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Original article

The Effect of Radiocontrast Exposure on Kidney Function of Cardiac Catheterization Patients

Heba Abuhelala*, Intisar Abukel

Department of Medical Laboratories, Faculty of Medical Technology, The University of Tripoli, Tripoli, Libya
***Corresponding email.** h.abuhelala@uot.edu.ly*

Abstract
One of the important organs in the body is the kidneys, and its primary function is to remove excess fluids and salts from the body and regulate blood pressure and many other balance factors. One medically important diagnostic and therapeutic procedure is cardiac catheterization, which can lead to acute kidney injury (AKI). Risk factors that predict the development of acute renal failure after cardiac catheterization include exposure to contrast materials. It is one of the essential elements of angiography. Providing contrast dye has disadvantages, especially in those who already have renal impairment, as they may develop contrast-induced nephropathy. This study aimed to investigate cardiac catheterization patients who were injected with contrast agent and compare the results of kidney function before and after cardiac catheterization for 3 days, and also compare the volume of contrast agent that was injected and the dose of radiation to which the patient is exposed, and compare kidney function (creatinine and urea) before and after cardiac catheterization. This cross-sectional descriptive study was conducted in private clinics, and 119 cases who underwent cardiac catheterization were collected; their ages ranged from 28 to 90 years. COBAS INTEGRA 400 PLUS was used to analyze the samples. The contrast agents used in angiography are Ultravist 370, Omnipaque 350, and Visipaque 320. The dose varies according to the patient's age, weight, and health condition. The results of the urea and creatinine test before and after cardiac catheterization showed that only urea levels changed after cardiac catheterization, and the results were statistically significant, P < 0.05. While the levels of urea and creatinine in people with chronic kidney disease did not differ, the results did not differ as urea decreased after cardiac catheterization. While comparing males and females, the results were found to be statistically significant, P < 0.05 for males. In light of the results of the study and its discussion, it was concluded that the contrast materials used in cardiac catheterization affect the kidney functions of patients. Kidney function levels may be affected by some factors, including contrast volume and intravenous fluids after cardiac catheterization. Medical history and duration of illness.
***Keywords.** Radiocontrast Media, Cardiac Catheterization, Contrast-Induced Nephropathy.*

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Introduction

One of the most important organs in the body is the kidney, a bilateral organ shaped like a bean. It is located behind the peritoneum in the upper right and left quadrants of the abdomen and forms part of the urinary system. Its primary function is to remove excess fluids and salts in the body and regulate blood pressure and many homeostasis factors [1]. One of the medically important diagnostic and treatment procedures is cardiac catheterization, which can lead to acute kidney injury (AKI) [2]. After cardiac catheterization, the incidence of acute renal failure (ARF) ranges between 1-30%. The development of kidney failure increases the patient's morbidity and exposes him to other complications in the postoperative period. Acute kidney failure develops in 1% to 5% of patients and is considered a risk and mortality factor after cardiac catheterization [3], with mortality rates ranging from 28% to 63% [4]. Risk factors that predict the development of acute renal failure after cardiac catheterization include advanced age, peripheral vascular disease, diabetes, and underlying renal insufficiency (creatinine _ 120 µmol/L) [5].
One of the serious consequences of cardiac catheterization is renal dysfunction, defined as an increase in creatinine of 0.5 (mg/dL) within 48 hours of exposure to contrast [6]. Due to damage to the renal tubules and their function, creatinine levels are raised within a period of 48 hours during exposure, and it is possible that they will return to the baseline within two weeks. If it returns within two weeks, it is considered a transient elevation of creatinine [7]. Previous studies have found that the development of acute renal failure is associated with the amount of contrast media used, as the use of large amounts of contrast media for patients undergoing combined heart procedures and coronary artery bypass surgery has been associated with the development of acute renal failure [5]. Other studies also found that contrast media and low-osmolar steroids have significant effects in reducing the rate of harmful reactions [8].
When a patient has coronary artery disease (CAD), coronary angiography is a crucial diagnostic procedure used to examine the coronary arteries [9]. Efficient capture of X-ray images during the procedure involves injecting a contrast agent into the coronary arteries, enabling cardiologists to see any blockages or irregularities in the blood vessels [10,11]. The essential elements of angiography are exposure to ionizing

radiation, which exposes patients and medical personnel to health problems [12]. In addition, the provision of contrast dye has disadvantages because sensitive individuals, especially those who already suffer from renal impairment, may develop contrast-induced nephropathy [13,14]. For patient safety and improved prognosis, it is necessary to compare contrast dye volume and radiation dose for different coronary angiographic access techniques.

