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Role of intravascular ultrasound in minimizing the use of contrast in Percutaneous coronary intervention in patients with chronic stable angina and chronic kidney disease stageIII

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ORIGINAL ARTICLE

Role of Intravascular Ultrasound in Minimizing the Use of Contrast in Percutaneous Coronary Intervention in Patients with Chronic Stable Angina and Chronic Kidney Disease Stage III

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Abstract

Background: **Percutaneous coronary procedures (PCIs) are frequently guided by intravascular ultrasonography (IVUS) (PCIs). Because it can precisely measure the size of the lumen, plaque, and vessel. The aim of this work was to evaluate the role of intravascular ultrasound in minimizing the use of contrast in PCI in patients with chronic stable angina and chronic kidney disease (CKD) stage III and the incidence of acute kidney injury after IVUS-based PCI and angiographic-based PCI in chronic kidney disease stage III patients.**

Methods: **50 patients with stage III chronic renal disease and chronic stable angina, both diabetes mellitus (DM) and non-DM, were enrolled in this prospective comparative cohort study. Patients were split into two equally sized groups: group (A) underwent PCI using angiography regardless of whether they had DM, while group (B) underwent PCI using IVUS regardless of whether they had DM.**

Results: **The incidence of nephropathy in DM patients was significantly higher compared with the non-DM patients (*P* value = 0.035). Post dilatation and stent diameter were significantly higher in group B compared with group A (*P* value < 0.001, 0.002, respectively) and the type of lesion was significantly different between both groups (*P* value < 0.001). In univariate regression analysis, DM was a significant predictor for nephropathy with (OR: 3.50, 95% CI: 1.068 −11.47, *P* value = 0.035).**

Conclusion: **Compared with angiographic PCI, IVUS-guided PCI considerably lowers contrast volume, serum creatinine, and Ck-MB while dramatically increasing creatinine clearance both during the hospital stay and the three-month follow-up.**

DM was a major predictor of nephropathy and considerably increased the incidence of nephropathy in DM patients compared with non-DM patients.

Keywords: Chronic kidney disease, Contrast, Intravascular ultrasound, Percutaneous coronary intervention, Stable angina

1. Introduction

The main cause of death in the industrialized world, accounting for about one death out of every six, is coronary artery disease (CAD).[1] In general, 23.4 million deaths from cardiovascular disease are anticipated worldwide in 2030.[2]

Invasive coronary angiography is the gold standard for identifying the presence, location, and severity of CAD.[3]

An angiographic procedure's potential complications include contrast-induced acute kidney damage (CI-AKI). Previous research has almost always demonstrated that CI-AKI is linked to less favorable

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clinical outcomes.[4] However, it is yet unclear if CI-AKI is merely a predictor of future morbidity or, on the other hand, if it also directly adds to the event of horrible occasions various systems have been tried to decrease the event of CI-AKI. Lively liquid organization when the strategy is the main prophylactic measure for patients in danger of CI-AKI.[5,6]

Albeit a few additional preventive measures have been researched in clinical examinations, none have acquired general acknowledgment, and truly, CI-AKI actually represents a serious clinical issue for patients going through angiographic methods.[6–8]

Notwithstanding the way that various clinical elements influence the probability of CI-AKI, the volume of differentiation is by all accounts a significant part adding to the condition, no matter what the patient's gauge risk profile.[7,9,10]

Curiously, there have only been a few methods put forth thus far to lessen the dose of the contrast agent, which is the main contributor to CI-AKI after PCI.[11–13] It is important to stress that efforts to reduce contrast use may be beneficial for patient populations other than those who are at risk of CI-AKI, such as those who are at risk of volume overload. Percutaneous coronary procedures (PCIs) are usually guided using intravascular ultrasonography (IVUS) (PCIs).[14]

IVUS is anticipated to replace angiography as a technique in several PCI phases due to its ability to properly measure lumen, plaque, and vessel diameters. As a result, we put out the theory that using fewer contrast agents during coronary angioplasty may be due to IVUS imaging. In the MOZART Randomized Controlled Trial study, it was investigated how precise IVUS guidance affected the total amount of contrast material given to PCI patients. In the current study, the main endpoint analyses are described.

