ACCURACY OF PRE-PROCEDURAL RENAL RESISTIVE INDEX IN PREDICTING CONTRAST INDUCED ACUTE KIDNEY INJURY IN PATIENTS WITH PRESERVED RENAL FUNCTION SUBMITTED TO ELECTIVE CORONARY ANGIOGRAPHY

DOCTOR OF MEDICINE

BRANCH I - GENERAL MEDICINE

APRIL 2019

THE TAMILNADU DR.M.G.R.MEDICALUNIVERSITY,

CHENNAI, TAMILNADU

MADURAI MEDICAL COLLEGE, MADURAI

CERTIFICATE FROM THE DEAN

This is to certify that the dissertation entitled **"ACCURACY OF PRE-PROCEDURAL RENAL RESISTIVE INDEX IN PREDICTING CONTRAST INDUCED ACUTE KIDNEY INJURY IN PATIENTS WITH PRESERVED RENAL FUNCTION SUBMITTED TO ELECTIVE CORONARY ANGIOGRAPHY"** submitted by **Dr.S.R.RAMPRASANTH.**, to The Tamil Nadu Dr. M.G.R. Medical University, Chennai, in partial fulfillment of the requirement for the award of degree of **Doctor Of Medicine (M.D) Branch-I - General Medicine,** is a bonafide research work carried out by him under my direct supervision & guidance.

Prof.DR.D. MARUTHUPANDIAN, M.S,

THE DEAN,

Madurai Medical College and

Government Rajaji Hospital,

Madurai

CERTIFICATE FROM HEAD OF DEPARTMENT

This is to certify that the dissertation entitled **"ACCURACY OF PRE-PROCEDURAL RENAL RESISTIVE INDEX IN PREDICTING CONTRAST INDUCED ACUTE KIDNEY INJURY IN PATIENTS WITH PRESERVED RENAL FUNCTION SUBMITTED TO ELECTIVE CORONARY ANGIOGRAPHY"** submitted by **Dr.S.R.RAMPRASANTH.**, to The Tamil Nadu Dr. M.G.R. Medical University, Chennai, in partial fulfillment of the requirement for the award of degree of **Doctor Of Medicine (M.D) Branch-I - General Medicine,** is a bonafide research work carried out by him under my direct supervision & guidance.

.

Dr.V.T.PREMKUMAR M.D

Professor and HOD,

Department of General Medicine,

Government Rajaji Hospital,

Madurai Medical College, Madurai

CERTIFICATE FROM GUIDE

This is to certify that the dissertation entitled **"ACCURACY OF PRE-PROCEDURAL RENAL RESISTIVE INDEX IN PREDICTING CONTRAST INDUCED ACUTE KIDNEY INJURY IN PATIENTS WITH PRESERVED RENAL FUNCTION SUBMITTED TO ELECTIVE CORONARY ANGIOGRAPHY"** submitted by **Dr.S.R,RAMPRASANTH.**, to The Tamil Nadu Dr. M.G.R. Medical University, Chennai, in partial fulfillment of the requirement for the award of degree of **Doctor Of Medicine (M.D) Branch-I - General Medicine,** is a bonafide research work carried out by him under my direct supervision & guidance.

Dr. J. SANGUMANI M.D.,

Professor of Medicine,

Department of General Medicine,

Government Rajaji Hospital,

Madurai Medical College, Madurai

DECLARATION

I, **Dr.S.R.RAMPRASANTH.** solemnly declare that, this dissertation — **"ACCURACY OF PRE-PROCEDURAL RENAL RESISTIVE INDEX IN PREDICTING CONTRAST INDUCED ACUTE KIDNEY INJURY IN PATIENTS WITH PRESERVED RENAL FUNCTION SUBMITTED TO ELECTIVE CORONARY ANGIOGRAPHY"** is a bonafide record of work done by me at the Department of General Medicine, Government Rajaji Hospital, Madurai, under the guidance of Professor **Dr. J. SANGUMANI M.D,** Department of General Medicine, Madurai Medical college, Madurai from march 2018 to august 2018. I also declare that this bonafide work or a part of this work was not submitted by me or any others for any award, degree, diploma to any other University, Board either in India or abroad. This dissertation is submitted to The Tamil Nadu Dr. M.G.R. Medical University, Chennai in partial fulfillment of the rules and regulations for the award of Degree of Doctor of Medicine (M.D.), general Medicine Branch-I, examination to be held in April 2019.

PLACE: Madurai **DR.S.R.RAMPRASANTH**

DATE:

ACKNOWLEDGEMENT

I would like to thank the dean **Prof.DR.D. MARUTHUPANDIAN, MS**, Madurai Medical College, for permitting me to utilize the hospital facilities for the dissertation.

I also extend my sincere thanks to **Dr.V.T.PREMKUMAR M.D.,** Head of the Department and Professor of Medicine for his constant support during the study. I would like to express my deep sense of gratitude and thanks to my unit Chief **Dr.J.SANGUMANI M.D,** my guide and Professor of Medicine, for his valuable suggestions and excellent guidance during the study. I thank the Assistant Professors of my Unit **Dr R.SUNDARAM M.D, Dr. K.S. RAGHAVAN** for their help and constructive criticisms.

I offer my special thanks to **Dr. BALASUBRAMANIAN M.D.,D.M** head of the department of cardiology for their kind co-operation and valuable guidance.

I thank all the patients who participated in this study for their extreme patience and kind co-operation. I wish to acknowledge all those, including my Post graduate colleagues, my parents who have directly or indirectly helped me to complete this work with great success.

TABLE OF CONTENTS

INTRODUCTION

The frequency of contrast induced acute kidney injury varies from 3 to 13% of patients posted for coronary angiographies, which has increased mortality and morbidity.

Intra renal vascular resistance may act as an additive factor for tubular injury caused by contrast media in renal medulla- due to action of contrast media causing imbalance of intra renal vasoconstriction and vasodilator agents.

Vasoconstriction of afferent arteriole, due to adenosine, triggered by the contrast causing overstimulation of tubular glomerular feedback- may lead to increased renal vascular resistance.

Renal resistive index (RRI) acts as a predictor of intra renal arterial stiffness, indirectly indicating renal vascular resistance.

So renal resistive index (RRI) is indicative for susceptibility to acute kidney injury and contrast mediated renal injury.

Ubiquitous application of contrast media (CM) confers a major risk of contrast induced-acute kidney injury (CIAKI). The rate of this frequently

overlooked complication varies from 2.5 to 13.1% of coronary angiographies and has been repeatedly linked to increased morbidity and mortality.

Given the late serum creatinine concentration (SCr) surge following renal injury and so far unsuccessful search for early diagnostic markers of CI-AKI, adequate pre-procedural risk stratification and prevention play strategic role in decreasing the burden of CI-AKI. A wide range of CI-AKI risk factors has so far been established, such as impaired baseline kidney function, volume of CM applied ,dehydration, advanced age, diabetes mellitus and atherosclerosis severity.

The development of renal injury is believed to be triggered by high osmolality and viscosity of CM, leading to increased renal vascular resistance and renal tubular hypoxia, eventually causing tubular cell apoptosis. Pre existing increased vascular stiffness, reflected by high central arterial pulse pressure could facilitate CI-AKI via impaired renal blood flow auto-regulation.

Renal arterial resistive index, a non CF invasive Doppler-measured parameter, is directly correlated with intrarenal arterial resistance, but also with arterial compliance (i.e., renal interstitial and intraabdominal pressures), age, and central hemodynamic parameters. This technique was initially used in nephrology by Radermacher et al, who reported that a high RI was associated with a poor long-term outcome for patients with renal allografts. Human studies

showed that RI was useful in distinguishing between parenchymatous renal failure and pre renal azotemia. In a study by Lerolle et al, a high RI was predictive of AKI in a population of septic shock patients. Darmon et al reported that RI was able to distinguish transient from persistent AKI (AKI lasting 93 days) in a selected population of mechanically ventilated critically ill patients.

The Doppler ultrasound of interlobular and/or arcuate arteries delivers indirect insight into renal hemodynamics. Out of all renal blood flow parameters, only renal resistive index (RRI) has been shown to be clinically useful, primarily in the evaluation of renovascular hypertension or the kidney allograft function or the risk of acute kidney injury (AKI) persistence. Of note, RRI assessed in the setting of intensive care unit (ICU) accurately predicted the development and persistence of AKI.

RRI could represent an indicator of diffuse arterial stiffness and cardiovascular risk factor, predicting long-term morbidity and mortality. Yet, several factors can interfere with RRI values, including pulse blood pressure, heart rate and rhythm, presence of significant aortic valve stenosis, age, renal interstitial disease or vascular compliance. Also, patients with chronic kidney disease were shown to have an altered and delayed vascular response to contrast media.

We thus hypothesized that RRI, after adjustment for its covariates, could serve as an indicator of baseline renal vascular resistance and contribute to CI-AKI risk stratification in patients devoid of pre existing kidney pathology. Accordingly, the purpose of the study was to evaluate the clinical significance of preoperative ultrasonographic parameters of intra-renal blood flow, along with numerous pre- and intra-operative risk factors, for the prediction of CI-AKI in patients with coronary artery disease (CAD) and preserved renal function, referred for elective and urgent coronary angiography.

AIMS AND OBJECTIVES

- To evaluate significance of pre-operative ultrasonographic parameter of intra renal blood flow (RRI), for prediction of contrast induced acute kidney injury in patients with coronary artery disease and preserved renal function, referred for elective coronary angiography.
- To suggest the possible application of renal resistive index (RRI) during initial check up of patient along with other routine investigation for risk stratification of patients, prone for contrast induced acute kidney injury.

REVIEW OF LITERATURE

ACUTE KIDNEY INJURY:

DEFINITION:

Acute kidney injury (AKI) defined by 'sudden decline in glomerular filtration rate (GFR) sufficient to decrease the elimination of nitrogenous waste products (urea and creatinine) and other uremic toxins'. This was previously called as acute renal failure (ARF), but in recent years all implemented the term acute kidney injury instead. So it is a decline in kidney function over 48 hours as demonstrated by an increase in serum creatinine of greater than 0.3 mg/dl, an increase in serum creatinine by 50%, or presence of oliguria. staging criteria has been developed after many studies all over the world, among the developed countries.

.KDIGO STAGING OF AKI:

STAGE	SERUM CREATININE	URINE OUTPUT
1	1.5-1.9× baseline OR ≥0.3 mg/dl (≥26 μmol/l) increase	<0.5 ml/kg/h for 6-12 h
2	2.0-2.9× baseline	<0.5 ml/kg/h for ≥12 h

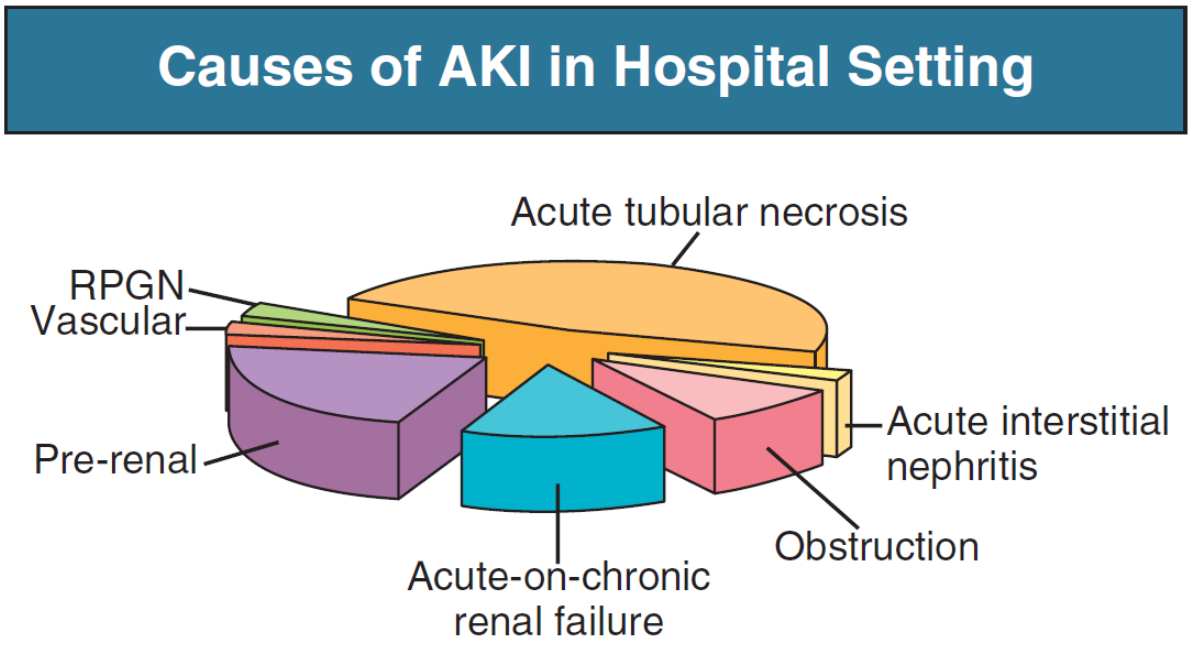
3	3.0× baseline OR Increase in serum creatinine to ≥4.0 mg/dl (≥352 μmol/l) OR Initiation of renal replacement therapy OR, in patients younger than 18 years, decrease in eGFR to <35 ml/min/1.73 m2	<0.3 ml/kg/h for ≥24 h OR Anuria for ≥12 h

ETIOLOGY:

Although AKI is defined by a reduced GFR, the underlying cause of the renal impairment is most frequently a result of tubular and vascular factors. AKI can have a broad range of causes, and the differential diagnosis must be considered in a systematic fashion to avoid missing multiple factors that may be contributing to the condition. All the causes are classified into pre-renal, renal, and post-renal causes. Among all, Pre-renal failure mainly caused by hypovolemia and/or any condition leading to decreased effective arterial volume. Post-renal obstructive renal failure is usually diagnosed by urinary tract dilation on renal ultrasound. Intrinsic renal causes of AKI should be considered under the different anatomic components of the kidney (vascular supply; glomerular, tubular, and interstitial disease. Always consider the diagnosis of extra-renal artery or venous occlusion. Similarly, disorders of the small intrarenal vasculature can result in AKI (e.g., vasculitis, thrombotic microangiopathy

[TMA], malignant hypertension, eclampsia, postpartum states, disseminated intravascular coagulation [DIC], scleroderma; All forms of acute glomerulonephritis (GN) can present as AKI, as can acute inflammation and space-occupying processes of the renal interstitium (e.g., drug-induced, infectious, and autoimmune disorders, leukemia, lymphoma, sarcoidosis).

In the hospital setting, pre-renal uremia and acute tubular necrosis (ATN) account for the majority of AKI cases, often in the setting of AKI superimposed on chronic kidney disease (CKD), so-called "acute-on-chronic renal failure". The term tubular necrosis is a misnomer because the alterations are not limited to the tubular structures and true cellular necrosis in human ATN is often minimal. However, the term acute tubular necrosis is commonly used in the clinical setting. All over the world in defining AKI, the terms acute tubular necrosis, acute renal failure, and acute kidney injury can be used interchangeably. Mainly the diagnosis of acute tubular necrosis should be reserved for cases where renal biopsy shows the changes of tubular cell injury, and presenting with findings of tubular injury (such as presence of mostly renal tubular epithelial cells in urine examination).