Contrast-induced nephropathy is defined as impairment of kidney function within 48 hours after contrast material administration [15]. It is characterized by an absolute or relative increase, as the relative increase amounts to 25% of the baseline value [16,17], while the absolute increase in blood creatinine levels is not less than 44 mol/L [18,19]. Hospital-acquired acute kidney injury (AKI) affects 1-2% of the general population, and 50% of subgroups are at risk after percutaneous coronary intervention (PCI) and coronary angiography (CA) [20].

In a study conducted in Iraq in 2016, the Health Directorate/Open Heart Surgery Center. The results of the study indicated that there was a significant increase in blood urea and blood creatinine before and after cardiac catheterization, which means that cardiac catheterization negatively affects kidney function, with the presence of other factors that affect, including age, health history, duration of the disease, and the size of the discrepancy [21]. These findings are supported by Del Duca et al., in Canada, 2007, where significant changes in kidney function were found after cardiac catheterization [5]. While Brown et al. found Al in the USA in 2008, the effect of other factors on kidney function, including the duration of the disease, health history, and also the type and size of the contrast [22]. The study was conducted to study cardiac catheterization patients who were injected with a contrast agent and compare the results of kidney function before and after cardiac catheterization for 3 days, and also compare the volume of contrast agent that was injected and the dose of radiation to which the patient is exposed, and compare kidney function (creatinine and urea) before and after cardiac catheterization.

Methods

Study Subjects and Classification

This descriptive cross-sectional study was conducted at Al-Fouad, AL-Fouz and Al-Khalil Clinic in Tripoli, Libya. 119 cases that underwent cardiac catheterization were collected during the period from January to March 2024, and their ages ranged from 28 to 90 years.

Sample Collection and Blood Testing

After the volunteers consented, blood was drawn to conduct kidney function tests for the patients. Where 2 ml of blood was drawn from each volunteer and placed in a white tube (clot activator), to measure the levels of (urea and creatinine). The samples were separated by centrifugation to extract serum from the samples. COBAS INTEGRA 400 PLUS was used to analyze the samples. The contrast agents used for angiography are Ultravist 370, Omnipaque 350, and Visipaque 320. The dosage varies according to the age, weight, and health condition of the patient.

Data Analysis

Statistical analysis was performed using IBM SPSS version 26. Two independent groups (renal function before cardiac catheterization and after cardiac catheterization) were compared to determine whether there was a statistically significant difference between the groups. Differences are expressed as mean ± standard deviation (SD). A P value <0.05 was considered statistically significant.

Results

The study included 119 cardiovascular patients who underwent cardiac catheterization. The results of the study showed that the percentage of males (58%) was higher than the percentage of females, while the highest age group was between 50-59 years, at 31%, with the average age reaching 62.87. ±12.56 years.

Table 1. Distribution of the Study Sample According to their Demographic Data

Demographic Data	Frequency (N)	Percent (%)
Gender		
Male	69	57.98%
Female	50	42.02%
Age		
28 – 30 Y	1	0.84%
31 – 39 Y	4	3.36%
40 – 49 Y	11	9.24%
50 – 59 Y	44	36.97%
60 – 69 Y	36	30.25%

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70 – 79 Y	28	23.53%
80 – 89 Y	15	12.61%
≥ 90 Y	1	0.84%