This study thought about the rate of intense kidney injury after intravascular ultrasound-based percutaneous coronary mediation (PCI) and angiographic-based percutaneous coronary mediation (angioplasty) in patients with stage III constant kidney sickness and persistent stable angina. Furthermore, research inspected how intravascular ultrasonography could assist DM and non-DM people with persistent stable angina and ongoing kidney infection use less difference during PCI. The aim of this work was to evaluate role of intravascular ultrasound in minimizing the use of contrast in PCI in DM and non-DM patients with chronic stable angina and chronic kidney disease (CKD) stage III and incidence of acute kidney injury after IVUS based PCI and angiographic based PCI in CKD stage III patients.

2. Patients and methods

50 patients who were admitted for PCI and had stage III chronic renal disease and stable chronic angina, both DM and non-DM, were included in this prospective comparative cohort research. From August 2021 to July 2022, the study was carried out at the National Heart Institute's (NHI) Cardiology Department in Cairo, Egypt.

The study received permission from the Al-Azhar University's Faculty of Medicine's ethics committee in Cairo, Egypt. The patient or a member of the patient's family gave written, informed consent. Acute coronary syndrome, using iodinated contrast agents within 72 h of surgery, using additional nephrotoxic agents within 7 days of surgery, being allergic to contrast agents, having unstable or uncertain renal function prior to PCI, and patient refusal were all considered exclusion criteria. Two groups of patients of similar size were formed: Whether or not they had DM, those in group (A) received PCI using angiography, while those in group (B) underwent PCI using IVUS. All patients underwent a thorough clinical examination, 12-lead standard ECG, resting transthoracic echocardiography (TTE), complete blood count (CBC), creatinine clearance, and hemoglobin A1C laboratory tests, as well as extensive history taking (age, sex, smoking status, and comorbidities).

The creatinine clearance was calculated based on the serum creatinine, using the equation proposed by Cockcroft and Gault. For all patients, sequential serum creatinine measurements were obtained in a daily basis during the index hospitalization. Post-PCI CI-AKI was defined as any increase in baseline serum creatinine values greater than 0.5 mg/dl.

2.1. Standard 12-leads ECG

Detected any cause of ischemia.

2.2. TTE

Assessed LV systolic function and find anomalies in wall motion.

End-diastolic diameter (EDD), end systolic diameter (ESD), P wave dispersion (PWD), IVSD, fractional shortening (FS), and LVEF were assessed using standard echocardiographic views on a Philips Echo machine, and the results were completed blindly by two echo experts for all patients in accordance with American Society of Echocardiography (ASE) recommendations.

For those allocated to the IVUS-guided group, intravascular ultrasound was performed with the

Atlantis™ SR Pro Imaging Catheter 40 MHz connected to an iLab Ultrasound Imaging System (both by Boston Scientific Corporation, Natick, MA, USA). Vessels were imaged during automated pullback at 0.5 mm/s, but additional manual runs were strongly stimulated to allow for detailed analysis of specific issues.

2.3. Coronary angiography

2.3.1. Technical description of IVUS guidance to minimize contrast utilization

To The proximal and distal reference sections still up in the air to ascertain the breadth and length of the IVUS stent. Utilize manual IVUS imaging widely to definitively lay out the two proximal and distal reference destinations. Choosing a stent's width: IVUS exhortation to pick stent measurement is particularly useful in sores with a huge error between the reference fragment breadths, in diffusely sick courses, or in injuries with tremendous rebuilding designs (either sure or negative).