There are three major classes of AKI according to various causes frequently used for various purposes:

1. Prerenal AKI—diseases characterized by effective hypoperfusion of the kidneys in which there is no parenchymal damage to the kidney
2. Intrinsic AKI—diseases involving the renal parenchyma
3. Postrenal (obstructive) AKI—diseases associated with acute obstruction of the urinary tract

CAUSES OF PRERENAL ACUTE KIDNEY INJURY:

Intravascular Volume Depletion Hemorrhage—trauma, surgery, postpartum, gastrointestinal Gastrointestinal losses—diarrhea, vomiting, nasogastric tube loss Renal losses—diuretic use, osmotic diuresis, diabetes insipidus Skin and mucous membrane losses—burns, hyperthermia Nephrotic syndrome Cirrhosis Capillary leak
Reduced Cardiac Output Cardiogenic shock Pericardial diseases—restrictive, constrictive, tamponade Congestive heart failure Valvular diseases Pulmonary diseases—pulmonary hypertension, pulmonary embolism Sepsis
Systemic Vasodilation Sepsis Cirrhosis Anaphylaxis

Drugs
Renal Vasoconstriction Early sepsis Hepatorenal syndrome Acute hypercalcemia Drugs—norepinephrine, vasopressin, nonsteroidal antiinflammatory drugs, angiotensin-converting enzyme inhibitors, calcineurin inhibitors Iodinated contrast agents
Increased Intraabdominal Pressure Abdominal compartment syndrome

Prerenal azotemia is the most common cause of AKI and accounts for about 40% to 55% of all cases. It results from kidney hypoperfusion owing to a reduced effective arterial blood volume. Effective arterial blood volume is the volume of blood effectively perfusing the body organs. Common conditions causing hypovolemia-mediated reduced effective arterial blood volume include hemorrhage (traumatic, gastrointestinal, surgical), gastrointestinal losses (vomiting, diarrhea, nasogastric suction), renal losses (over diuresis, diabetes insipidus), and third spacing (pancreatitis, hypoalbuminemia). In addition, cardiogenic shock, septic shock, cirrhosis, hypoalbuminemia, and anaphylaxis all

are pathophysiologic conditions that decrease effective arterial circulating volume, independent of total body volume status, and result in reduced kidney blood flow. Prerenal azotemia reverses rapidly if kidney perfusion is restored, because by definition the integrity of the renal parenchyma has remained intact. However, severe and prolonged hypoperfusion may result in tissue ischemia leading to ATN. Therefore, prerenal azotemia and ischemic ATN are part of a continuous spectrum of manifestations of renal hypoperfusion.

Extracellular fluid volume depletion is the most common secondary cause of pre- renal form of acute kidney injury mostly, resulting from gastrointestinal losses like diarrhea, vomiting; renal losses by use of diuretics, osmotic diuresis in cases of hyperglycemia; dermal losses mainly in burns and by sweating, and third space loss (e.g., acute pancreatitis, muscle trauma). Perfusion to kidneys are reduced although there is normal or elevated extracellular fluid. For example, renal perfusion may be reduced by a decreased cardiac output (heart failure) or by systemic arterial vasodilation with redistribution of cardiac output to extrarenal vascular beds (e.g., sepsis, liver cirrhosis).

MAJOR CAUSES OF INTRINSIC ACUTE KIDNEY INJURY

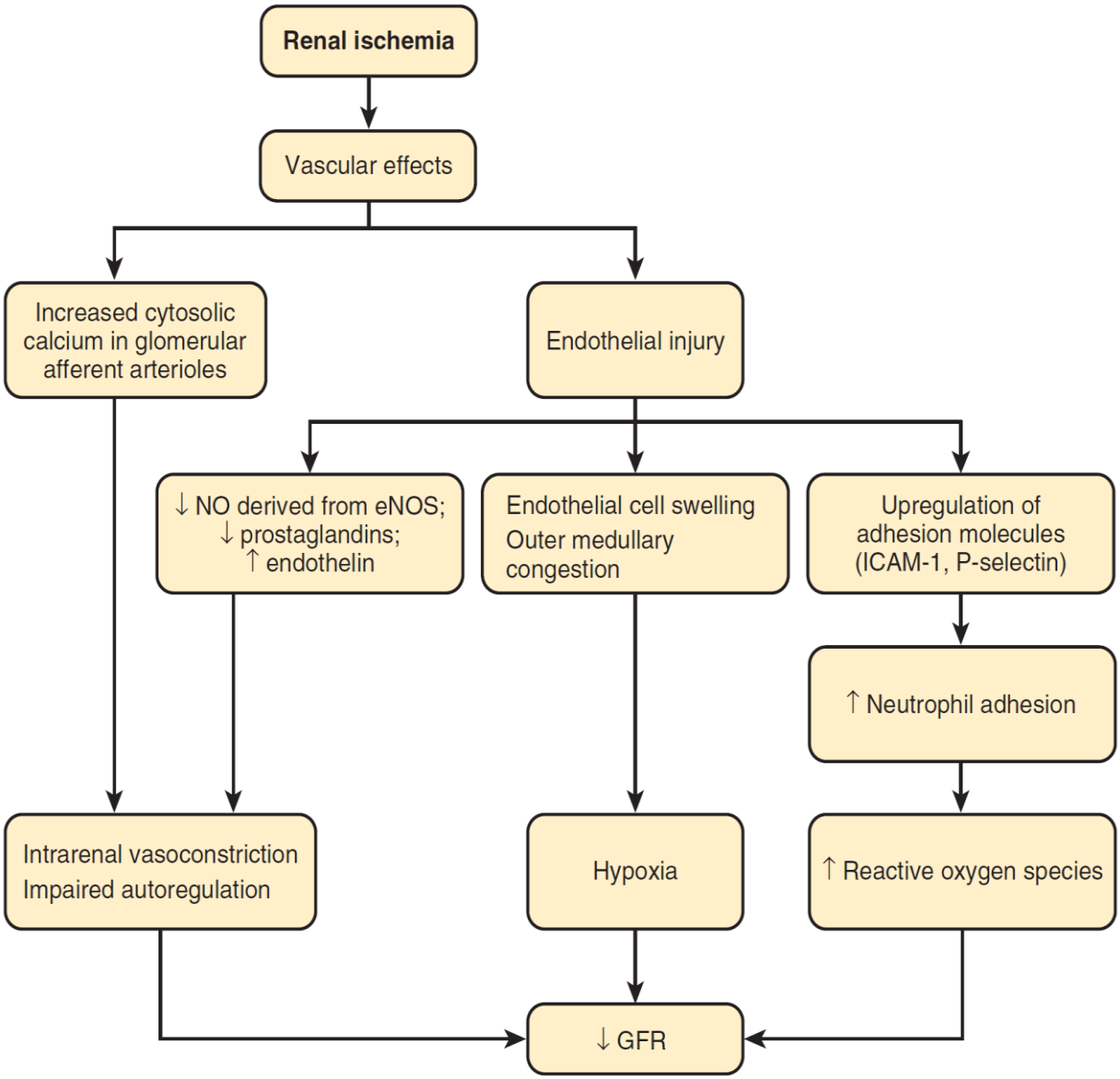
Larger renal vessels: • Renal artery occlusion due to thrombosis or dissection. • Cholesterol emboli • Renal vein thrombosis • ACE-I + bilateral renovascular disease
Diseases involving the small renal vessels and glomeruli: • Glomerulonephritis • Vasculitis • Thrombotic microangiopathies • Malignant hypertension • Scleroderma renal crisis
Diseases of the tubule interstitium: • Acute interstitial nephritis • Cast nephropathy (complicating multiple myeloma) • Contrast nephrotoxicity • Tumour lysis or acute urate nephropathy
Acute tubular necrosis (ATN) Ischemia Nephrotoxins Rhabdomyolysis

Radiocontrast agents
Acute interstitial nephritis Drugs Infection Systemic disease

Vascular and cardiac surgery, severe burns, pancreatitis, sepsis, and chronic liver disease are the major etiological causes of acute tubular necrosis. Among the various studies, the highest cause of AKI in hospital setup is due ATN, which is usually a result of ischemic or nephrotoxic injury. Most of the cases occur as a result of the combination of impaired renal perfusion, sepsis, and nephrotoxic agents. In animal studies, ATN is not caused by severe and prolonged hypotension (<50 mm Hg for 2 to 3 hours in the rat), and also very high doses of single nephrotoxic agents are required to induce AKI. These features may reflect an inherent resistance to tubular injury in animal models, but also illustrate the fact that a single insult alone is rarely sufficient to induce ATN. Fever may exacerbate ATN by increasing the renal tubular metabolic rate, thereby increasing adenosine triphosphate (ATP) consumption. In an experimental model (renal artery occlusion in the rat), renal ischemia for 40 minutes resulted in minimal renal injury at 32° C but marked renal injury at 39.4°

C. The typical course of uncomplicated ATN is recovery over 2 to 3 weeks; however, superimposed renal insults often alter this pattern. For example, episodes of hypotension induced by hemodialysis may lead to additional ischemic lesions, potentially prolonging renal functional recovery, and patients with AKI often have multiple comorbidities.

The typical features of ATN on renal biopsy include vacuolization and loss of brush border in proximal tubular cells. Sloughing of tubular cells into the lumen leads to cast obstruction, manifested by tubular dilation. Interstitial edema can produce widely spaced tubules, and a mild leukocyte infiltration may be present. Despite the term acute tubular "necrosis," frankly necrotic cells are not a common finding on renal biopsy, and histologic evidence of injury frequently involves only 10% to 15% of the tubules despite marked functional impairment. This implies that factors other than just tubular cell injury (such as vasoconstriction and tubular obstruction) are important in the loss of GFR.



CAUSES OF POSTRENAL ACUTE KIDNEY INJURY

Upper Urinary Tract Extrinsic Causes Retroperitoneal space—lymph nodes, tumors Pelvic or intraabdominal tumors—cervix, uterus, ovary, prostate Fibrosis—radiation, drugs, inflammatory conditions Ureteral ligation or surgical trauma Granulomatosis diseases Hematoma
Lower Urinary Tract Causes Prostate—benign prostatic hypertrophy, carcinoma, infection Bladder—neck obstruction, calculi, carcinoma, infection (schistosomiasis) Functional—neurogenic bladder secondary to spinal cord injury, diabetes, multiple sclerosis, stroke, pharmacologic side effects of drugs (anticholinergics, antidepressants) Urethral—posterior urethral valves, strictures, trauma, infections, tuberculosis, tumors
Upper Urinary Tract Intrinsic Causes Nephrolithiasis Strictures Edema

Debris, blood clots, sloughed papillae, fungal ball Malignancy

Postrenal azotemia is caused by either ureteric obstruction or bladder or urethral obstruction. AKI due to ureteric obstruction requires that the blockage occur either bilaterally at any level of the ureters or unilaterally in a patient with a solitary functioning kidney or CKD. Ureteric obstruction can be either intraluminal or external. Bilateral ureteric calculi, blood clots, and sloughed renal papillae can obstruct the lumen. External compression from tumor or hemorrhage can block the ureters as well. Fibrosis of the ureters intrinsically or from the retroperitoneum can narrow the lumen to the point of complete luminal obstruction. The most common cause of postrenal azotemia is structural or functional obstruction of the bladder neck. Prostatic conditions, therapy with anticholinergic agents, and a neurogenic bladder can all cause postrenal AKI. Relief of the obstruction usually leads to prompt return of GFR if the duration of obstruction has not been excessive. The rate and magnitude of functional recovery is dependent on the extent and duration of the obstruction.

In any patient presenting with AKI, an obstructive cause must be excluded because prompt intervention can result in improvement or complete recovery of renal function. Extra renal and intratubular are the two major postrenal forms of

AKI all over the world. The following are those condition that increase the intratubular pressure which is the pressure within the renal tubules: Tubular precipitation of insoluble crystals (phosphate, oxalate, uric acid, methotrexate, acyclovir, sulfonamides, indinavir, triamterene) or protein (hemoglobin, myoglobin, paraprotein).when these intratubular pressures are high oppose the glomerular filtration and can lead to dangerous effect of GFR reduction. post renal form of AKI can be caused by obstruction at any level in the extrarenal collecting system of the kidney like the renal pelvis, ureters, bladder, or urethra and can lead to harmful effects. In older men , prostatic disease is leading cause for obstructing uropathy leading to renal failure and also in patients with a single kidney or intra-abdominal, particularly pelvic, cancer renal failure can occur due to various mechanisms.one of the major reason for Severe ureteral obstruction is retroperitoneal fibrosis. The prognosis of various causes of obstructive uropathy is food because there are various modalities of treatment exists for them depending on the underlying nature of disease.

CLASSIFICATION OF VARIOUS COMMON DRUGS BASED ON PATHOPHYSIOLOGIC CATEGORIES OF ACUTE KIDNEY INJURY

Vasoconstriction/Impaired Microvasculature Hemodynamics (Prerenal) Nonsteroidal antiinflammatory drugs (NSAIDs), angiotensin converting enzyme inhibitors, angiotensin receptor blockers, norepinephrine, tacrolimus, cyclosporine, diuretics, cocaine, mitomycin C, estrogen, quinine, interleukin-2, cyclooxygenase-2 inhibitors
Tubular Cell Toxicity Antibiotics—aminoglycosides, amphotericin B, vancomycin, rifampicin, foscarnet, pentamidine, cephaloridine, cephalothin Radiocontrast agents, NSAIDs, acetaminophen, cyclosporine, cisplatin, mannitol, heavy metals, intravenous immune globulin (IVIG), ifosfamide, tenofovir
Acute Interstitial Nephritis Antibiotics—ampicillin, penicillin G, methicillin, oxacillin, rifampicin, ciprofloxacin, cephalothin, sulfonamides NSAIDs, aspirin, fenoprofen, naproxen, piroxicam, phenylbutazone, radiocontrast agents, thiazide diuretics, phenytoin, furosemide, allopurinol, cimetidine, omeprazole

Tubular Lumen Obstruction Sulfonamides, acyclovir, cidofovir, methotrexate, triamterene, methoxyflurane, protease inhibitors, ethylene glycol, indinavir, oral sodium phosphate bowel preparations
Thrombotic Microangiopathy Clopidogrel, cocaine, ticlopidine, cyclosporine, tacrolimus, mitomycin C, oral contraceptives, gemcitabine, bevacizumab
Osmotic Nephrosis IVIG, mannitol, dextrans, hetastarch

DIAGNOSIS OF ACUTE KIDNEY INJURY:

Differentiating the two most common causes of AKI in hospitalized patients, pre-renal AKI and acute tubular necrosis (ATN), may be difficult when both the effective arterial blood volume and the time course of the kidney injury are unknown. Here the term acute tubular injury (ATI) may be added to ATN to more accurately describe the pathology involved in intrinsic AKI from ischemic or toxic insults. Evaluation of urine volume, urinary sediment, and urinary indices (the last is useful only in patients with oliguria) is particularly helpful in making the correct diagnosis. Initial laboratory tests include a urinalysis and basic

