-322-8990, ryan.hsi@vanderbilt.edu.

*Dr. Shyr and Dr. Hsi contributed equally to this work.

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Conflict of Interest: None.

3-year (HR 1.36, 95% CI 1.02–1.81) myocardial infarction. In the NHIRD, kidney stone history was associated with 1-year (HR 1.12, 95% CI 1.03–1.21) and 3-year (HR 1.14, 95% CI 1.06–1.22) myocardial infarction. In a sensitivity analysis, stone formers undergoing kidney stone surgery were marginally associated with 30-day in-hospital mortality (OR 1.21, 95% CI 0.99–1.48) and were associated with 3-year myocardial infarction (HR 1.13, 95% CI 1.02–1.25).

CONCLUSION—Kidney stone history is associated with poorer cardiac outcomes after PCI. Improving secondary cardiac prevention strategies after PCI may be necessary for patients with a history of kidney stone disease.

Keywords

Kidney stone disease; coronary artery disease; percutaneous coronary intervention; outcomes research

INTRODUCTION

Kidney stone disease is highly prevalent, and the global disease burden has dramatically increased over the past few decades.^{1, 2} The condition has traditionally been recognized as an episodic, painful condition limited to the renal and genitourinary systems. However, recent studies have linked kidney stone disease to multiple systemic conditions, including diabetes mellitus, obesity and chronic kidney disease.^{3–8}

In addition, kidney stone disease has been associated with subclinical atherosclerosis in adults without known coronary artery disease (CAD).^{9, 10} The Multi-Ethnic Study of Atherosclerosis reported that recurrent kidney stone formation is independently associated with both the presence and severity of coronary artery calcification (CAC),⁹ which is a marker of subclinical atherosclerosis quantified noninvasively by computerized tomography¹¹. A subsequent large cross-sectional study similarly demonstrated that nephrolithiasis diagnosed by screening ultrasonography is associated with the presence of CAC,¹⁰ suggesting that these conditions may share a common pathophysiology. Furthermore, kidney stone history is associated with a higher risk of CAD and cardiovascular events,^{8, 12–15} which is particularly notable because ischemic heart disease remains the leading cause of death worldwide.¹⁶

As a systemic condition linked to subclinical CAD, CAD, and cardiovascular events, kidney stone history may represent an independent cardiac risk factor beyond CAD. Whether patients with pre-existing CAD and kidney stone history have different cardiac outcomes compared to those without kidney stone history is unknown. In current clinical practice, percutaneous coronary intervention (PCI) is the most frequently used revascularization procedure for CAD.¹⁷ Given the association of kidney stone disease with greater CAD severity and risk of cardiovascular events, we hypothesized that kidney stone formers have poorer outcomes after PCI compared to those without a history of kidney stones. In this study, we evaluated outcomes after PCI in patients with and without kidney stone disease in two cohorts.

MATERIALS AND METHODS

Data Source and Study populations

This retrospective study was performed using the Vanderbilt University Medical Center (VUMC) Synthetic Derivative and National Health Insurance Research Database (NHIRD) of Taiwan. The VUMC Synthetic Derivative contains a de-identified copy of over 2.9 million patient electronic health records with >125 million clinical notes since 1990s, enabling longitudinal studies on disease risk. To ensure continuous follow-up, we excluded patients without follow-up data after hospital discharge, ending up with a final cohort of 11,289 adult patients who underwent first-time PCI from January 2008 to December 2016. The Taiwan National Health Insurance program is a mandatory health insurance system in which all Taiwanese citizens (approximately 23 million people, 98% Han Chinese) are obliged to participate. The program covered 93.7% of the hospitals in Taiwan by the end of 2013. In this de-identified database, we found 155,762 adult patients (age ≥ 18 years) who underwent first-time PCI from January 2005 to December 2012 as the PCI cohort. Our access to the NHIRD was approved by the Review Committee of the National Health Research Institutes.

Information has been updated until June 2018 for the VUMC Synthetic Derivative and December 2013 for the NHIRD of Taiwan. The study was approved by the Institutional Review Board of VUMC (approval number: #180260) and National Cheng Kung University Hospital (approval number: A-EX-107-041).