Picking the length of a stent: The ideal stent length ought to range the 'from one ordinary to another' range. Using longitudinal estimations from an IVUS run performed with computerized pullback at a predetermined speed (in a perfect world 0.5 mm/s), the length of the stent ought to be assessed. A supportive strategy for deciding or checking stent length is manual IVUS imaging. Consistent imaging is finished with the IVUS test while together picking the proximal and distal reference areas. The length estimation saved in the electronic presentation of the pullback gadget can be utilized to rapidly work out the distance physically between the chose landing zones. Decrease the differentiation while embedding stents with IVUS. Use the IVUS probe to perform a plain radiography at the proximal and distal references sites: To reduce contrast 'puffing', have these images on hand when putting stents and use them as positioning aids in a different monitor. IVUS should be used to evaluate the success of stent placement rather than angiography.

Treatment for stent under expansion frequently involved the use of a noncompliant balloon of the proper size and additional pressure after dilating the stent. Postdilatation utilizing the appropriate size semi-compliant balloons should be used to treat incomplete apposition. In order to determine whether additional stenting is required and to choose the size of the additional stent to treat any residual plaque or edge dissection, the results initially evaluated by IVUS rather than angiography. There should only be one projection in the final angiogram. A second angiography is not required if IVUS imaging of sufficient quality produces fruitful results.

2.4. Statistical analysis

The statistical analysis application SPSS v26 was utilized (IBM Inc., Chicago, IL, USA). Quantitative data from the two groups were compared using the unpaired Student's *t*-test. Mean and standard deviation were supplied for quantitative variables (SD). When appropriate, the χ^2test or Fisher's exact test was used to analyze qualitative variables. The results are shown as frequency and percentage (%). The edge for factual importance was a two-followed *P* worth of 0.05.

3. Results

Baseline characteristics (Age, sex, weight, height, BMI, DM, HTN, smoking, previous PCI and previous CABG), serum creatinine, creatinine clearance and HBA1C were insignificantly different between both groups Table 1.

Postdilatation and stent diameter were significantly higher in group B compared to group A (*P* value < 0.001, 0.002, respectively) and type of lesion was significantly different between both groups (*P* value < 0.001). Affected vessels, bifurcation, predilatation, number of stents, overlapping and stent length were insignificantly different between both groups. Total contrast volume, contrast volume/stent implant and contrast volume/creatinine clearance were significantly lower in group B compared to group A (*P* value < 0.001, <0.001, 0.004, respectively). Procedural time and fluoroscopy time were significantly higher in group B compared to group A (*P* value < 0.001, 0.002, respectively). Number of cines was insignificantly different between both groups Table 2.

Serum creatinine was considerably lower in group B than in group A during the in-hospital follow-up (*P* value = 0.028). There was a negligible difference in ck-mb between the two groups. Both groups did not experience death, acute MI, unintentional revascularization, or stent thrombosis. Serum creatinine was considerably lower in group B than in group A throughout the 3-month follow-up (*P* value = 0.005). Creatinine clearance considerably improved in group B compared to group A during the in-hospital follow-up and 3-month follow-up (*P* values = 0.025 and 0.004, respectively). None of the following occurred in either group: stent thrombosis, acute MI, death, or unexpected revascularization. Creatinine clearance − delta was significantly higher in group B than group A (*P* value = 0.028) while serum creatinine − delta was significantly lower in group B than group A (*P* value < 0.001) Table 3.

Table 1. Baseline characteristics and laboratory investigation of the studied groups.