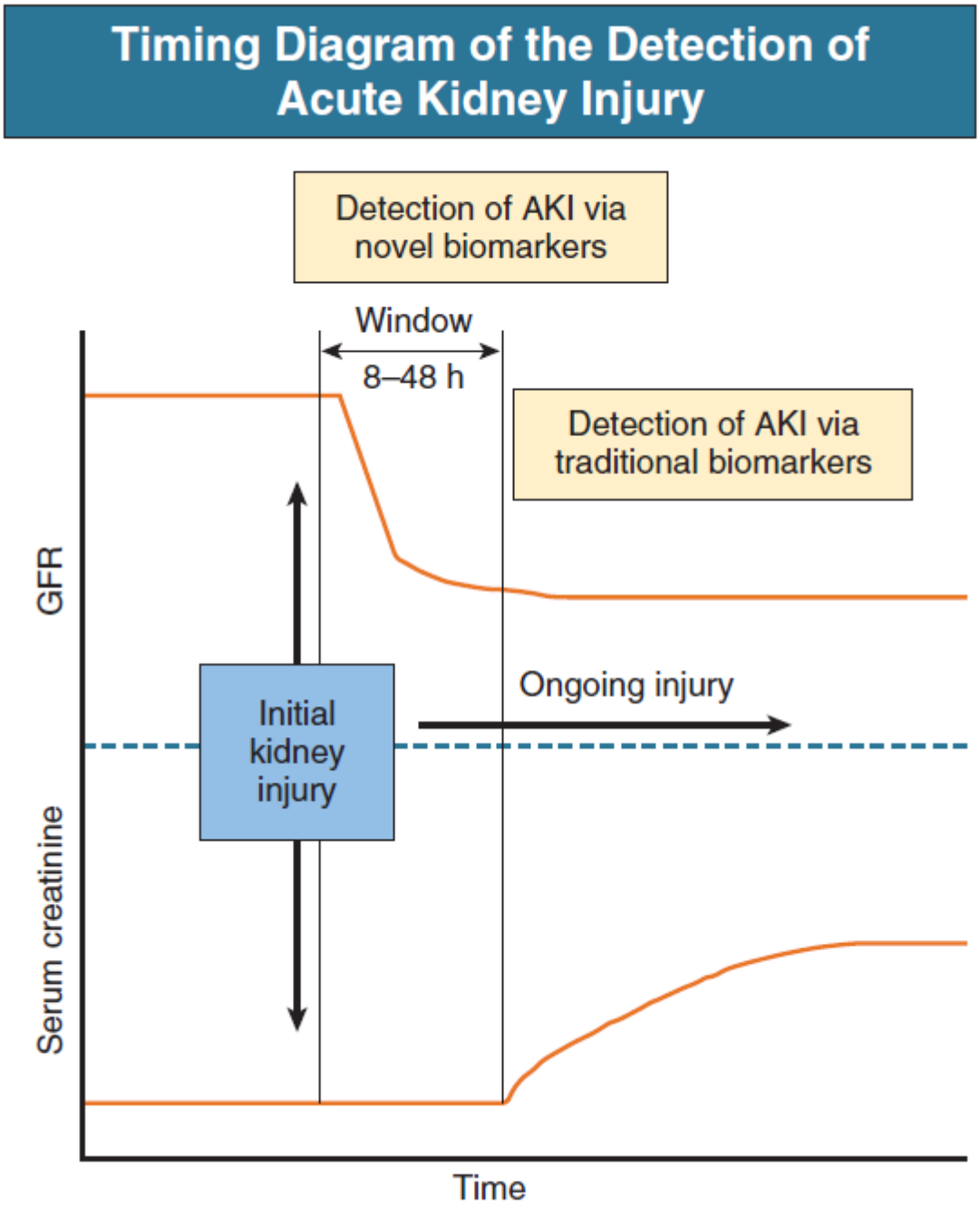
metabolic panel with measurement of blood urea nitrogen (BUN) and serum sodium, potassium, bicarbonate, and creatinine levels. These tests are important not only for the diagnosis but also for assessment of complications of AKI.

Results from initial laboratory testing may prompt further testing. For example, glycosuria occurring with a normal plasma glucose level offers evidence for proximal tubular dysfunction. The presence of amino acids and bicarbonate in the urine along with elevated urinary levels of phosphate and uric acid confirm Fanconi syndrome, a form of proximal tubular injury seen with AKI from cisplatin or tenofovir use and immunoglobulin free light-chain (FLC) cytotoxicity.

Ratio of Blood Urea Nitrogen to Creatinine:

The BUN-creatinine ratio is 10:1 to 15:1 (when both are expressed in mg/dl; 40 to 60 when expressed in mmol/l) in normal individuals. In pre-renal AKI the ratio may be greater than 20:1 because of a disproportionate increase in urea reabsorption resulting from elevated antidiuretic hormone levels. A high ratio is not specific for pre-renal injury because gastrointestinal bleeding, impaired protein anabolism (e.g., systemic corticosteroid or tetracycline administration), increased catabolism (e.g., sepsis), and increased protein intake can raise BUN levels. Pre-renal AKI should not be excluded by a normal ratio because diminished urea production from decreased protein intake or underlying

liver disease can prevent the expected rise in the BUN by increased tubular reabsorption. Also, elevations in creatinine levels may exceed BUN levels in patients with creatinine kinase release from muscle breakdown, as in rhabdomyolysis.



Urine Volume:

In AKI, urine volume has been shown to directly correlate with residual GFR. Urine volume therefore can both indicate the severity of AKI and provide important diagnostic information. Oliguric AKI (urine output less than 500 ml/day) is typically associated with worse outcomes than AKI with preserved urine Volume, especially with a positive fluid balance in the critical care setting. Oliguria commonly occurs in AKI caused by ATN, although it can also be seen in pre-renal AKI with early detection or AIN. Wide variations in daily urine output suggest obstruction. Complete anuria (no urine output) suggests obstruction or an acute vascular catastrophe, such as renal vein or renal artery occlusion, although it can be seen in ATN and AIN. For a vascular event to cause complete anuria, it must affect both kidneys or a single functioning kidney.

Urinalysis and Urine Microscopy:

In the setting of AKI a dipstick urinalysis provides the first clue to the presence of red blood cells (RBCs) or protein in the urine. However, urinary dipstick results have significant limitations and must be interpreted in conjunction with more specific tests such as a spot urinary protein- or albumin-creatinine ratio and urine microscopy. A few notable limitations of the dipstick urinalysis include an inability to detect FLC protein components of immunoglobulins and the false-positive detection of protein in the setting of

radiographic contrast or alkaline urine. The dipstick urinalysis can provide useful diagnostic information when used in conjunction with urine microscopy.

For example, the presence of hemoglobin or myoglobin in the urine is supported by finding blood by dipstick and no RBCs by urine microscopy. Urine microscopy has been validated as a diagnostic and prognostic tool in hospitalized patients with AKI. A fresh urine sample is centrifuged and the sediment examined by light microscopy for the presence of cells, casts, and crystals. A normal urine sediment contains few cells or casts, termed a "bland" sediment. Urine microscopy in early pre-renal AKI is typically normal with occasional hyaline casts. The picture supporting ATN related cause for AKI in urine are "Muddy brown" granular casts and renal tubular epithelial cells. In a study of 197 hospitalized patients with AKI defined by the AKIN criteria, the presence of more than 10 granular casts per low power field had a positive predictive value of 100% for a final diagnosis of ATN. In this same study, a urine sediment score based on granular casts and renal tubular epithelial cells was directly associated with worsening AKI, defined as a composite outcome of higher AKIN stage, dialysis requirement, and death. These findings suggest that urine microscopy is useful both in distinguishing ATN related AKI from pre-renal AKI and in predicting the severity of AKI.

Findings on urinalysis and urine microscopy may offer insights into renal history (broad, waxy casts are often seen in CKD) but, more important, may be diagnostic clues to a rare cause of AKI. A proliferative GN is characterized by a urinary dipstick with 3+ to 4+ blood and 2+ to 3+ protein with an active sediment of RBCs and RBC casts identified with urine microscopy. In this setting the history and physical examination findings should be supported by serologic testing and a kidney biopsy, if the kidneys are normal in size. The presence of white blood cells in clumps and casts, in the absence of bacteria, suggests AIN. Renal tubular epithelial cells, granular casts, RBCs, and even RBC casts can be seen in the urinary sediment of patients with AIN. Urinary eosinophils are neither highly sensitive nor specific for diagnosis of drug-associated AIN. Cystitis, prostatitis, pyelonephritis, athero embolic disease, ATN, and rapidly progressive glomerulonephritis (RPGN) may all cause eosinophiluria in the absence of AIN. A urine sediment with abundant uric acid crystals accompanying high serum phosphorus levels in a patient undergoing chemotherapy may indicate tumor lysis syndrome.

CHARACTERISTICS OF URINE SEDIMENT IN THE

DIFFERENTIALDIAGNOSIS OF ACUTE KIDNEY INJURY:

Normal or Few Red Blood Cells or White Blood Cells Prerenal azotemia Arterial thrombosis or embolism Preglomerular vasculitis Hemolytic uremic syndrome/thrombotic thrombocytopenic purpura Scleroderma crisis Postrenal acute kidney injury
Granular Casts Acute tubular necrosis Glomerulonephritis or vasculitis Interstitial nephritis
Red Blood Cell Casts Glomerulonephritis or vasculitis Malignant hypertension Rarely interstitial nephritis
White Blood Cell Casts Acute interstitial nephritis or exudative glomerulonephritis Severe pyelonephritis

Marked leukemic or lymphomatous infiltration
Eosinophiluria (>5% Eosinophils) Allergic interstitial nephritis (antibiotics much more frequently than nonsteroidal antiinflammatory drugs) Atheroembolism
Crystalluria Acute urate nephropathy Calcium oxalate (ethylene glycol intoxication) Acyclovir Indinavir Sulfonamides Radiocontrast agents

Fractional Excretion of Sodium and Urea:

The urine-serum concentrations of sodium in relation to the urine serum concentrations of creatinine (fractional excretion of sodium [FENa]) has been used to approximate renal tubular function.

The basic premise is that renal tubular cells will reabsorb sodium in the pre-renal setting, whereas tubules damaged by ATN will not. FENa below 1% is consistent with pre-renal AKI, and FENa above 3% is typical of ATN. However,

many exceptions to these cutoffs have been discovered since FENa was first introduced into clinical practice in 1976. FENa may be less than 1% despite the presence of ATN in the setting of sepsis, hemoglobinuria or myoglobinuria, radiocontrast exposure, nonoliguria, heart failure, and advanced cirrhosis. Underlying CKD, diuretic use, recent intravenous fluid administration, glucosuria, bicarbonaturia, and salt-wasting disorders may be associated with elevated FENa despite the presence of pre-renal AKI. Therefore FENa has significant limitations in the setting of hospital acquired AKI, where confounders abound, yet may be helpful in differentiating pre-renal AKI from ATN in specific patient populations with oliguria. Urea reabsorption, primarily occurring in proximal tubules, is less affected by loop and thiazide diuretics, and the fractional excretion of urea (FEUrea) may be a useful alternative to FENa in patients receiving diuretics. FEUrea calculation is identical to that of FENa, with replacement of urea for sodium, and values less than 35% favor pre-renal AKI over ATN.

URINE INDICES USED IN THE DIFFERENTIAL DIAGNOSIS OF PRERENAL ACUTE KIDNEY INJURY AND ACUTE TUBULAR NECROSIS:

DIAGNOSTIC INDEX	PRERENAL ACUTE KIDNEY INJURY	ACUTE TUBULAR NECROSIS
Fractional excretion of sodium (%)	<1*	>2
Urine sodium concentration (mEq/L)	<20	>40
Urine creatinine/ plasma creatinine ratio	>40	<20
Urine urea nitrogen/ plasma urea nitrogen ratio	>8	<3
Urine specific gravity	>1.018	<1.010
Urine osmolality (mOsm/kg H2O)	>500	<300
Plasma blood urea nitrogen/creatinine ratio	>20	10-15
Renal failure index, UNa/(UCr/PCr)	<1	>1
Urine sediment	HYALINE CAST	GRANULAR CAST

RENAL BIOPSY:

Renal biopsy is reserved for patients in whom pre-renal and postrenal AKI have been excluded and the cause of intrinsic renal AKI remains unclear. Renal biopsy is particularly useful when clinical assessment and laboratory investigations suggest diagnoses other than ischemic or nephrotoxic injury that may respond to disease specific therapy. Examples include RPGN, vasculitis, systemic lupus erythematosus, and AIN.

RADIOLOGICAL EVALUATION:

Imaging of the abdomen is a highly useful adjunct to laboratory testing to determine the cause of AKI. In cases of suspected obstructive uropathy, post void residual volumes of more than 100 to 150 mL suggest a diagnosis of bladder outlet obstruction. Although plain radiographs rarely provide definitive evidence of postrenal AKI, they may identify the presence of calcium-containing stones that can cause obstructive disease. Renal ultrasonography is the screening test of choice to assess cortical thickness, differences in cortical and medullary density, the integrity of the collecting system, and kidney size. Although pelvicaliceal dilatation is usual in cases of urinary tract obstruction (98% sensitivity), dilatation may not be observed when the patient is volume depleted, during the initial 1 to 3 days after obstruction, when the collecting system is relatively noncompliant, or when obstruction is caused by ureteric encasement or infiltration (e.g.,

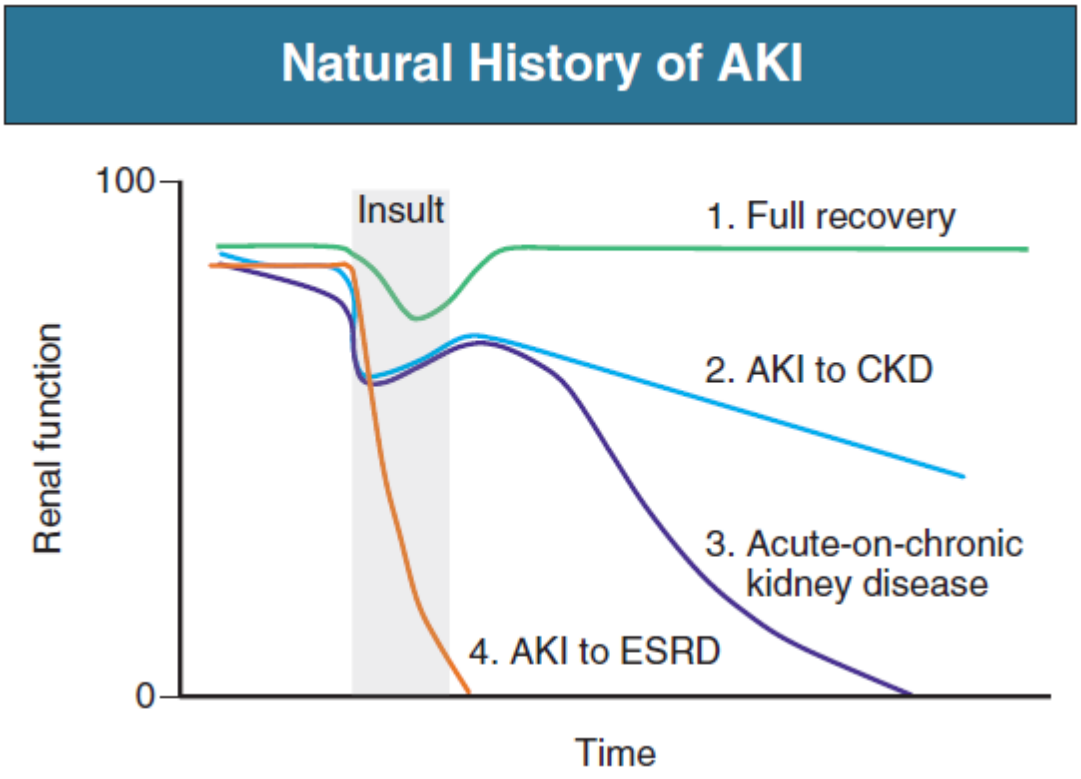
retroperitoneal fibrosis, neoplasia). Alternatively, computed tomography (CT) may be used to visualize the kidneys and collecting system, although radiocontrast agent administration should be avoided in patients with AKI. Visualization of the collecting system may be suboptimal in the absence of contrast agent enhancement; however unenhanced CT scans are useful for the identification of obstructing ureteral stones. Ultrasonography and CT have essentially replaced the use of intravenous pyelography, which now has little role in the evaluation of AKI. Cystoscopic retrograde or percutaneous anterograde pyelography is useful for precise localization of the site of obstruction and can be combined with placement of ureteral stents or percutaneous nephrostomy tubes to allow therapeutic decompression of the urinary tract. Radionuclide scans have been proposed as useful for assessing renal blood flow, glomerular filtration, tubule function, and infiltration by inflammatory cells in AKI; however, these tests generally lack specificity or yield conflicting or poor results in controlled studies. Magnetic resonance angiography (MRA) of the kidneys is extremely useful for detecting renal artery stenosis and has been used in the evaluation of acute renovascular crises. However, given the association of gadolinium-based contrast agent administration with the development of nephrogenic systemic fibrosis, contrast medium–enhanced MRA is relatively contraindicated in the majority of patients with AKI. Doppler ultrasonography

and spiral CT are also useful in patients with suspected vascular obstruction; but the best investigation till date for detection and definitive diagnosis is CT angiography.