Baseline Variables and Outcome Measurements

The ninth and tenth revision of the *International Classification of Diseases* (ICD-9 and ICD-10 codes, respectively) and Current Procedural Terminology are used to define diseases and procedures in the VUMC Synthetic Derivative; ICD-9 codes are used in the NHIRD of Taiwan. The codes used in this study are listed in Supplementary Table S1. Kidney stone history was determined by the presence of a kidney stone-related diagnosis or surgery, including shock wave lithotripsy, ureteroscopic stone removal and percutaneous nephrolithotomy. The identification of kidney stone patients using ICD codes has been previously shown to have high validity (PPV > 95%).¹⁸

In addition to age at PCI and sex, we recorded baseline medical comorbidities, including hypertension, diabetes mellitus, hyperlipidemia, congestive heart failure, chronic kidney disease, end-stage renal disease, peripheral artery disease, stroke, chronic obstructive pulmonary disease, atrial fibrillation and gout. End-stage renal disease was considered in the NHIRD of Taiwan if the patient had the catastrophic illness certificate of dialysis. We determined whether patients underwent PCI with the concurrent diagnosis of acute myocardial infarction (MI) and whether coronary artery stenting was performed during PCI. We also recorded race and body mass index (BMI) in the VUMC cohort, and additionally identified the hospital level (tertiary referral centers, regional hospitals or district hospitals) where the PCI procedure was conducted in the NHIRD of Taiwan.

The primary outcome analyzed in this study was 30-day in-hospital mortality. The secondary outcomes were 1- and 3-year adverse outcomes after the PCI procedure, which included

overall mortality, repeat revascularization (defined as either repeat PCI or coronary artery bypass grafting) and MI. Patients were evaluated for any occurrence of repeat revascularization and MI until either the date of mortality, most recent clinic visit (for VUMC patients), withdrawal from the insurance system (for NHIRD patients), or the most recent update of each database. For patients who had multiple repeat revascularization procedures or MI episodes, the date of the first episode was used in the analysis.

Statistical analysis

In the following analysis, both cohorts were divided into 2 comparison groups: the unexposed group (no history of kidney stone disease) and kidney stone formers. Categorical variables were compared by the chi-square test, and continuous variables were compared by the Wilcoxon rank-sum test. The two groups were then matched using a propensity score based on a logistic regression model (matching ratio = 3, caliper = 0.25).¹⁹ In both cohorts, covariates included potential confounding factors considered in relevant cardiovascular studies to calculate the probability (propensity) of being in either the unexposed group or stone former group, including age, comorbidities/risk factors (i.e., hypertension, diabetes mellitus, hyperlipidemia, congestive heart failure, chronic kidney disease, peripheral artery disease, prior stroke, chronic obstructive pulmonary disease, atrial fibrillation and gout), acute MI, coronary artery stenting and year of PCI.^{20, 21} Race and BMI in the VUMC Synthetic Derivative and the hospital level in the NHIRD of Taiwan were also added as covariates, respectively. Odds ratios (ORs) of 30-day in-hospital mortality associated with kidney stone history were estimated using logistic regression analysis. Hazard ratios (HRs) of 1-year and 3-year overall mortality, repeat revascularization and MI associated with kidney stone history were estimated using the Cox regression model. Because the competing risk of mortality is an important consideration in studies involving geriatric patients with multiple comorbidities,²² the competing risk regression model in which mortalities over the follow-up period were treated as competing risk events was conducted as a sensitivity analysis for the significant associations revealed by Cox regression analysis. Statistical analyses were performed using R software (Version 3.4.3; Foundation for Statistical Computing, Vienna, Austria). A two-tailed *P*-value less than 0.05 was considered statistically significant.