	Group A ($n = 25$)	Group B ($n = 25$)	P value
Age (years)	56.4 ± 8.64	59.8 ± 6.88	0.135
Sex			
Male	9 (36%)	11 (44%)	0.563
Female	16 (64%)	14 (56%)	
Weight (kg)	66.6 ± 6.43	70.2 ± 7.8	0.078
Height (m)	1.7 ± 0.06	1.6 ± 0.07	0.381
BMI (kg/m^2)	24.5 ± 2.4	26.4 ± 4.36	0.068
DM	14 (56%)	16 (64%)	0.563
HTN	11 (44%)	13 (52%)	0.778
Smoking	12 (48%)	11 (44%)	0.776
PAD	0	0	–
Previous PCI	8 (32%)	9 (36%)	0.765
Previous CABG	1 (4%)	2 (8%)	1.000
Laboratory investigation			
Serum creatinine (mg/dl)	1.28 ± 0.15	1.35 ± 0.1	0.056
Creatinine clearance (ml/min)	56.52 ± 2.79	54.64 ± 4.21	0.069
HBA1C (%)	6.36 ± 1.48	7.06 ± 1.16	0.067

Data are presented as mean ± SD or frequency (%).
BMI, body mass index; CABG, Coronary arteries bypass graft; DM, diabetes mellitus; HTN, hypertension; PAD, peripheral arterial disease; PCI, percutaneous coronary intervention.

The incidence of nephropathy in DM patients was significantly higher compared with the non- DM patients (P value = 0.035). Grade I nephropathy occurred in 9 (30.0%) of the DM patients and in 12 (60.0%) of the non-DM patients. Grade II nephropathy occurred in 21 (70.0%) of the DM patients and in 12 8 (40.0%) of the non-DM patients. In univariate regression analysis, DM was a significant predictor

Table 2. Angiographic data and procedural characteristics of the studied groups.

	Group A ($n = 25$)	Group B ($n = 25$)	P value
Affected vessels			
LM	0	2 (8%)	0.113
LAD	17 (68%)	18 (72%)	
LCX	2 (8%)	6 (24%)	
OM	3 (12%)	0	
RCA	5 (20%)	3 (12%)	
Type of lesion			
Type A	16 (64%)	3 (12%)	<0.001*
Type B	7 (28%)	18 (72%)	
Type C	2 (8%)	4 (16%)	
Bifurcation	0	3 (12%)	0.235
Predilatation	11 (44%)	17 (68%)	0.154
Postdilatation	9 (36%)	22 (88%)	<0.001*
Number of stents			
1	16 (64%)	9 (36%)	0.166
2	8 (32%)	12 (48%)	
3	1 (4%)	4 (16%)	
Overlapping	6 (24%)	11 (44%)	0.232
Stent diameter (mm)	4.2 ± 1.61	6.1 ± 2.38	0.002*
Stent length	39.6 ± 21.14	50.5 ± 24.3	0.096
Procedural characteristics			
Total contrast volume (ml)	248 ± 52.99	181.8 ± 60.5	<0.001*
Contrast volume/stent implant	193.7 ± 52.17	109.6 ± 42.74	<0.001*
Contrast volume/creatinine clearance	4.3 ± 0.95	3.3 ± 1.21	0.004*
Procedural time (min)	41.8 ± 10.1	68.1 ± 15.48	<0.001*
Fluoroscopy time (min)	18.4 ± 6.03	23.8 ± 5.48	0.002*
Number of cines	32.4 ± 11.08	42.7 ± 23.22	0.051

Data are presented as mean ± SD or frequency (%).
*Significant as P value less than or equal to 0.05.
LAD, left anterior descending artery; LCX, left circumflex artery; LM, left main coronary artery; OM, obtuse marginal arteries; RCA, right coronary artery.

Table 3. In hospital and 3-months follow-up of the studied groups.