PATIENT-SPECIFIC RISK FACTORS FOR ACUTE KIDNEY INJURY (AKI):

Age Gender (male) Chronic kidney disease Proteinuria Diabetes
Congestive heart failure Sepsis Volume depletion Chronic liver disease Hyperuricemia

NATURAL HISTORY OF AKI:



TREATMENT :

Appropriate therapeutic management requires timely diagnosis of the clinical condition. Considerable effort and investment have been directed in the search for a more sensitive and specific biomarker to diagnose AKI. Because serum creatinine is a relatively late indicator of renal injury, significant AKI can occur without major increases in serum creatinine levels. Appropriate therapeutic interventions to reduce kidney function loss and for prevention and treatment of the associated complications of AKI need to be instituted even with minimal changes in serum creatinine. Initial management of established AKI includes

careful assessment of the cause of renal dysfunction and the patient's volume status. The main goal includes maintenance of adequate hemodynamic status to ensure renal perfusion and avoidance of further kidney injury. Any potentially nephrotoxic agents should be avoided, including intravascular radiocontrast dye. Gadolinium-based contrast agents should be avoided because of the risk of development of nephrogenic systemic fibrosis (NSF). If gadolinium-based contrast agents need to be used in AKI, patients should be informed about the risk of NSF, and macrocyclic chelate (i.e., gadobutrol, gadoteridol, or gadoterate meglumine) should be preferred over linear chelates. The lowest dosage possible should be administered, and repeated exposures should be avoided. Antimicrobial agents such as aminoglycosides, amphotericin, acyclovir, and pentamidine should be avoided whenever possible, or their dose should be adjusted to prevent further insult. Any other medications associated with AKI (hemodynamic, nephrotoxic, immune mediated) should also be avoided if possible.

SUPPORTIVE MANAGEMENT OF ACUTE KIDNEY INJURY:

Intravascular volume overload	Restriction of salt (<1-1.5 g/day) and water (<1 L/day) Consideration of diuretic therapy Ultrafiltration
Hyponatremia	Restriction of oral and intravenous free water
Hyperkalemia	Restriction of dietary potassium Discontinuation of K+ supplements or K+-sparing diuretics K+-binding resin Loop diuretics Glucose (50 mL of 50%) + insulin (10-15 units regular) intravenously Sodium bicarbonate (50-100 mEq intravenously)

	Calcium gluconate (10 mL of 10% solution over 5 min) Renal replacement therapy
Metabolic acidosis	Restriction of dietary protein Sodium bicarbonate (if HCO3 – <15 mEq/L) Renal replacement therapy
Hyperphosphatemia	Restriction of dietary phosphate intake Phosphate-binding agents (calcium carbonate, calcium acetate, sevelamer, lanthanum
Hypocalcemia	Calcium carbonate (if symptomatic or sodium bicarbonate to be administered)
Hypermagnesemia	Discontinuation of magnesium-containing antacids

Nutrition	Restriction of dietary protein (<0.8g/kg/day up to 1.5 g/kg/day for patients undergoing continuous renal replacement therapy) Provision of 25-30 kcal/day Enteral route of nutrition preferred
Drug dosage	Adjustment of all dosages for glomerular filtration rate and renal replacement modality

Renal replacement therapy (RRT):

RRT is the term for the multiple modalities of dialysis and hemofiltration employed in the management of kidney failure. Although kidney transplantation is also a form of RRT for end-stage renal disease (ESRD), transplantation does not play a role in the management of AKI given the potential for recovery of kidney function. RRT facilitates the management of patients with AKI, allowing correction of acid-base and electrolyte disturbances, amelioration of volume overload, and removal of uremic waste products. Although RRT can forestall or reverse the life-threatening complications of uremia associated with severe and

prolonged AKI, it does not hasten and can potentially delay the recovery of kidney function in patients with

AKI and can be associated with potentially life-threatening complications.

INDICATIONS FOR RENAL REPLACEMENT THERAPY:

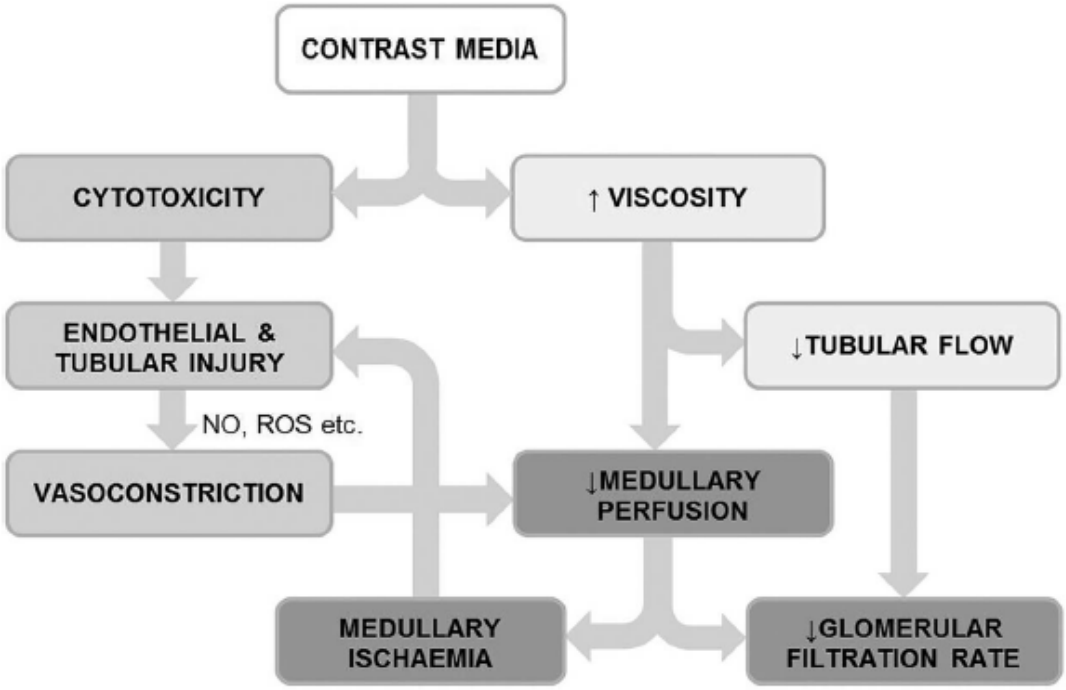
Absolute indications	Relative indications
Volume overload unresponsive to diuretic therapy Hyperkalemia despite medical treatment Persistent metabolic acidosis Overt uremic symptoms Encephalopathy Pericarditis Uremic bleeding diathesis	Progressive azotemia without uremic manifestations Persistent oliguria

RADIOCONTRAST-INDUCED NEPHROPATHY:

Acute kidney injury secondary to contrast nephrotoxicity typically occurs in patients with underlying renal impairment and is rarely seen in patients with normal renal function. It may occur with both intravenous and intra-arterial

contrast, but not with oral contrast (assuming the bowel is intact). The incidence of contrast nephropathy (as defined by an increase in serum creatinine of more than

0.5 mg/dl [44 μmol/l]) is about 20% in patients with serum creatinine levels exceeding 2 mg/dl (176 μmol/l) and 50% when levels exceed 5 mg/dl (440 μmol/l). Other risk factors for the development of this condition include diabetic nephropathy, advanced age (older than 75 years), congestive heart failure, volume depletion, and high or repetitive doses of radiocontrast agent. High osmolar contrast is more nephrotoxic than low or iso-osmolar contrast agents. Concurrent use of NSAIDs, ACE inhibitors, or diuretics may increase the risk.



PATHOGENESIS:

Medullary hypoxia and direct tubular epithelial cell toxicity are the main factors in the pathogenesis of contrast nephrotoxicity. Typically, a biphasic hemodynamic response is seen. An initial vasodilation (lasting a few seconds to minutes) is followed by a more prolonged renal vasoconstriction. The consequent medullary hypoxia may be exacerbated by the osmotic diuresis, leading to increased sodium delivery to the medullary thick ascending loop and requiring greater oxygen consumption for reabsorption. Radiocontrast agents also cause direct tubular epithelial cell injury and induce apoptosis of these cells. Human studies have demonstrated low-molecular-weight proteinuria, suggestive of proximal tubular injury, partly mediated by ROSs. Increased markers of lipid peroxidation have been described, and the administration of anti oxidants ameliorates contrast nephrotoxicity in animals.

COMPARISON OF CM AGENTS BY OSMOLALITY AND VISCOSITY

	Blood plasma	**Iso-osmolar eg, Visipaque**	**Low-osmolar eg,Omnipaque**	**High-osmolar eg, Hypaque**
OSMOLALITY	290mosmol/L	290mosmol/L	890mosmol/L	2100mosmol/L

VISCOSITY	3–4 mPa s	8.8 mPa s	6.8 mPa s	4.1 mPa s
CIN RISK	N/A	LOW	LOW	HIGH

PREVENTION OF CONTRAST INDUCED AKI:

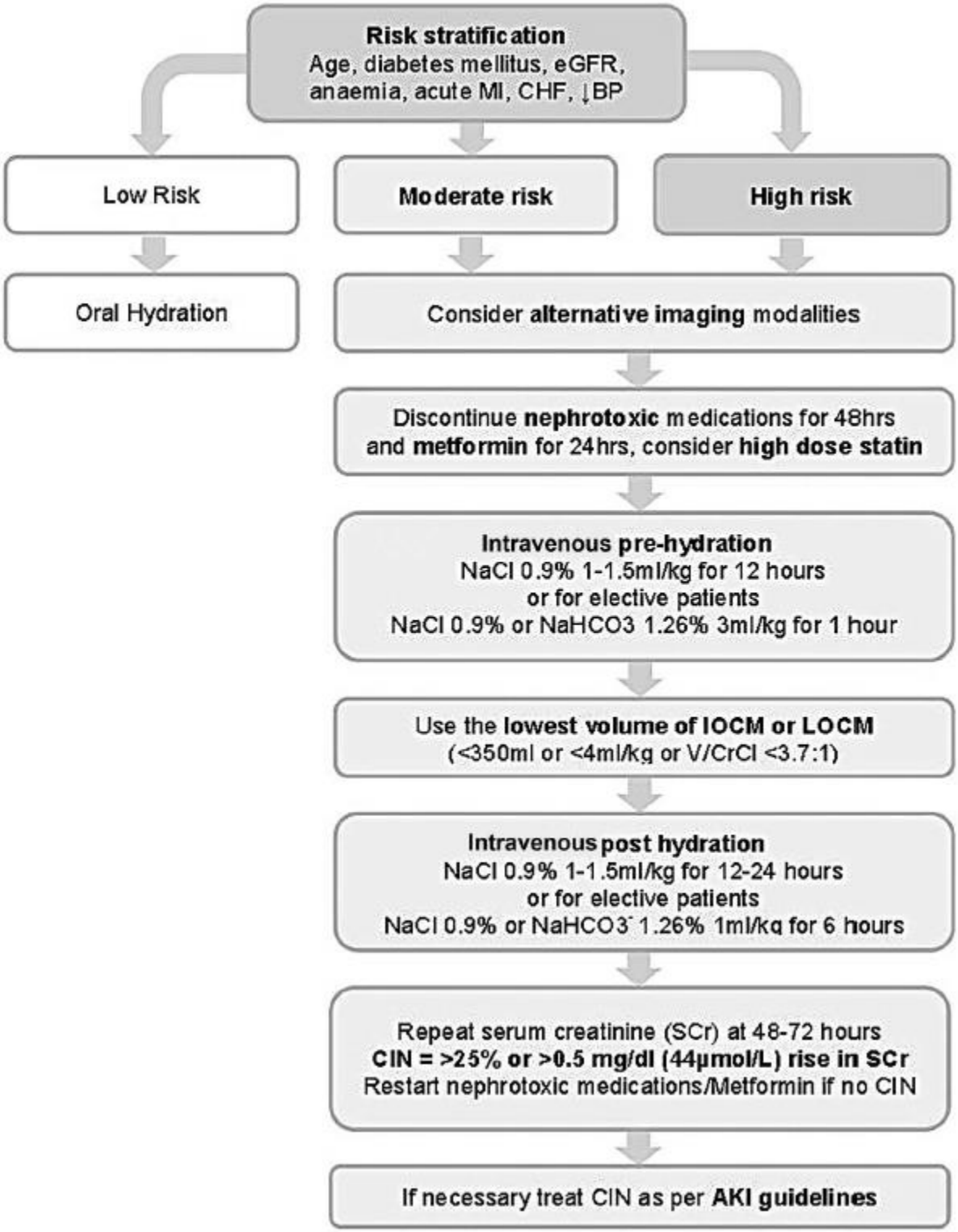
Hydrating the patient adequately before exposure to contrast medium is the only proven prophylactic measure. when renal blood is maintained due to adequate blood flow, it acts to dilute the contrast by improving renal blood flow in both the blood plasma and tubular filtrate.