Table 2. Distribution of the Study Sample According to their Clinical Data

Clinical Data	Frequency (N)	Percent (%)
Chronic disease		
No	69	57.98
Yes	50	42.02
Type of chronic disease		
Diabetes mellitus (DM)	83	69.75
Chronic kidney disease (CKD)	10	8.40
Hypertension (HTN)	82	68.91
Cardiomyopathy	5	4.20
Hypothyroidism	3	2.52
Ventricular Tachycardia (VT)	1	0.84
Arrhythmia	2	1.68
Chest Pain	1	0.84
Hyperthyroidism	1	0.84
Heart failure	8	6.72
Dyslipidemia	1	0.84
High body mass index (BMI)	2	1.68
Asthma	3	2.52
Smokers		
No	104	87.40
Yes	15	12.60
Diagnostic		
Coronary obstruction	43	36.13
Angina	71	59.66
Other	5	4.20
Duration of the disease (Years)		
1.00	60	50.42
2.00	26	21.85
3.00	22	18.49
5.00	5	4.20
7.00	4	3.36
8.00	2	1.68
Type of catheter		
Diagnostic	30	25.21
Therapeutic	4	3.36
Dual	85	71.43
Number of previous catheterization operations		
0	83	69.75
1	9	7.56
2	23	19.33
3	4	3.36
Contrast type		
Ultravist 370	37	31.09
Omnipaque 350	72	60.50
Visipaque 320	10	8.41

42% of patients suffer from chronic diseases, 39.8% diabetes, 38.7% high blood pressure, and 4.7% also suffer from chronic kidney disease. Also, 12.6% of patients were smokers, and 59.7% were diagnosed with Angina.

Table 3. Comparison of kidney function tests before and after cardiac catheterization

Renal Function Tests	Pre-Cardiac Catheterization	Post Cardiac Catheterization (After 1 week)	T Test	P Value
	Mean ± SD	Mean ± SD		
Blood Urea mg/dl	43.26 ± 25.80	46.68 ± 22.18	-2.047	0.043
Serum Creatinine mg/dl	1.22 ± 1.23	1.27 ± 1.15	-1.232	0.220

Regarding the statistical mean and standard deviation calculated for blood urea and creatinine before and after cardiac catheterization, these study results indicate that there is a significant increase in the urea means after cardiac catheterization, as this was statistically significant (P=0.043), which means that cardiac catheterization may affect kidney function.

Table 4. Comparison of kidney function tests before and after cardiac catheterization for CKD Patients

Renal Function Tests "CKD Patients"	Pre-Cardiac Catheterization	Post Cardiac Catheterization (After 1 week)	T Test	P Value
	Mean ± SD	Mean ± SD		
Blood Urea mg/dl	82.181 ± 40.649	77.772 ± 51.698	0.312	0.762
Serum Creatinine mg/dl	3.547 ± 2.696	3.463 ± 2.526	0.245	0.811

The results of the urea and creatinine test before cardiac catheterization showed that the mean results were high, 82.181 ± 40.649 mg/dl, 3.547 ± 2.696 mg/dl, compared to the mean results after cardiac catheterization, 77.772 ± 51.698 mg/dl, 3.463 ± 2.526 mg/dl, where the values were not significant. Statistical significance (P=0.762, 0.811).

Table 5. Comparison of kidney function tests before and after cardiac catheterization for Smoker Patients

Renal Function Tests " Smoker Patients"	Pre-Cardiac Catheterization	Post Cardiac Catheterization (After 1 week)	T Test	P Value
	Mean ± SD	Mean ± SD		
Blood Urea mg/dl	31.725 ± 8.625	34.229 ± 12.873	1.057	0.301
Serum Creatinine mg/dl	0.874 ± 0.298	0.947 ± 0.354	0.886	0.385

The results of the urea and creatinine test after cardiac catheterization showed that the mean results were high, 31.725 ± 8.625 mg/dl, 0.874 ± 0.298 mg/dl, compared to the mean results before cardiac catheterization, 34.229 ± 12.873 mg/dl, 0.947 ± 0.354 mg/dl, where the values were not statistically significant (P=0.301, 0.385).