	Group A ($n = 25$)	Group B ($n = 25$)	P value
Death	0	0	–
Acute MI	0	0	–
Unplanned revascularization	0	0	–
Stent thrombosis	0	0	–
Serum creatinine (mg/dl)	1.3 ± 0.13	1.2 ± 0.22	0.028*
Creatinine clearance (ml/min)	53.9 ± 6.25	57.1 ± 2.69	0.025*
Ck-mb (mg/dl)	19.04 ± 1.46	18.2 ± 1.79	0.089
3-months follow up			
Death	0	0	–
Acute MI	0	0	–
Unplanned revascularization	0	0	–
Stent thrombosis	0	0	–
Serum creatinine (mg/dL)	1.3 ± 0.15	1.1 ± 0.18	0.005*
Creatinine clearance (ml/min)	56.8 ± 7.17	62.9 ± 7.04	0.004*
Creatinine clearance - delta	2.9 ± 8.03	8.6 ± 9.64	0.028*
Serum creatinine - delta	0 ± 0.13	−0.2 ± 0.19	<0.001*

*Significant as P value less than or equal to 0.05.
Ck-mb, creatine kinase myocardial band; MI, myocardial infarction.

for nephropathy with (OR: 3.50, 95% CI: 1.068–11.47, P value = 0.035) Table 4.

Patient had a significant lesion in RCA, after stent deployment in RCA it showed good angiographic results after post dilatation. IVUS showed that the distal edge of the stent is mal opposed which would be a nidus for stent thrombosis or restenosis Figure 1.

Although the LAD stent appears angiographically of good appearance and does not need any post-dilatation, but IVUS examination show clearly mal-opposed stent after which the operator decision was changed, postdilatation was a must Figure 2.

4. Discussion

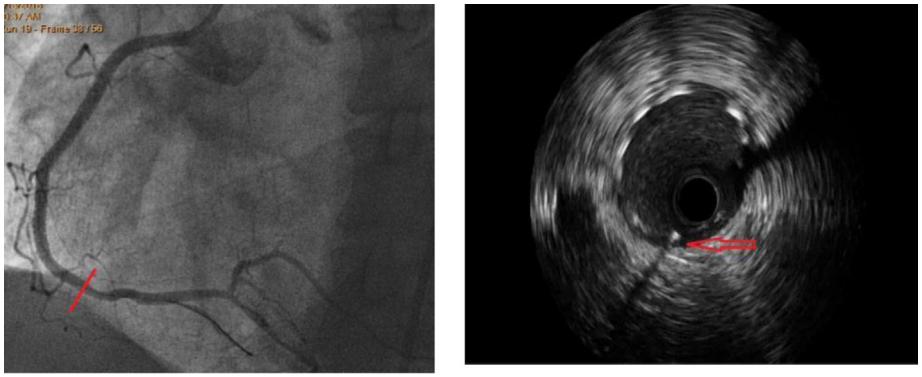
Two of the most recent clinical practice European Society of Cardiology Guidelines on Coronary Syndromes have highlighted significant and reliable recommendations (class I, level of evidence A) on restricting the use of iodinated contrast agents during percutaneous coronary interventions (PCIs) in patients with severe CKD (e.g., acute from Collet and colleagues[15] and, respectively, chronic from 2019[16]). This is done to stop things from getting worse and turning into another incident CKD Kumar and colleagues.[17]

Table 4. Relation between the incidence of nephropathy and diabetes and Univariate logistic regression of diabetes mellitus for prediction of nephropathy.

	Diabetic	Non-diabetic	P value
Nephropathy			
Grade I	9 (30.0%)	12 (60.0%)	0.035*
Grade II	21 (70.0%)	8 (40.0%)	
	Odds ratio	**95% CI**	***P* value**
Diabetes mellitus	3.50	1.068–11.47	0.035*

*Significant as P value less than or equal to 0.05.