The oral route may be appropriate, In lower risk ambulant patients, if adequate fluid intake is taken. In various studies it is found that in moderate/higher risk or in hospitalised patients; intravenous hydration with a crystalloid fluid; is preferred over any other method and way; as it helps in delivery of sufficient amount of fluid volumes and has been demonstrated as superior in clinical trials. The choice of which crystalloid to use is found out to be isotonic saline; because in various studies, when compared with isotonic (normal) saline (0.9%), intravenous sodium bicarbonate (1.26%) may have additional ROS scavenging properties. This is due to be mediated through urine alkalinisation and as it naturally lacks chloride ions that are thought to exacerbate renal vasoconstriction. Many of the recent studies done in the field of CIN has clearly demonstrated a modest reduction in CIN; when using intravenous sodium

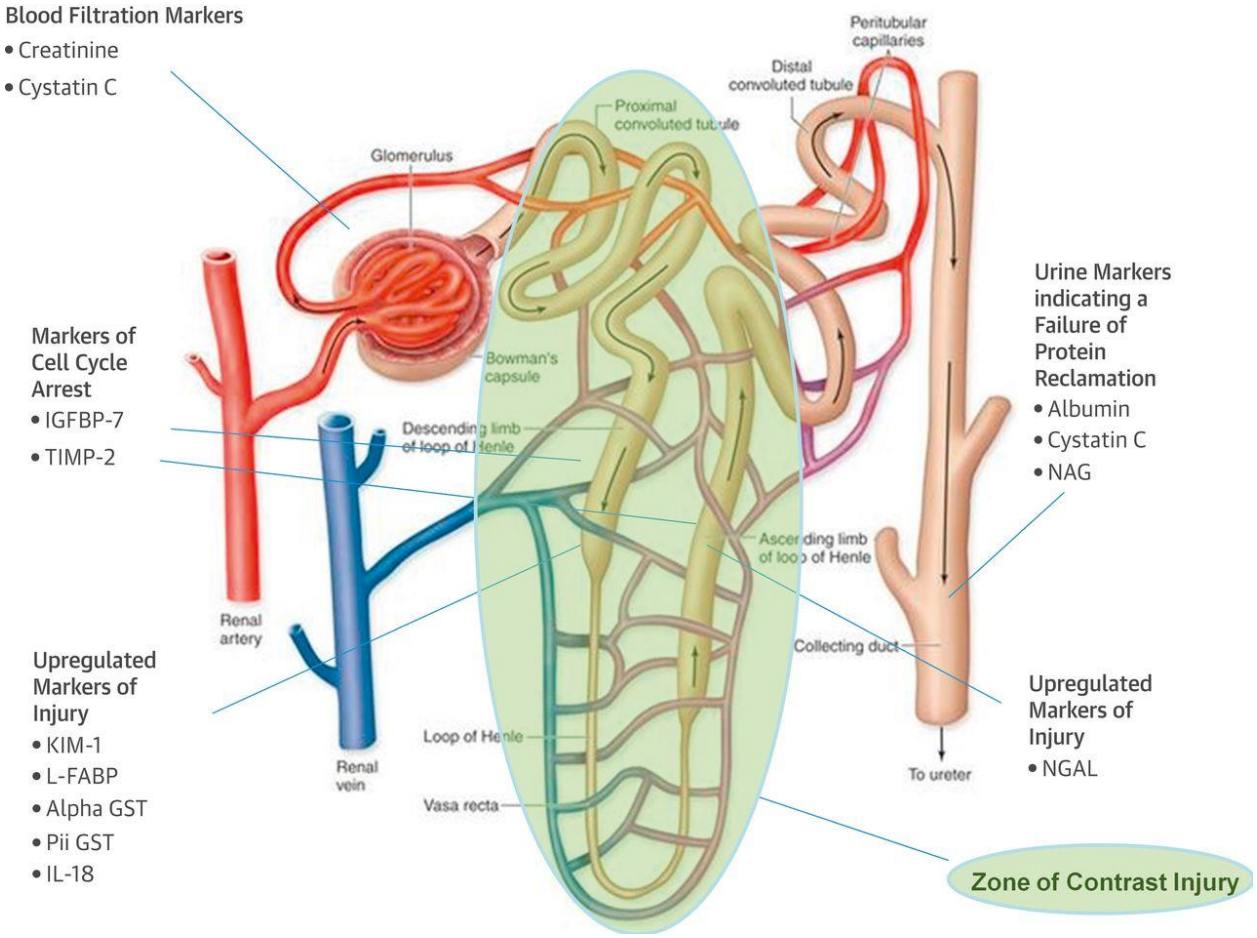
bicarbonate 1.26% as compared with isotonic saline.so after various recommendations, the current ESC guidelines recommend pre-hydration with sodium chloride 0.9% at 1–1.5 mL/kg/h for 12 h pre-procedure and up to 24 h post procedure. Another alternative and reasonable method is to use an alternative protocol delivering a shorter duration and volume of sodium chloride 0.9% for elective day case patients and for those with features suggestive of heart failure where the large volumes of intravenous fluid infused may lead to occurrence of pulmonary edema. SCr levels measured in all patients; following CM exposure; who are at risk of developing CIN in hospital setup; should have between 48 and 72 h. the standard AKI guidelines must be used regularly for treatment of CIN If it is diagnosed, ;such as the recent European Best Practice position statement on AKI;'. This includes measurements of serum creatine and should be charted daily, along with stopping all nephrotoxic medication

And avoiding use of loop diuretics, along with electrolyte and hydration optimization must be done, nutritional advice given must be followed and, if severe AKI occurs, early hospitalisation with referral to a specialist nephrologist.

Anaphylactoid Reactions to Contrast Medium
Cutaneous and mucosal
Angioedema
Flushing Laryngeal edema
Pruritus
Urticaria
Smooth muscle
Bronchospasm
Gastrointestinal spasm
Uterine contraction
Cardiovascular
Arrhythmia
Hypotension (shock)
Vasodilatation


Risk stratification
Age, diabetes mellitus, eGFR, anaemia, acute MI, CHF, ↓BP
Low Risk
Moderate risk
High risk
Oral Hydration
Consider alternative imaging modalities
Discontinue nephrotoxic medications for 48hrs and metformin for 24hrs, consider high dose statin
Intravenous pre-hydration
NaCl 0.9% 1-1.5ml/kg for 12 hours
or for elective patients
NaCl 0.9% or NaHCO3 1.26% 3ml/kg for 1 hour
Use the lowest volume of IOCM or LOCM
(<350ml or <4ml/kg or V/CrCl <3.7:1)
Intravenous post hydration
NaCl 0.9% 1-1.5ml/kg for 12-24 hours
or for elective patients
NaCl 0.9% or NaHCO3 1.26% 1ml/kg for 6 hours
Repeat serum creatinine (SCr) at 48-72 hours
CIN = >25% or >0.5 mg/dl (44µmol/L) rise in SCr
Restart nephrotoxic medications/Metformin if no CIN
If necessary treat CIN as per AKI guidelines

Patients should be advised to stop all non-essential nephrotoxic medications for 24h prior to and for 48 h following the CM procedure. The various other recommendations are that patients receiving intra-arterial CM with an eGFR of <60 mL/min/1.73 m2, or those receiving intravenous CM with an eGFR of <45 mL/min/1.73 m2, must discontinue metformin for 48 h prior to CM exposure and can also be restarted once a 48 h SCr measurement excludes the presence of CIN.



This is to mitigate the risk of lactic acidosis due to reduced renal clearance of metformin that may occur following a potential CIN episode, rather than metformin nephrotoxicity per se. Recent studies have investigated whether IOCM formulations, which are thought to induce less osmotic stress despite generally having higher viscosity, are preferable over LOCM. A number of meta-analyses have been performed, some of which suggest the superiority of IOCM; however, others have shown no benefit. The current guidelines recommend the use of either IOCM or LOCM, although a preference for IOCM is reasonable, with the more important proviso that the minimum amount of CM required for diagnostic accuracy is used. During CA or PCI, the use of biplane imaging by experienced operators may reduce the amount of contrast required as simultaneous orthogonal views can be acquired following each CM injection.

INTRAVENOUS PRE-HYDRATION REGIMES:

Intravenous fluid	Pre-hydration	Post-hydration
Isotonic saline (0.9%)	12 h, 1–1.5 mL/kg/h	12–24 h, 1–1.5 mL/kg/h
Isotonic saline (0.9%) or sodium bicarbonate (1.26%)	1 h at 3 mL/kg/h	6 h at 1 mL/kg/h

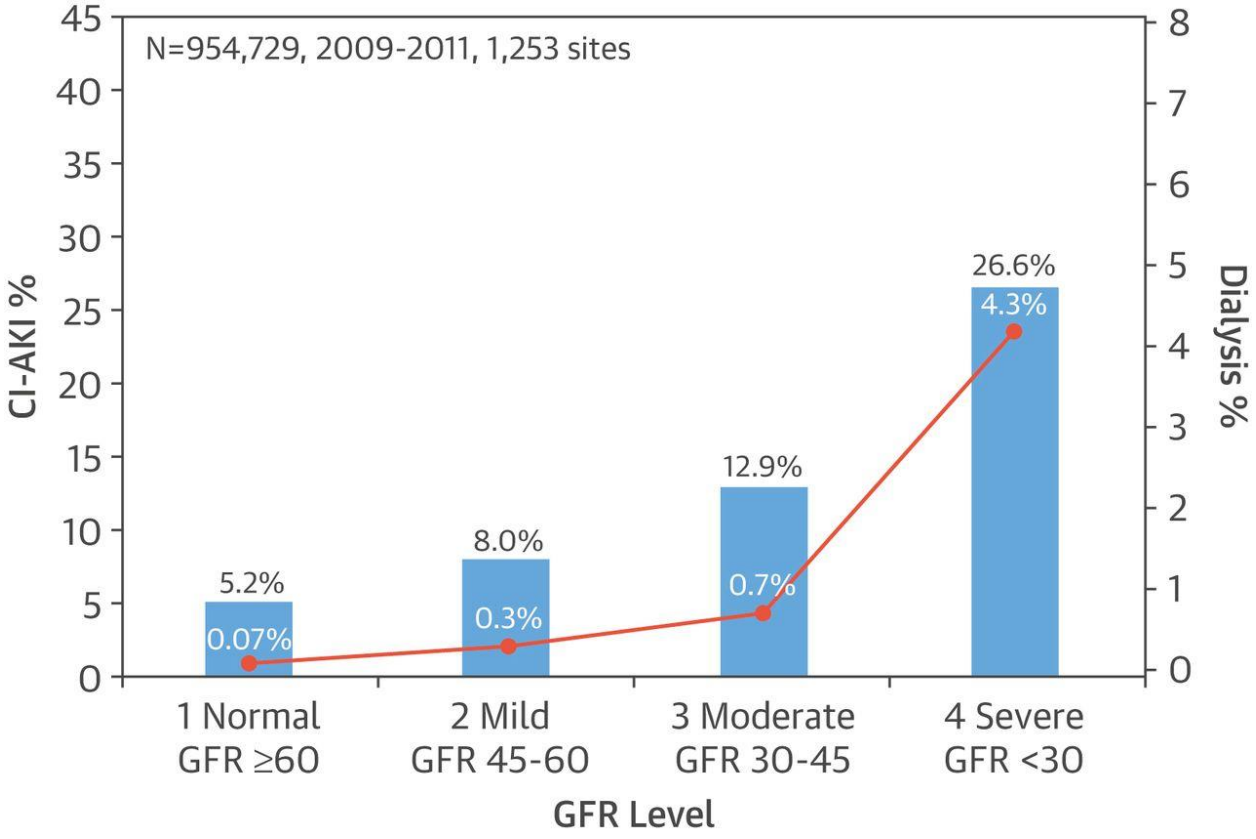
A number of prophylactic pharmacological agents have been investigated; however, at present the evidence for benefit in CIN prevention is limited.

Originally one of the most promising agents, N-acetyl-cysteine (NAC), is inexpensive, well tolerated and has both antioxidant and vasodilatory properties. Several large RCTs have shown oral NAC at dose of 600 mg twice a day for 24 h pre procedure and post procedure reduces the incidence of CIN. However meta-analyses have failed to reach consensus, most likely due to clinical heterogeneity, variable reporting and publication bias in the included studies. As such the ESC guidelines recommend that NAC is not to be used alone, although it may be used in addition to standard intravenous hydration regimes. More recently high-dose statin therapy (eg, rosuvastatin 40/20 mg, atorvastatin 80 mg or simvastatin 80 mg) has shown efficacy in preventing CIN in statin-naïve patients in several clinical studies and as such is regarded as reasonable preventative therapy in the current ESC guidelines. Other pharmaceutical agents with antioxidant (eg, ascorbic acid) and vasodilatory properties have also been investigated and although some have shown promise, further evaluation is required.

CIN represents a significant clinical and health economic problem that may be under-recognized through limitations in the currently available biomarkers. Although often a transient injury, CIN may progress to significant persistent renal impairment, ESRF and adverse cardiovascular outcomes. There are a number of recognized risk factors, although the prediction of CIN, particularly prior to contrast administration, remains challenging. Current

interventions are largely centered on the avoidance of dehydration, the withdrawal of nephrotoxic agents and minimization of contrast load, which has limited efficacy in preventing CIN in vulnerable patients. The unmet clinical need in CIN therefore resides in accurate prediction, effective intervention and rapid detection to prevent adverse cardiorenal outcomes. Each of these areas, particularly predictive risk scoring systems, innovative pharmacological and mechanical interventions and novel biomarkers are currently the subject of intensive research and development that may lead to the future development effective strategies to mitigate the risk of CIN.

Incidence of CI-AKI and New ESRD Requiring Dialysis From the ACC Cath-PCI Registry



CORONARY ANGIOGRAPHY:

Among the recent inventions cardiac Catheterization has become a standard medical procedure, which allows us to use all those physiologic data acquired through it to guide treatment; also to guide in measuring cardiovascular hemodynamics such as pressures, cardiac output, and oximetry data; thereby help us to get an accurate radiographic images of coronary arteries and cardiac chambers; and even it can be used to examine the aorta, pulmonary veins, and peripheral vessels and major vessels for diseases, anomalies, or obstructions.

- To visualize coronary arteries, branches, collaterals and anomalies
- Precise localization relative to major and minor side branches, thrombi and areas of calcification
- To visualize vessel bifurcations, origin of side branches and specific lesion characteristics (length, eccentricity, calcium etc)

INDICATIONS:

1. Diagnosis of CAD in clinically suspected pts.
2. Providing peri-interventional information for percutaneous coronary intervention
3. Coronary anomalies

4. In various non cardiac surgeries to rule out stenotic lesions of the valves(valve surgery after 40 yrs of age)

5. Determine patency of coronary artery bypass grafts

 In patients with non–ST-segment elevation acute coronary syndromes with high-risk features (e.g., ongoing ischemia, heart failure)

 In patients with acute ST-segment elevation myocardial infarction (STEMI)

 Primary percutaneous intervention (PCI) is usually performed in the same procedure, immediately after the diagnostic procedure.

CONTRAINDICATIONS:

Absolute contraindications	**Relative contraindications**
Inadequate equipment or catheterization facility	Acute gastrointestinal bleeding or anemia Anticoagulation (or known uncontrolled bleeding diathesis) Electrolyte imbalance Infection/fever Medication intoxication (eg, digitalis, phenothiazine) Pregnancy

	Recent cerebral vascular accident (>1 month) Renal failure Uncontrolled congestive heart failure, high blood pressure, arrhythmias Uncooperative patient

VASCULAR ACCESS:

A variety of vascular approaches are available for coronary arteriography. The selection of the vascular access depends on operator and patient preferences, anticoagulation status, and presence of peripheral vascular disease.