RESULTS

The PCI cohort at VUMC

Patient characteristics of the unexposed group and kidney stone formers undergoing PCI at VUMC are summarized in Table 1. In this cohort, 294 patients had a history of kidney stones. The median age was 64 years in the unexposed group and 63 years among kidney stone formers. There was a male-predominance in both groups, and hypertension was the most common comorbidity. Distributions by race and BMI were similar in both groups. Notably, kidney stone formers had significantly higher rates of all identified comorbidities compared to the unexposed group (all *P* < 0.001). After propensity score matching, the two groups were balanced in the distribution of age, sex, race, BMI, comorbidities, acute MI and coronary artery stenting.

The median follow-up period was 2.5 years (interquartile range: 0.6–5.0 years) for the VUMC cohort. Odds ratios of 30-day in-hospital mortality and hazard ratios of overall mortality, repeat revascularization and MI associated with kidney stone history in the VUMC PCI cohort are summarized in Table 2. Kidney stone formers were at higher risk of 30-day in-hospital mortality compared to the unexposed group (OR 2.15, 95% confidence interval [CI] 1.05–3.90, $P=0.02$) before matching. Kidney stone formers also had increased risks of 1-year overall mortality, repeat revascularization, and MI; and 3-year overall mortality and MI (each $P<0.05$). After matching, kidney stone history was associated with 30-day in-hospital mortality (OR 2.79, 95% CI 1.15–6.69, $P=0.02$). Kidney stone history was associated with MI by 1 year (HR 1.59, 95% CI 1.13–2.24, $P=0.008$) and 3 years (HR 1.36, 95% CI 1.02–1.81, $P=0.04$) after PCI. Consistently, the competing risk regression model also showed that kidney stone history was associated with MI by 1 year (HR 1.12, 95% CI 1.01–1.24, $P=0.03$) and was marginally associated with MI by 3 years (HR 1.31, 95% CI 0.98–1.75, $P=0.07$) after PCI.

The PCI cohort in the NHIRD

Patient characteristics of the unexposed group and stone formers undergoing PCI in the NHIRD of Taiwan are summarized in Table 3. In this cohort, 12,286 patients were identified with a history of kidney stones. The median age was 66 years in the unexposed group and 65 years among kidney stone formers. Similar to the VUMC cohort, both groups were male-predominant, and hypertension remained the most common comorbid condition. Concomitant hypertension, diabetes mellitus, hyperlipidemia, chronic kidney diseases, end-stage renal disease, prior stroke, chronic obstructive pulmonary disease and gout were higher among kidney stone formers than in the unexposed group (all $P<0.001$). Kidney stone formers were less likely to undergo first-time PCI at the occurrence of acute MI and less likely to receive PCI in tertiary referral centers (both $P<0.001$). After propensity score matching, the two groups were balanced in the distribution of age, sex, comorbidities, acute MI, coronary artery stenting and hospital levels.

The median follow-up time was 3.7 years (interquartile range: 1.9–5.8 years) for the NHIRD cohort. The risks of in-hospital mortality and adverse outcomes during follow-up associated with kidney stone history in the NHIRD PCI cohort are summarized in Table 4. No differences in 30-day in-hospital and overall mortality were observed before propensity score matching. Kidney stone formers had an increased risk of repeat revascularization by 3 years (HR 1.08, 95% CI 1.04–1.12, $P<0.001$) compared to the unexposed group. Also, kidney stone formers had significantly higher risks of MI by 1 year (HR 1.15, 95% CI 1.07–1.24, $P<0.001$) and 3 years (HR 1.18, 95% CI 1.11–1.25, $P<0.001$). After matching, kidney stone history maintained associations with increased risks of repeat revascularization by 3 years (HR 1.04, 95% CI 1.01–1.08, $P=0.03$). Kidney stone history was associated with MI by 1 year (HR 1.12, 95% CI 1.03–1.21, $P=0.01$) and 3 years (HR 1.14, 95% CI 1.06–1.22, $P=0.003$) after PCI. The estimates from the competing risk regression model by 1 year (HR 1.12, 95% CI 1.04–1.21, $P=0.008$) and 3 years (HR 1.14, 95% CI 1.06–1.22, $P=0.0003$) after PCI were consistent.