In the current study, the type of lesion was considerably different between the two groups (P value 0.001), and postdilatation and stent diameter were both significantly higher in group B compared with group A. In accordance with our findings, Sakai and colleagues[18] found that the ACC/AHA lesion type varied considerably between Angiography-guided PCI and IVUS-guided PCI. Mariani and colleagues finding's that post-dilatation was considerably higher in IVUS-guided groups compared with angiography-guided groups (95.1 vs. 78.6; $P = 0.048$) provide support for our findings. Regarding stent diameter and lesion kind, they reported no significant differences. The difference from our findings may be explained by the varied sample size and patient characteristics that were used. In this study, affected vessels, bifurcation, predilatation, number of stents, overlapping and stent length were insignificantly different between both groups. Our results agreed with Mariani and colleagues,[19] revealed that there was no significant difference between the angiography-guided and IVUS-guided groups in terms of predilatation, number of stents, total sum of stent length, mm, treated vessel, and bifurcation lesion. In the current investigation, group B considerably underperformed group A in terms of total contrast volume, contrast volume/stent implant, and contrast volume/creatinine clearance (P values 0.001, 0.001, and 0.004, respectively). Rahim and colleagues[20] study of the procedural features, The incidence of renal replacement therapy (RRT) at 1-year follow-up was consistent with our findings, according to a prospective registry of patients with CKD stages IV



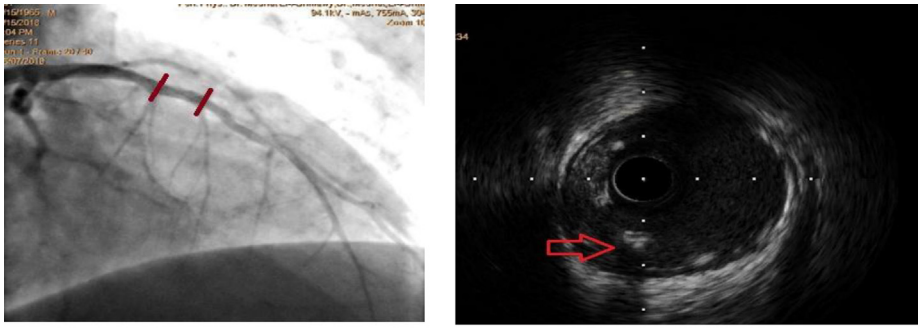
(A) (B)

Figure 1. (A) Angiographic result after RCA post stent dilatation, the stent ends at the red line, (B) mal-opposed stent, arrow points to gap between stent and wall.

to stage V who underwent no contrast. In staged operations, the amount of contrast used ranged from 1.3 to 2.8 ml on average, and in 72% of cases, none was used.

Moreover, Sacha and colleagues[21] showed the viability of zero-PCI in patients with extreme CKD, including those getting hemodialysis, who utilized this way to deal with keep up with their renal capability. 20 patients with extreme CKD, most of them in stages, went through 19 zero-PCIs. Before zero-PCI, nine patients (remembering those for hemodialysis) had super low differentiation coronary angiography (middle difference volume: 13 (11–24) ml). A little measure of differentiation color was infused after the mediation to approve the result and preclude any issues (middle difference volume: 5 (3.5–9) ml). They might have utilized less differentiation than we did since they stuck to without a doubt the zero-contrast convention, instead of us, who utilized a mean of 20 ml of difference to coordinate the interaction. Method time and fluoroscopy time in the ongoing examination were considerably longer in bunch B contrasted with bunch A (*P* values 0.001 and 0.002, separately). There was an irrelevant contrast in the quantity of films between the two gatherings IVUS procurement and understanding probably caused the lengthy season of IVUS-directed methodology. This study shows that in order to fully utilize the capabilities of the technology and be skilled in interactions, specialized IVUS training is necessary Mariani and colleagues.[19]

Our study supports Kumar and colleagues assessments of the immediate effects and safety of 'outright' zero-contrast PCI performed in CKD patients under IVUS guidance in their previous study. For simple zero difference PCI, 42 patients (66 vessels) with a mean age of 69.04 11.9 years were taken into account. The fluoroscopy took 36.3 17 min, and the strategy took 76.8 33.1 min to complete. Sakai



(A) (B)

Figure 2. (A) LAD stent between both two red lines appeared well deployed, (B) IVUS showed mal-opposed stent (red arrow).