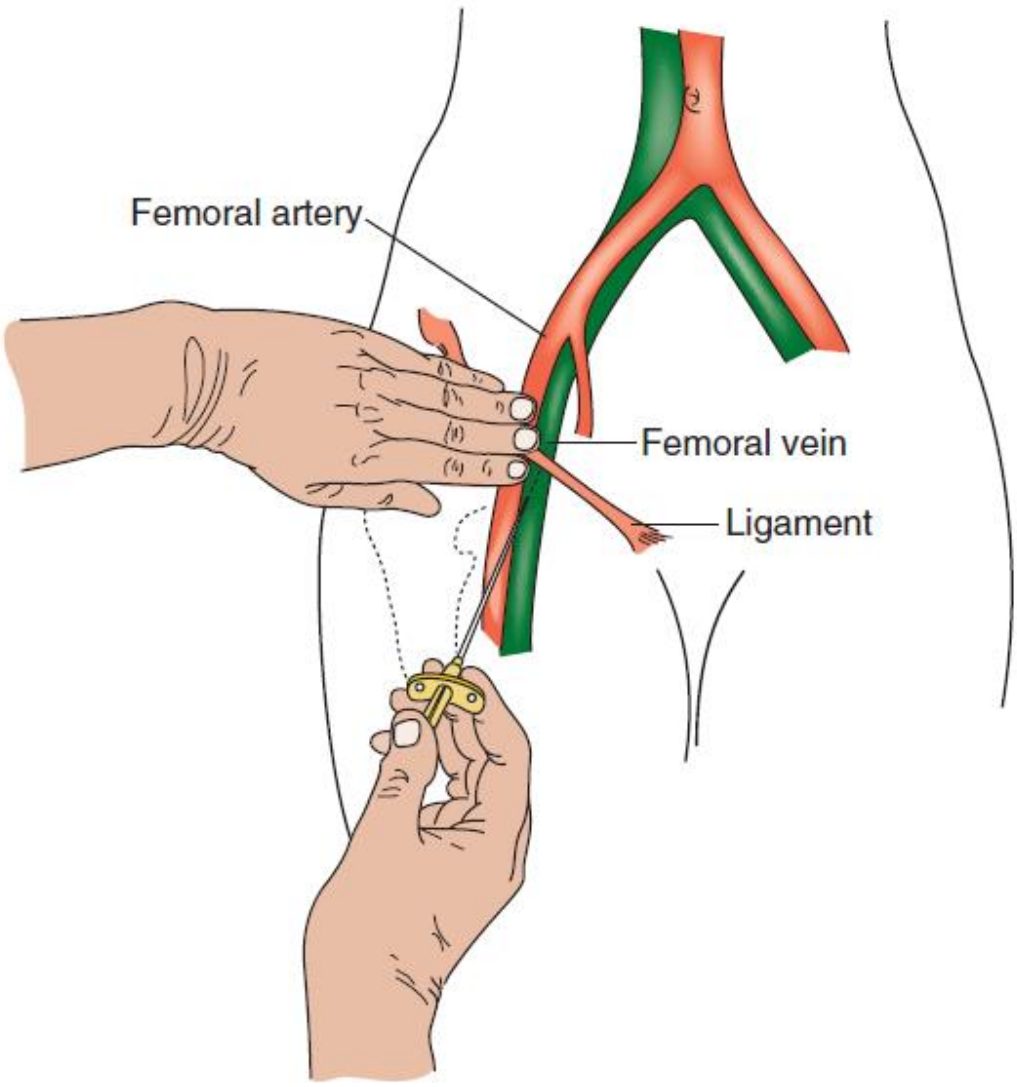
Arterial	**Venous**
axillary Brachial Femoral Radial Subclavian—not used for cardiac catheterization Translumbar—not used for cardiac catheterization	Brachial Femoral Internal jugular Subclavian

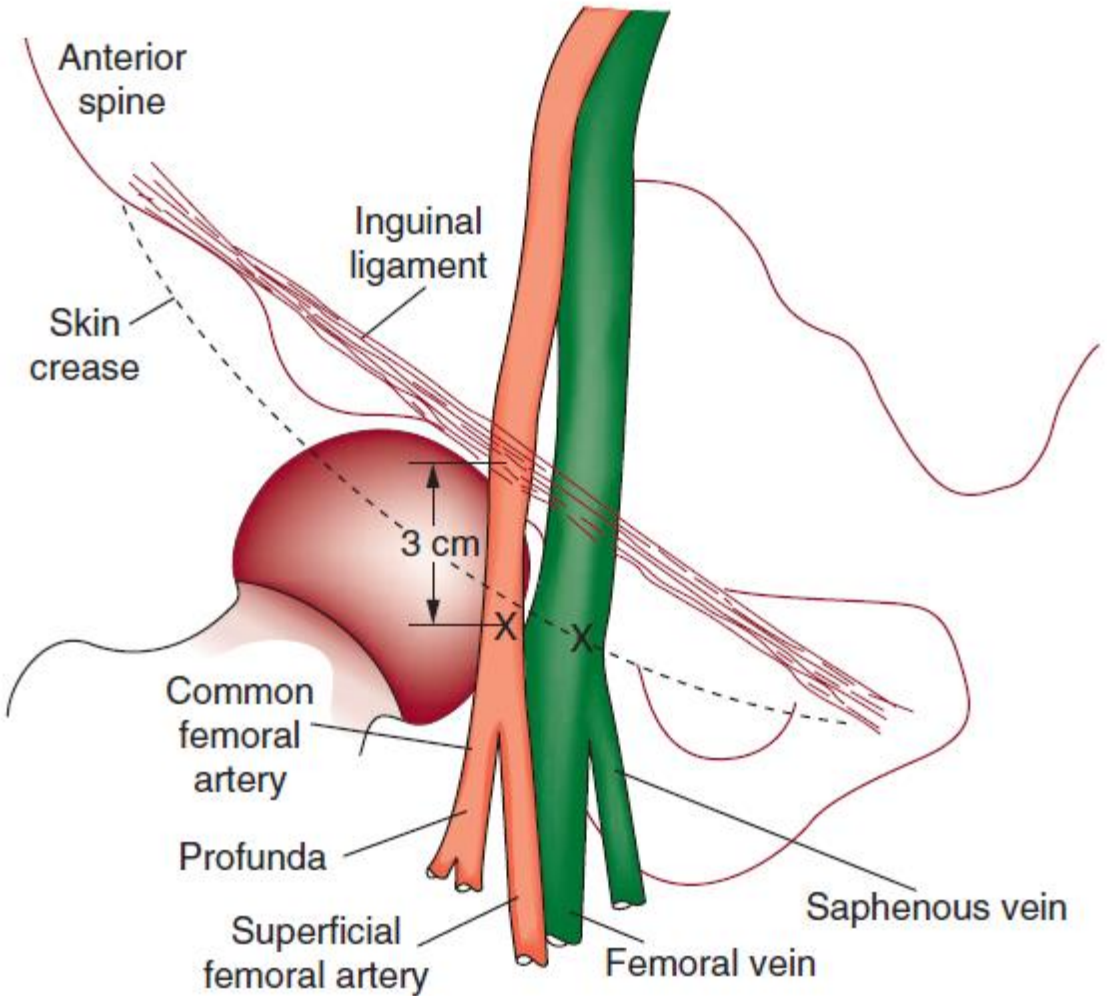
Femoral Artery Approach:

The right and left femoral arteries are the most commonly used access sites for coronary arteriography. The common femoral artery courses medially to the femoral head, and the bifurcation of the common femoral artery into its branches generally is distal to the middle third of the femoral head, which can be localized by means of fluoroscopy before arterial cannulation. The anterior wall of the common femoral artery should be punctured several centimeters below the inguinal ligament but proximal to the bifurcation of the superficial femoral and profunda arterial branches. If the puncture site is proximal to the inguinal ligament, hemostasis after the procedure may be difficult to achieve with manual compression, leading to an increased risk of retroperitoneal hemorrhage. If the puncture site is at or distal to the femoral bifurcation, the procedure carries a higher risk of pseudoaneurysm formation after sheath removal. Ipsilateral cannulation of the femoral artery and femoral vein also is associated with increased risk of arteriovenous fistula formation. Optimal femoral artery cannulation can be facilitated with vascular ultrasound guidance.

Femoral artery sheaths can be removed when the activated clotting time is less than 180 seconds. Patients should be confined to bed rest for 1 to 2 hours after the removal of a 4F or 5F sheath and for 2 to 4 hours after the removal of a 6F to 8F sheath, or longer if there is higher risk of bleeding. Vascular closure devices

also may be used, provided that a femoral angiogram confirms presence of the sheath in the common femoral artery.





Brachial Artery Approach:

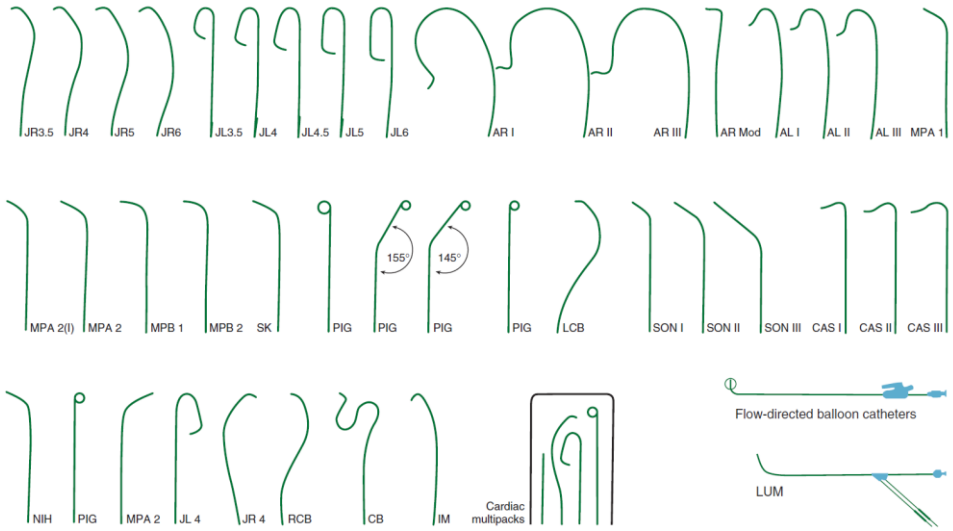
Although Sones first introduced the cutdown approach to the brachial artery for coronary arteriography, percutaneous access to the brachial and radial arteries is now most often used. In cases of severe peripheral artery disease and in morbid obesity where femoral approach is difficult this approach can be used instead.The brachial artery easily accommodates an 8F (1F = 0.33-mm diameter) sheath. A specific risk associated with the brachial artery approach is compromise

of the blood supply to the forearm and hand in the event of a vascular complication.

Radial Artery Approach:

Radial artery access generally is preferred to brachial access because of its ease of catheter entry and removal and the dual blood supply with the ulnar artery to the hand. The radial artery is an increasingly utilized access site for coronary arteriography, now used in up to 20% of diagnostic procedures in the United States. An Allen test is performed before the procedure to determine the adequacy of ulnar arterial flow, using plethysmography or assessment of palmar hand color during manual compression of the radial artery. Systemic anticoagulation with unfractionated heparin (up to 5000 units) or bivalirudin is used for both brachial and radial artery approaches. Use of a hydrophilic sheath and intra-arterial administration of verapamil and nitroglycerin will reduce the occurrence of radial artery spasm, although rare episodes of radial artery trauma and avulsion have been reported. The long-term radial artery patency rate also may be improved with use of a compression device that allows perfusion of the hand during hemostasis. Several anatomic factors are associated with an unsuccessful trans radial access, including a high bifurcation radial origin, full radial loop, and extreme radial artery tortuosity.

TIP CONFIGURATIONS FOR VARIOUS CATHETERS USEFUL IN CORONARY ARTERIOGRAPHY:



. AL = Amplatz left; AR = Amplatz right; CAS = Castillo; CB = coronary bypass catheter; IM = internal mammary; JL = Judkins left; JR = Judkins right; LCB = left coronary bypass graft; LUM = lumen; Mod = modified; MP = multipurpose; NIH = National Institutes of Health; PIG = pigtail; RCB = right coronary bypass graft; SON = Sones

COMPLICATIONS:

After diagnostic catheterization, the risk of death, <0.2%; risk of myocardial infarction, <0.05%; risk of stroke, <0.07%; risk of serious ventricular arrhythmia, <0.5%; and major vascular complications (thrombosis, bleeding requiring transfusion, or pseudoaneurysm), are found from many major studies across the world <1%. Vascular complications are more frequent when the brachial approach is used. Risks are higher in well described subgroups.

Major	**Other**
Cerebrovascular accident Death Myocardial infarction Ventricular tachycardia, fibrillation, or serious arrhythmia	Aortic dissection Cardiac perforation, tamponade Congestive heart failure Contrast reaction /anaphylaxis /nephrotoxicity Heart block, asystole Hemorrhage (local, retroperitoneal, pelvic) Infection Protamine reaction Supraventricular tachyarrhythmia, atrial fibrillation Thrombosis/embolus/air embolus Vascular injury, pseudoaneurysm Vasovagal reaction

PREDICTORS OF ADVERSE OUTCOME:

Thrombus
Bypass graft
Left main trunk
Lesion >20 mm in length
Excessive tortuosity of proximal segment
Extremely angulated lesions >90'
Total occlusion >3 months old and/or bridging collaterals
Inability to protect major side branches
Degenerated vein grafts with friable lesions
Unprotected left main trunk

PITFALLS IN CORONARY ARTERIOGRAPHY:

There are a number of pitfalls in coronary arteriography that should be avoided.

Short Left Main or Double Left Coronary Orifices:

When the left main orifice is very short or absent, selective injection of the anterior descending or circumflex arteries may be done. The absence of circumflex or anterior descending artery filling, either primarily or through

collaterals from the right coronary artery, may indicate that the artery was missed by subs elective injection, or an anomalous location.

Ostial Lesions:

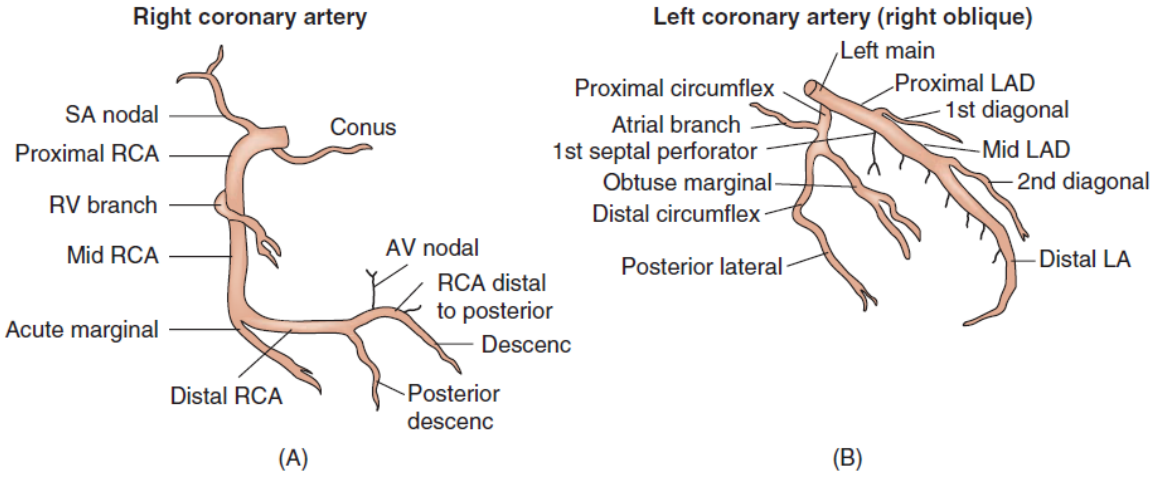
The left and right coronary artery orifices need to be seen on a tangent with the aortic sinuses. Some contrast reflux from the orifices is needed to fully opacify the ostium to see whether an ostial narrowing is present. Catheter pressure damping is an additional indication of an ostial stenosis.