Finally, we performed a sensitivity analysis, in which patients with kidney stone history requiring a stone-related surgery were compared to patients without a history of kidney stone disease (Supplementary Table S2). After propensity score matching (Supplementary Table S3), kidney stone formers with prior stone-related surgery had a marginally higher risk of 30-day in-hospital mortality (OR 1.21, 95% CI 0.99–1.48, $P=0.05$). Kidney stone formers with prior stone-related surgery were associated with increased risks of MI by 3 years (HR 1.13, 95% CI 1.02–1.25, $P=0.02$) after PCI. A similar positive association, as estimated by the competing risk regression model, was observed with MI by 3 years (HR 1.12, 95% CI 1.01–1.24, $P=0.03$) after PCI.

COMMENT

In this study, patients with kidney stone history undergoing PCI had a higher prevalence of most cardiovascular risk factors compared to those without kidney stone disease in both cohorts. This finding is consistent with previous studies linking nephrolithiasis to components of the metabolic syndrome, including hypertension, diabetes mellitus, obesity, and hyperlipidemia.^{3–7} Given these associations, the finding that patients with kidney stone formation are more likely to have CAD is not surprising.^{8, 12–15}

Although the specific associations were not entirely consistent across the two cohorts, the present study demonstrates an association between kidney stone disease and adverse outcomes after PCI. Before matching, stone disease in the VUMC cohort carried higher risks of early mortality and overall mortality. Both cohorts demonstrated increased risks of repeat revascularization and MI among stone formers. These results could be partly explained by the synergistic effect of the accumulated risk factors for CAD observed in stone formers, since these comorbid conditions may substantially influence PCI outcomes. Notably, even after adjustment for these factors, stone formers had an increased risk of MI after PCI in both cohorts. Also, kidney stone history maintained an association with early mortality with a trend toward significance in the VUMC cohort and a significant association with early mortality among NHIRD patients with prior stone-related surgery. Kidney stone patients who undergo stone surgery may be considered to have a more intense disease phenotype than, say, those who have passed stones at home without requiring intervention. At the very least, the diagnosis of kidney stone disease is likely more reliable in patients coded for stone-specific surgery rather than stone diagnoses in general. Taken together, these results suggest that patients with kidney stone disease history may benefit from earlier or more intensive cardiac follow-up after PCI to prevent adverse cardiac outcomes.

It is plausible to speculate that kidney stone disease is a marker of the presence of more severe clinical or subclinical cardiovascular risk factors leading to poorer outcomes following PCI. Nephrolithiasis has been independently associated with fatal or nonfatal myocardial infarction,^{8, 12–15} which in the short-term may acutely pose a greater risk to patients undergoing PCI. Two studies have reported higher severity of CAC among patients with kidney stone disease or recurrent stone formation versus controls.^{9, 10} Stoller *et al.* hypothesized that atherosclerotic plaques in the vasa recta of the kidney ultimately erode and are exposed to urine, serving as a nidus for stone formation.²³ Khan *et al.* reported that Randall plaque formation in the kidney, the precursor lesion for most stone types, is similar

to that of vascular calcification.²⁴ Implicating a common pathophysiology shared by atherosclerosis and nephrolithiasis, it is possible that coronary atherosclerosis could be accelerated in patients with kidney stone disease. Patients with kidney stone disease tend to have risk factors associated with atypical presentations of myocardial ischemia (e.g., diabetes and hypertension), and these factors may lead to delayed recognition of myocardial ischemia.²⁵

The pathogenesis of kidney stones and coronary atherosclerosis may additionally be linked via inflammatory mechanisms. Abundant evidence demonstrates that statins possess potent anti-inflammatory properties which, in addition to their lipid-lowering effects, exert protective effects against atherosclerosis and cardiovascular events.²⁶ Two studies have demonstrated that statins may reduce the risk of urinary stones in hyperlipidemic patients.^{27, 28} Given that kidney stone formation could be a consequence of renal tubular cell injury and inflammation,²⁹ some have speculated that the benefits may stem from the anti-inflammatory or anti-oxidant properties of statins rather than their direct lipid-lowering effects²⁷. Overall, these data suggest that these medications may provide benefit both as secondary prevention of cardiovascular events and for recurrent stone events.