and colleagues[18] reported no discernible difference between IVUS-guided PCI and angiography-guided PCI in terms of fluoroscopy time (min). This is in conflict with what we found. Different patient characteristics, a different sample size, and a different study design could all be appropriate explanations for this difference given that we included patients with mild stages of CKD. During the in-hospital follow-up of the current experiment, serum creatinine, creatinine clearance, and Ck-MB were all substantially lower in group B than in group A (*P* values = 0.028, 0.020, and 0.016, respectively). In contrast to our findings, Mariani and colleagues[19] found that Ck-MB and lowest creatinine clearance (ml) were not significantly different between IVUS-guided PCI and angiography-guided PCI ($P > 0.05$). During the in-hospital follow-up of the current investigation, blood creatinine, creatinine clearance, and Ck-MB were all substantially lower in group B than in group A (*P* values = 0.028, 0.020, and 0.016, respectively). It was also demonstrated that patients who were not on dialysis had a lower incidence of contrast-induced AKI. Sacha and colleagues,[21] in PCI, guided by IVUS.

In disagreement with our findings, Mariani and colleagues,[19] reported that Ck-MB and lowest creatinine clearance (ml) were insignificantly different between IVUS-guided PCI compared to angiography-guided PCI ($P > 0.05$). Death, acute MI, unexpected revascularization, and stent thrombosis were not observed in either group in the current investigation. In agreement with our findings, Ali and colleagues,[22] documented that none of the following occurred: stent thrombosis, acute MI, mortality, or unexpected revascularization. During the 3-month follow-up in the current study, group B's serum creatinine levels were considerably lower than group A's (*P* value = 0.005). None of the following occurred in either group: stent thrombosis, acute MI, death, or unexpected revascularization.

Our results disagree with Sacha and colleagues,[21] a lady with serious pneumonic hypertension passed on following a half year from right ventricular cardiovascular breakdown; this demise was inconsequential to the zero-contrast PCI medical procedure did under IVUS direction. In the ongoing review, DM patients had a fundamentally more noteworthy occurrence of nephropathy than non-DM patients (P esteem = 0.035). Grade I nephropathy happened in 9 (30.0%) of the diabetic patients and in 12 (60.0%) of the non-DM patients. Grade II nephropathy happened in 21 (70.0%) of the DM patients and in 12 8 (40.0%) of the non-DM patients. In univariate relapse examination, DM was a critical indicator for nephropathy with (OR: 3.50, 95% CI: 1.068–11.47, P esteem = 0.035).

Zuo and colleagues[23] investigation of the prognostic significance of glycemic variation (GV) in DM patients with AMI who underwent PCI supports our conclusions. The review bunch consisted of 252 DM patients with AMI who underwent PCI; they were divided into bunches with and without contrast-initiated nephropathy (CIN). Using a continuous glucose monitoring device, the average sufficiency of the glycemic journey (MAGE), a standard list of GV, was calculated (CGMS). 55 patients overall had CIN, and when compared to the non-CIN group, their MAGE levels were noticeably higher, suggesting that MAGE might be used to independently predict CIN. Limitations: Small sample size, single-center study and a shorter follow-up period may compromise the significance of the results. The research is not random. Selection bias cannot, therefore, be disregarded. There was no PCI-free control group in this study. A Significant mortality rate might be seen if the control group without PCI was added.

4.1. Conclusion

Compared with angiographic PCI, IVUS-guided PCI considerably lowers contrast volume, serum creatinine, and Ck-MB while dramatically increasing creatinine clearance both throughout the hospital stay and the subsequent three months. Nephropathy was significantly predicted by DM, and DM patients had a significantly greater frequency of the condition than non-DM patients.

Authorship

All authors have a substantial contribution to the article.

Disclosure

The authors have no financial interest to declare in relation to the content of this article.

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Conflict of interest

The authors declared that there were no conflicts of interest.

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