Myocardial Bridges:

The anterior descending, diagonal, and marginal branches occasionally run intramyocardial. The overlying myocardium may compress the artery during systole. If the coronary artery is not viewed carefully in diastole, this bridging may give the appearance of an area of stenosis.

Foreshortening:

Foreshortening is the viewing of a vessel in plane with its long axis. Vessels seen on end cannot display a lesion along its length. When possible, arteries that are seen coming toward or away from the image intensifier should be viewed in angulated (cranial/ caudal) views. Dense opacification of segments seen end-on-end may produce the appearance of a lesion in an intervening segment.



Coronary Spasm:

Catheter-induced spasm may appear as a lesion. When spasm is suspected (usually at the catheter tip in the right coronary artery), intracoronary nitroglycerin (100-200 μg) should be given, and the angiogram should be repeated in 1 to 2 minutes.

Spontaneous coronary artery:

spasm may also present as an atherosclerotic narrowing. When this is suspected, an angiogram is obtained before and after administration of nitrates. If clinically indicated, provocation with ergot derivatives will identify most patients with spontaneous coronary artery spasm.

Totally Occluded Arteries or Vein Grafts:

Absence of vascularity in a portion of the heart may indicate total occlusion of its arterial supply. Collateral channels often permit visualization of the distal occluded artery. Vessels filled solely by collaterals are under low

pressure and may appear smaller than their actual lumen size. This finding should not exclude the possibilities for surgical anastomosis.

Anomalous Coronary Arteries:

Coronary arteries may arise from anomalous locations, or a single coronary artery may be present. Only by ensuring that the entire epicardial surface has an adequate arterial supply can one be confident that all branches have been visualized. Misdiagnosis of unsuspected anomalous origin of the coronary arteries is a potential problem for any angiographer. Because the natural history of a patient with an anomalous origin of a coronary artery may be dependent on the initial course of the anomalous vessel, it is the angiographer's responsibility to define accurately the origin and course of the vessel. It is an error to assume a vessel is occluded when in fact it has not been visualized because of an anomalous origin. It is often difficult even for experienced angiographers to delineate the true course of an anomalous vessel. For the most critical anomaly, the anomalous left main artery originating from the right cusp, a simple dot and eye method for determining the proximal course of anomalous artery from an RAO ventriculogram, an RAO aortogram, or selective RAO injection is proposed. The RAO view best separates the normally positioned Ao and PA. Placement of right-sided catheters or injection of contrast in the PA is unnecessary and often misleading. Alternative imaging modalities such as MRI

angiography or CT angiography can provide information on the course of anomalous coronary arteries and their relationship to surrounding structures.

RENAL DOPPLER ULTRASONOGRAPHY:

Renal vasoconstriction is the major pathology behind AKI. This renal vasoconstriction can be assessed using Doppler ultrasound of the renal arteries by using an index called renal resistive index (RI). This value is derived from the spectral waveforms corresponding to the flow at the renal arteries and is determined using the formula

$$\textbf{Renal Resistive Index} = \frac{\text{Peak systolic frequency shift - Lowest diastolic frequency shift}}{\text{Peak systolic frequency shift}}$$

RI in AKI is increased when compared to the normal population. And studies have shown that a high RI value (more than 0.7) can be documented in patients prone for CIN AKI, even in whom RFT is normal.

It has also been shown that normally RI exhibits a gradient decreasing from the hilum towards the outer cortex. However raised RI does not differentiate whether the cause of renal dysfunction is due to vasoconstriction alone or if it is associated with intrinsic kidney damage.

MATERIALS AND METHODS

STUDY POPULATION:

- The study will be conducted in 100 patients admitted in government Rajaji hospital and Madurai medical college, for purpose of elective coronary angiography, during the study period from March 2018 to August 2018.

INCLUSION CRITERIA:

- Stable angina with positive treadmill test
- ST elevation acute coronary syndrome after thrombolysis
- Non ST elevation acute coronary syndrome
- Unstable angina

EXCLUSION CRITERIA:

- Significant hemodynamic instability (cardiogenic shock; killip class>2; catecholamine use)
- Respiratory failure (acute or chronic; blood oxygen saturation<90%)

- Severe heart failure with left ventricular ejection fraction (LVEF<35%)
- chronic kidney disease (with eGFR < 50 mL/min/1.73 m2 or proteinuria >500 mg/L)
- evidence of renal artery stenosis or hydronephrosis
- moderate to severe aortic valve stenosis
- severe valvular heart disease of any kind
- severe obesity (body mass index, BMI > 40 kg/m2)
- liver dysfunction (any hepatic aminotransferase >3× upper reference limit)
- age <18 or >80 years old

ANTICIPATED OUTCOME:

- Baseline renal resistive index is higher in patients who developed contrast induced acute kidney injury following elective coronary angiography, suggesting the superior predictive value of renal resistive index for predicting acute kidney injury due to contrast administration, even when the pre procedural RFT was normal.

DATA COLLECTION:

- After confirmation of diagnosis and explaining the purpose & procedure of study , written informed consent in Tamil will be obtained. The selected patients will be evaluated as per pro forma.
- Serum urea and serum creatinine will be taken at the time of admission. Ultrasonography and renal doppler for measuring renal resistive index will be taken prior to coronary angiography. Serum urea and serum creatinine will be taken 24 hours and 48 hours post procedure

DESIGN OF STUDY: Prospective analytical study.

PERIOD OF STUDY: March 2018 to August 2018

COLLABORATING DEPARTMENTS:

Department of Biochemistry

Department of Radiology

Department of Cardiology

ETHICAL CLEARANCE: Approved

CONSENT: Individual written and informed

ANALYSIS: STATISTICAL METHODS:

The data collected during the study was formulated into a master chart in Microsoft office excel and statistical analysis was done with help of computer using statistical software package SPSS V.17 for windows. Using this software, frequencies, range, mean, standard deviation and 'p'were calculated through student 't' test, one way ANOVA, pearson correlation and chi square test .

P value of < 0.05 was taken as significant.

CONFLICT OF INTEREST: NIL

FINANCIAL SUPPORT: NIL

PARTICIPANTS: Patients of age>18yrs, admitted as in-patients at Govt.Rajaji hospital, Madurai who are electively subjected for coronary angiography.

PROFORMA

ACCURACY OF PRE-PROCEDURAL RENAL RESISTIVE INDEX IN PREDICTING CONTRAST INDUCED ACUTE KIDNEY INJURY IN PATIENTS WITH PRESERVED RENAL FUNCTION SUBMITTED TO ELECTIVE CORONARY ANGIOGRAPHY

PARTICULARS OF THE PATIENT:

Name:

Case no:

Age/ Sex:

I.P. no:

Address:

Date of admission:

Date of discharge:

Final diagnosis:

COMPLAINTS WITH DURATION:

Past history: DM Y/N HTN Y/N CAD Y/N

CKD Y/N CLD Y/N

Personal history: SMOKING Y/N ALCOHOL Y/N

Family history:

On Examination,

Vital signs Pulse: B.P.: R.R.:

SpO2: Temperature:

CVS:

RS:

ABDOMEN:

CNS:

INVESTIGATION:

a) Complete blood count
b) Renal function test
c) Liver function test
d) Serum electrolyte
e) Serum calcium
f) Electrocardiogram
g) Urine examination for albumin, sugar, deposits
h) Echocardiography
i) Ultrasonography abdomen and pelvis
j) Renal artery duplex doppler

RENAL RESISTIVE INDEX-

RIGHT KIDNEY	LEFT KIDNEY

SERUM CREATININE-

PRE-PROCEDURE	24 HOURS POST-PROCEDURE	48 HOURS POST-PROCEDURE

INTAKE/OUTPUT CHART-

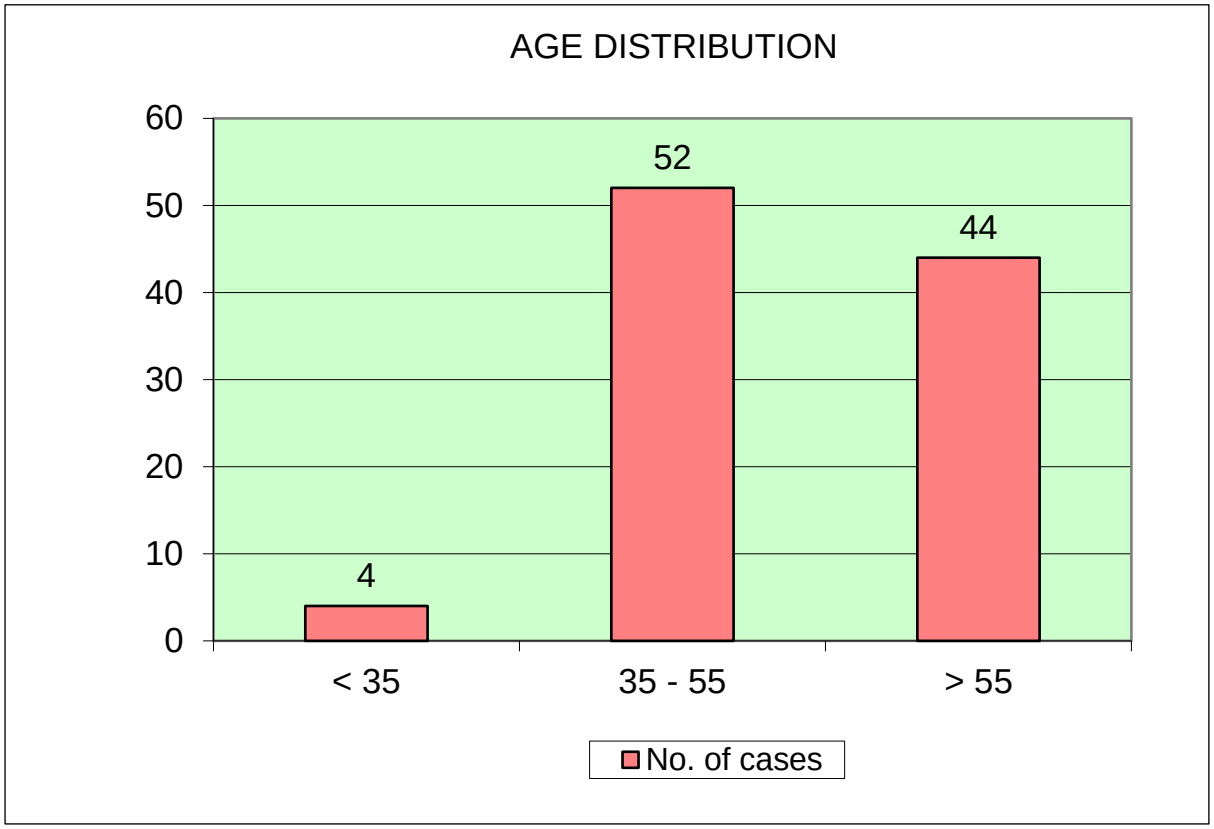
PRE-PROCEDURE	24 HOURS POST-PROCEDURE	48 HOURS POST-PROCEDURE

STATISTICAL ANALYSIS

A total of 100 patients who were admitted in GRH with STEMI and NSTEMI for favour of coronary angiography.

TABLE 1: AGE DISTRIBUTION

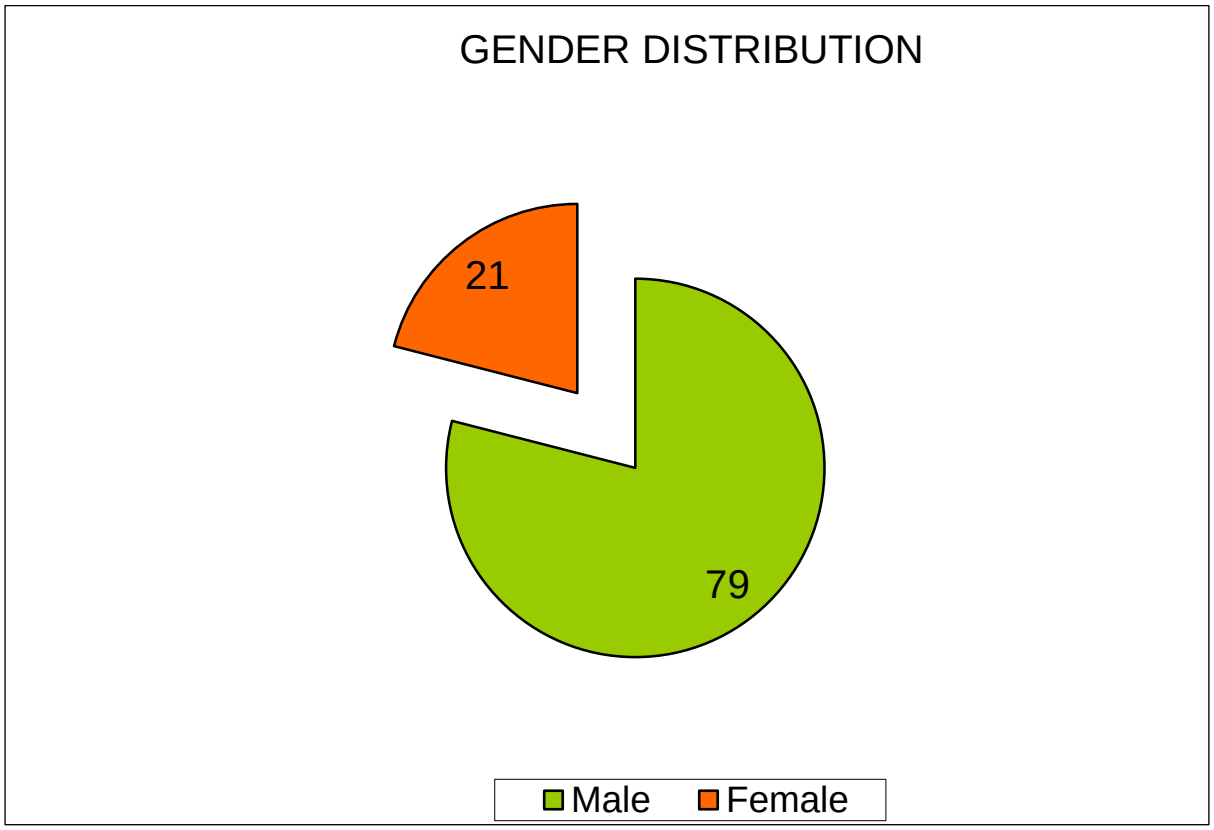
Age	No. of cases
< 35	4
35 - 55	52
> 55	44
Total	100



In our study we found that most of the patients were of the age group between 35 to 55 years of age, 52%. The least number of cases were of age group <35 years of age, 4%.