The findings of this study must be interpreted within the context of the study limitations. First, while we demonstrated the increased risk of adverse outcomes after PCI in stone formers, our study design does not address the underlying causal mechanisms. Further mechanistic studies are thus required. Second, several potential confounding variables, including stone composition, 24-hour urine data, lifestyle (e.g., diet and smoking status), the extent of CAD and medications (e.g., thiazide and statins), and cause of death were unavailable and thus were not included in the analysis. Such unmeasured confounders could have biased effect estimates demonstrated in this study. Third, a relatively small percentage of data missing or miscoding of diagnoses is inherent in retrospective database studies. Such coding errors, however, are likely to be random and would be expected to produce biases toward the null. Moreover, reimbursement cuts to the health care system in Taiwan, as evidenced by the low total hospital costs in the cohort, may reduce the quality of cardiac care.³⁰ Therefore, patients with kidney stone disease may have been disproportionately impacted by these economic factors as they require more comprehensive, multi-disciplinary care for their comorbidities during the follow-up period. Finally, the findings from the VUMC cohort may be influenced by local referral practices, and thus validation of our results in other healthcare systems strengthen the generalizability of our findings.

In conclusion, among patients who undergo PCI, those with kidney stone disease history have a higher prevalence of cardiovascular risk factors than patients without kidney stone disease. We demonstrate that kidney stone patients undergoing PCI have increased risks of early and late adverse cardiac outcomes. These findings suggest that kidney stone history may be a clinical indicator to risk-stratify patients undergoing PCI to better inform more aggressive secondary cardiac prevention measures. Our study adds to the growing body of literature linking kidney stone disease and coronary artery disease.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

ACKNOWLEDGEMENTS

Part of this study was based on data from the NHIRD provided by the National Health Insurance Administration, Ministry of Health and Welfare of Taiwan, and managed by the National Health Research Institutes of Taiwan. However, the interpretation and conclusions contained herein do not represent those of the NHI administration, Ministry of Health and Welfare of Taiwan, or the National Health Research Institutes of Taiwan. The Vanderbilt Synthetic Derivative database used in this study is supported by institutional funding and by the Vanderbilt CTSA grant ULTR000445 from the National Center for Advancing Translational Sciences or the National Institutes of Health (NCATS/NIH). Its contents are solely the responsibility of the authors and do not necessarily represent official views of NCATS/NIH. This work was supported by grants from the Ministry of Science and Technology (MOST 107-2314-B-006-072 to C.H.L.), Executive Yuan, Taiwan and National Cheng Kung University Hospital (NCKUH-10802055 to C.H.L.), Tainan, Taiwan.

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Table 1.

Comparison of patient characteristics between patients without kidney stones (unexposed group) and kidney stone formers within the VUMC PCI cohort, 2008–2016.