Table 6. Comparison of kidney function tests before and after cardiac catheterization for male and female Patients

Renal Function Tests	Pre-Cardiac Catheterization	Post Cardiac Catheterization (After 1 week)	T Test	P Value
	Mean ± SD	Mean ± SD		
Blood Urea mg/dl " Male Patients"	41.141 ± 23.176	47.288 ± 28.557	2.307	0.024
Serum Creatinine mg/dl " Male Patients"	1.188 ± 0.992	1.304 ± 1.111	2.484	0.015
Blood Urea mg/dl " Female Patients"	44.029 ± 27.365	47.666 ± 23.822	1.909	0.061
Serum Creatinine mg/dl " Female Patients"	1.177 ± 1.361	1.184 ± 1.064	0.110	0.913

The results of the urea and creatinine test after cardiac catheterization for males and females showed that the mean results were high compared to the mean results before cardiac catheterization, as the values were not statistically significant for urea and creatinine in females (P = 0.061, 0.913). The results for males were statistically significant (P = 0.024, 0.015).

Discussion

It was found that the arithmetic mean and standard deviation of creatinine were not statistically significant before and after cardiac catheterization, while urea was found to be statistically significant, which means that cardiac catheterization may negatively affect kidney function. There are some factors that affect kidney function, including health history, duration of illness, intravenous fluids, and contrast volume.

Kidney functions are affected due to the contrast dye that is used in cardiac catheterization, as it is toxic to the kidneys and can cause direct injury to renal tubular epithelial cells and the microvasculature during excretion. The results of this study are supported by a study conducted by Del Duca et al. (2007, which found changes after cardiac catheterization in renal function testing [5]. While a study conducted by Brown et al. Al, 2008, that the duration of the disease, health history, receiving Intravenous fluids, and the type and size of contrast affected creatinine levels by increasing them [22], while our study found that creatinine was not affected. The results in this study showed that urea and creatinine were not affected in patients with chronic kidney disease, as the contrast material did not affect kidney function tests, and this was supported by a study conducted by Kameda et al., which did not find any effect on creatinine levels [22].

In this study, kidney function was reassessed 7 days after cardiac catheterization, which is at the upper end of the time window in which contrast-associated acute kidney injury typically evolves and often begins to resolve. Given that serum creatinine usually rises within 24-72 hours after contrast exposure, peaks around days 3-5, and tends to return toward baseline by 7-10 days, any transient deterioration in kidney function may have already resolved by the time of measurement, resulting in no detectable change in creatinine levels [23]. The size and type of contrast used during catheterization have an impact on the kidneys, as high contrast media sizes are associated with an increased rate of contrast-induced nephropathy, especially in patients with diabetes and chronic kidney disease [24, 25]. In this study, the quantities of contrast media that were used for patients were limited, and Ultravist 370, Omnipaque 350, and Visipaque 320 were used, which are non-ionic osmolar substances that have been proven to have a lower risk of kidney disease and mortality [26, 27].

Several studies have shown that the use of low-osmolarity contrast agents with iodine can reduce the incidence of contrast-induced nephropathy to less than 5% [28]. This supports our study, as low-osmolarity contrast agents with iodine were used, and therefore results were not high after cardiac catheterization. This is consistent with the study of Al-Amir et al. [29], who found no change in serum creatinine level. Porter's study [30] reported that patients with renal failure induced by iodine contrast material had an increased serum creatinine level of 90% after 48 hours.

Conclusion

In light of the results of the study and its discussion, it was concluded that the contrast materials used in cardiac catheterization affect the kidney functions of patients. There was a defect in kidney function, represented by a high level of urea in the blood, which could be affected by the volume of contrast and intravenous fluids after cardiac catheterization. Medical history, duration of the disease, and the size of contrast material may affect the impairment of kidney function due to high levels of creatinine in the blood. From the conclusion, we recommend that contrast materials with low iodine osmosis be used to reduce their effect on kidney function. We also recommend conducting tests before starting cardiac catheterization, especially testing kidney function before and after cardiac catheterization.

Conflict of interest. Nil

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