Characteristics ^a	Before propensity score matching		After propensity score matching	
	Unexposed group (n=10,995)	Kidney stone formers (n=294)	Unexposed group (n=858)	Kidney stone formers (n=286)
Age, median (interquartile range)	64 (56–72)	63 (56–70)	63 (55–71)	63 (56–70)
Sex				
Female	30.6% (3,360)	28.6% (84)	27.2% (233)	29.4% (84)
Male	69.4% (7,635)	71.4% (210)	72.8% (625)	70.6% (202)
Race				
White	87.8% (9,653)	88.4% (260)	89.5% (768)	88.8% (254)
Non-white	12.2% (1,342)	11.6% (34)	10.5% (90)	11.2% (32)
Body mass index ^b				
<18kg/m ²	0.7% (68)	1.0% (3)	1.2% (10)	1.0% (3)
18–30 kg/m ²	55.0% (5,191)	53.8% (154)	54.2% (465)	53.8% (154)
30 kg/m ²	44.3% (4,177)	45.1% (129)	44.6% (383)	45.1% (129)
Comorbidities/risk factors				
Hypertension	76.6% (8,420)	88.8% (261)	89.3% (766)	89.5% (256)
Diabetes mellitus	30.3% (3,336)	49.7% (146)	49.2% (422)	50.0% (143)
Hyperlipidemia	67.3% (7,405)	78.2% (230)	77.4% (664)	78.3% (224)
Congestive heart failure	23.3% (2,566)	35.7% (105)	35.1% (301)	35.7% (102)
Chronic kidney disease	11.8% (1,297)	37.4% (110)	38.7% (332)	37.8% (108)
Peripheral artery disease	9.9% (1,087)	22.8% (67)	23.3% (200)	23.1% (66)
Prior stroke	13.3% (1,465)	26.9% (79)	28.1% (241)	27.6% (79)
Chronic obstructive pulmonary disease	13.6% (1,494)	24.1% (71)	25.6% (220)	23.8% (68)
Atrial fibrillation	14.5% (1,590)	22.1% (65)	23.5% (202)	22.0% (63)
Gout	4.6% (505)	17.0% (50)	16.0% (137)	17.5% (50)
Acute myocardial infarction	37.4% (4,109)	41.8% (123)	40.6% (348)	42.0% (120)
Coronary artery stenting	85.1% (9,361)	87.8% (258)	89.3% (766)	88.1% (252)
Year				
2008–2010	37.6% (4,138)	32.0% (94)	33.9% (291)	31.5% (90)
2011–2013	36.3% (3,994)	29.9% (88)	28.9% (248)	29.4% (84)
2014–2016	26.0% (2,863)	38.1% (112)	37.2% (319)	29.2% (112)

VUMC, Vanderbilt University Medical Center; PCI, percutaneous coronary intervention.

^aData are expressed as percentage (number) unless indicated otherwise.

^bBody mass index data were missing or undetermined in 1,567 patients (13.9%).

Table 2.

Odds ratios of 30-day in-hospital mortality and hazard ratios of overall mortality, repeat revascularization, and myocardial infarction associated with kidney stone history in the VUMC PCI cohort, 2008–2016.

Outcomes	Unexposed group (n=10,995)	Kidney stone formers (n=294)	OR/HR (95% CI) before propensity score matching	OR/HR (95% CI) after propensity score matching
30-day in-hospital mortality	1.6% (177)	3.4% (10)	2.15 (1.05–3.90) *	2.79 (1.15–6.69) *
Overall mortality				
1-year	2.7% (301)	6.1% (18)	2.08 (1.29–3.34) *	1.56 (0.88–2.76)
3-year	3.7% (402)	8.2% (24)	2.08 (1.38–3.14) *	1.50 (0.92–2.46)
Repeat revascularization				
1-year	9.3% (1,026)	15.0% (44)	1.46 (1.08–1.98) *	1.32 (0.92–1.89)
3-year	15.9% (1,745)	21.4% (63)	1.27 (0.99–1.64) [†]	1.15 (0.86–1.55)
Myocardial infarction				
1-year	8.8% (966)	17.0% (50)	1.78 (1.34–2.36) *	1.59 (1.13–2.24) *
3-year	13.8% (1,514)	23.1% (68)	1.59 (1.25–2.03) *	1.36 (1.02–1.81) *

VUMC, Vanderbilt University Medical Center; PCI, percutaneous coronary intervention; OR, odds ratio; HR, hazard ratio.

* signifies statistical significance.

^a p=0.06.

Table 3.

Comparison of patient characteristics between patients without kidney stones (unexposed group) and kidney stone formers in the NHIRD PCI cohort, 2005–2012.

Characteristics ^a	Before propensity score matching		After propensity score matching	
	Unexposed group (n=143,476)	Kidney stone formers (n=12,286)	Unexposed group (n=36,855)	Kidney stone formers (n=12,285)
Age, median (interquartile range)	66 (56–76)	65 (56–74)	65 (56–75)	65 (56–74)
Sex				
Female	28.1% (40,351)	24.2% (2,971)	24.2% (8,910)	24.2% (2,971)
Male	71.9% (103,125)	75.8% (9,315)	75.8% (27,945)	75.8% (9,314)
Comorbidities/risk factors				
Hypertension	68.0% (97,557)	76.9% (9,442)	76.8% (28,308)	76.8% (9,441)
Diabetes mellitus	40.6% (58,213)	45.6% (5,598)	45.8% (16,881)	45.6% (5,597)
Hyperlipidemia	43.1% (61,896)	46.6% (5,728)	46.7% (17,194)	46.6% (5,727)
Congestive heart failure	19.4% (27,829)	20.3% (2,492)	20.2% (7,432)	20.3% (2,492)
Chronic kidney disease	5.6% (8,065)	9.9% (1,211)	9.6% (3,536)	9.8% (1,210)
End-stage renal disease	5.1% (7,306)	7.9% (975)	7.9 (2,916)	7.9% (975)
Peripheral artery disease	3.2% (4,538)	3.2% (391)	3.0% (1,122)	3.2% (391)
Prior stroke	15.2% (21,774)	18.9% (2,316)	18.5% (6,821)	18.8% (2,315)
Chronic obstructive pulmonary disease	8.8% (12,695)	12.1% (1,489)	11.8% (4,341)	12.1% (1,488)
Atrial fibrillation	7.1% (10,164)	6.8% (836)	6.6% (2,425)	6.8% (836)
Gout	8.0% (11,428)	14.1% (1,733)	13.5% (4,986)	14.1% (1,732)
Acute myocardial infarction	40.4% (57,975)	38.0% (4,663)	37.9% (13,974)	38.0% (4,663)
Coronary artery stenting	69.8% (100,210)	70.8% (8,704)	71.1% (26,192)	70.8% (8,703)
Hospital level				
Tertiary referral center	37.9% (54,313)	34.6% (4,257)	34.7% (12,794)	34.7% (4,257)
Regional hospital	47.0% (67,396)	49.6% (6,091)	49.6% (18,293)	49.6% (6,090)
District hospital	15.2% (21,767)	15.8% (1,938)	15.7% (5,768)	15.8% (1,938)
Year				
2005–2007	32.6% (46,728)	29.0% (3,557)	28.9% (10,650)	29.0% (3,557)
2008–2010	39.7% (56,900)	39.5% (4,849)	29.2% (14,431)	39.5% (4,849)
2011–2012	27.8% (39,848)	31.6% (3,880)	31.9% (11,774)	31.6% (3,879)

NHIRD, National Health Insurance Research Database; PCI, percutaneous coronary intervention.

^aData are expressed as percentage (number) unless indicated otherwise.

Table 4.

Odds ratios of 30-day in-hospital mortality and hazard ratios of overall mortality, repeat revascularization, and myocardial infarction associated with kidney stone history in the NHIRD PCI cohort, 2005–2012.

Outcomes	Unexposed group (n=143,476)	Kidney stone formers (n=12,286)	OR/HR (95% CI) before propensity score matching	OR/HR (95% CI) after propensity score matching
30-day in-hospital mortality	2.5% (3,533)	2.4% (294)	0.97 (0.86–1.09)	1.10 (0.96–1.26)
Overall mortality				
1-year	10.4% (14,867)	10.2% (1,259)	0.99 (0.93–1.04)	0.98 (0.92–1.04)
3-year	17.0% (24,390)	17.2% (2,119)	1.02 (0.98–1.07)	0.98 (0.93–1.03)
Repeat revascularization				
1-year	20.8% (29,888)	21.7% (2,660)	1.04 (1.00–1.08)	1.01 (0.96–1.05)
3-year	28.7% (41,157)	30.6% (3,763)	1.08 (1.04–1.12)*	1.04 (1.01–1.08)*
Myocardial infarction				
1-year	5.5% (7,821)	6.3% (769)	1.15 (1.07–1.24)*	1.12 (1.03–1.21)*
3-year	7.6% (10,959)	8.9% (1,094)	1.18 (1.11–1.25)*	1.14 (1.06–1.22)*

NHIRD, National Health Insurance Research Database; PCI, percutaneous coronary intervention; OR, odds ratio; HR, hazard ratio.

* signifies statistical significance.