TABLE 2: SEX DISTRIBUTION:

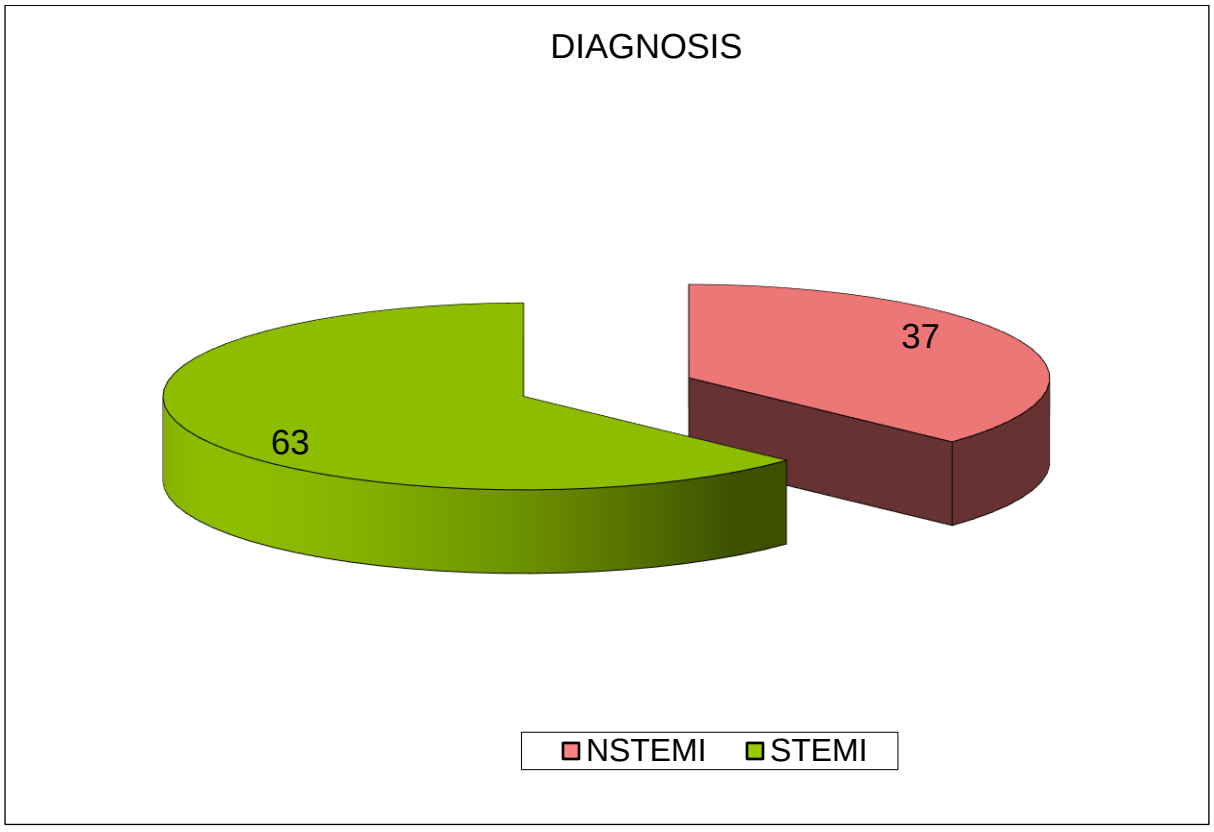
SEX	No. of cases
Male	79
Female	21
Total	100



In our study we found that most of the patients were male patients comprising of about 79% and the other sex female is of 21%. Thus this Makes male sex a risk factor for MI and for CIN AKI.

TABLE 3: PRESENTATION OF MYOCARDIAL INFARCTION:

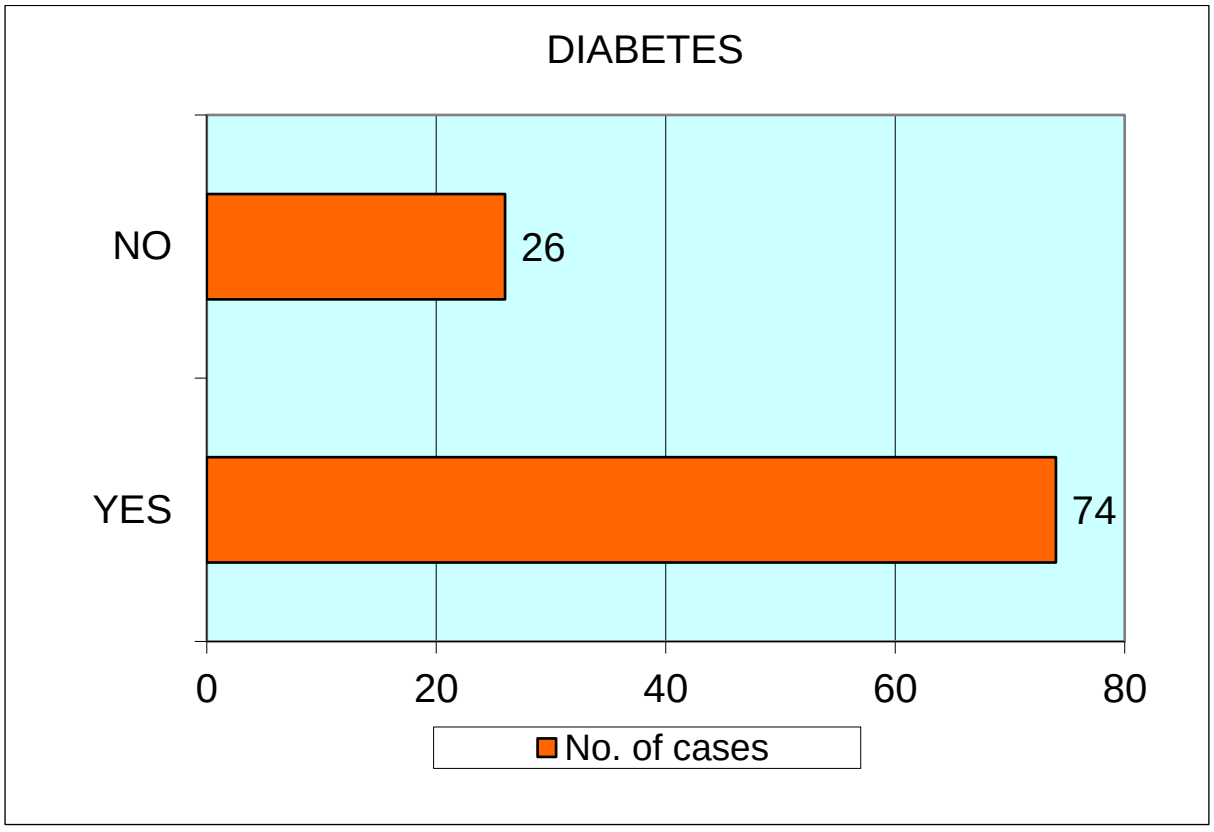
DIAGNOSIS	No. of cases
NSTEMI	37
STEMI	63
Total	100



STEMI comprised most of the cases in our study, about 63%. This has significance because the presentation is earlier and the complications are comparatively more in STEMI. The other 37% is made by NSTEMI.

TABLE 4: INCIDENCE OF DIABETES

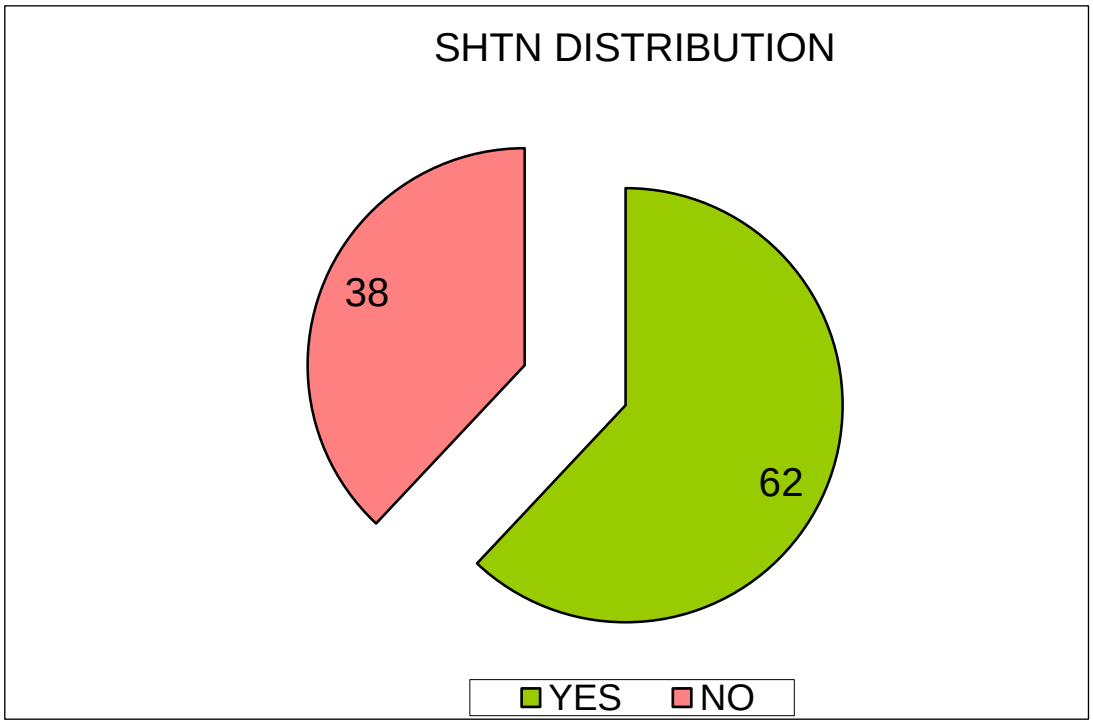
DIABETES	No. of cases
YES	74
NO	26
Total	100



74% of patients in this study are diabetic and rest are non diabetic. This is significant because this being a cause for atherosclerosis has more effect on intra renal vasculature. Leading to increased risk of AKI after contrast study.

TABLE 5: INCIDENCE OF HYPERTENSION

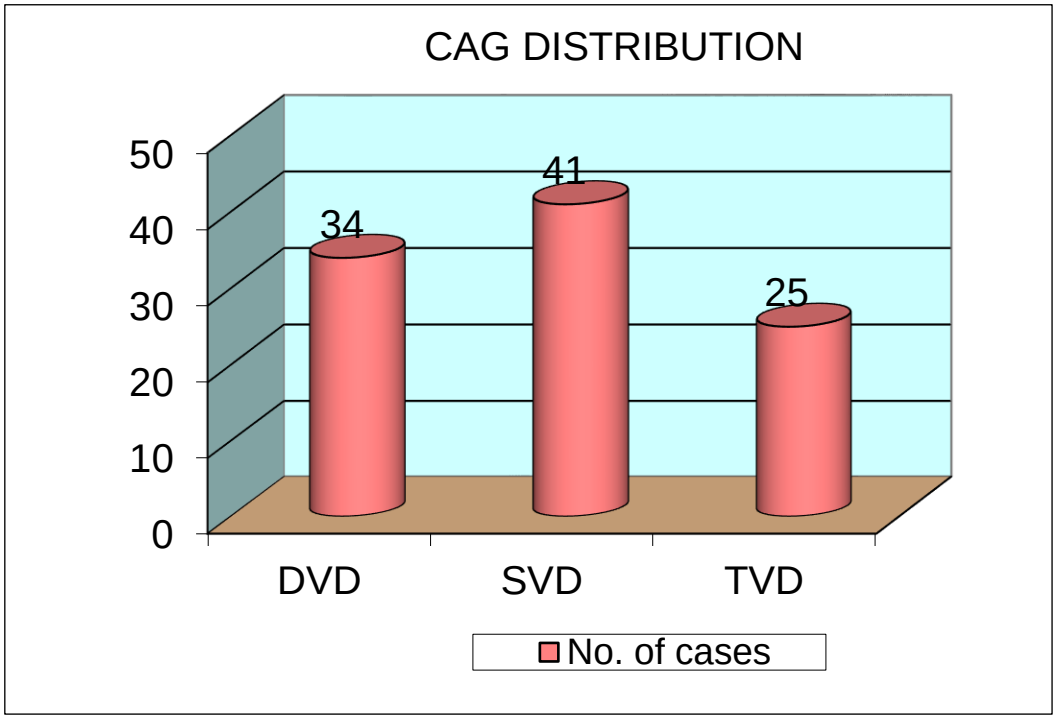
SHTN	No. of cases
YES	62
NO	38
Total	100



62% of the patients are hypertensive making hypertension an important etiology for myocardial infarction and atherosclerosis. This makes the intra renal arteries and arterioles stiff and less pliable, making these patients more prone for CIN AKI.

TABLE 6: CAG DIAGNOSIS:

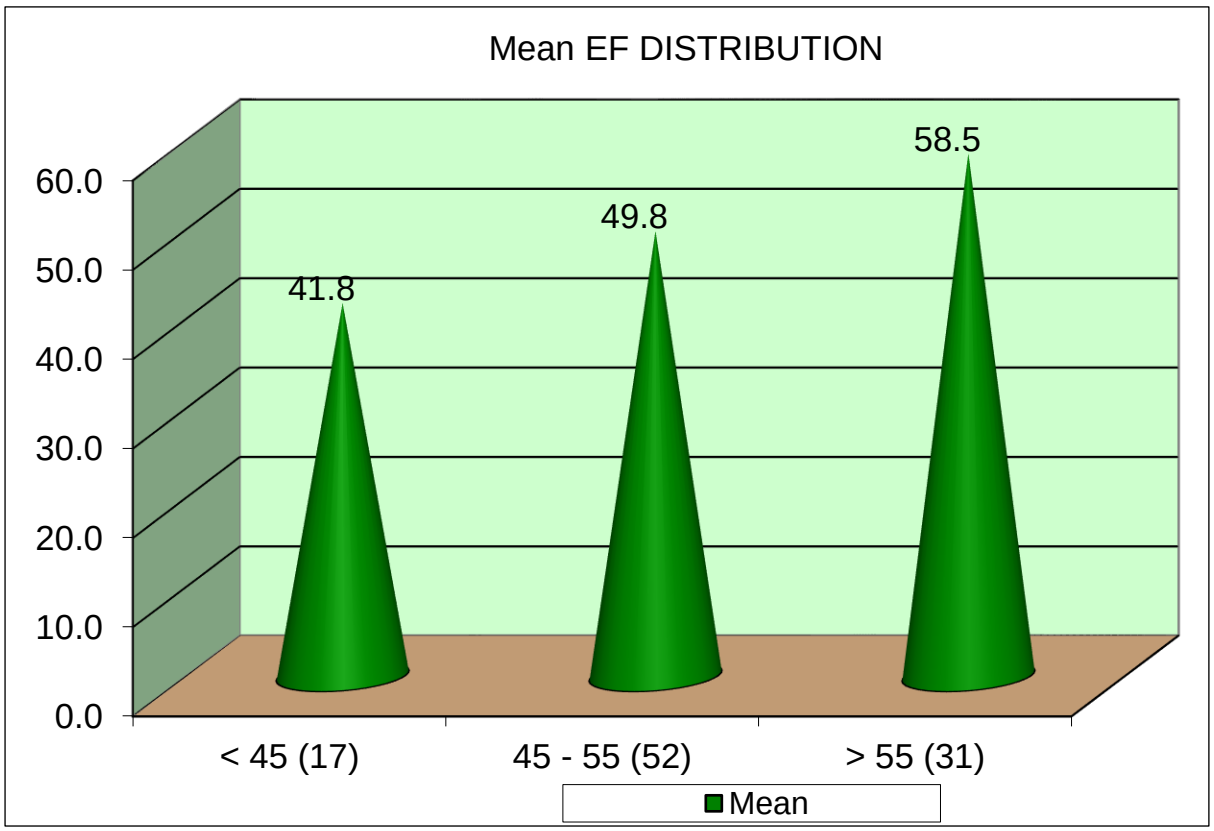
CAG	No. of cases
DVD	34
SVD	41
TVD	25
Total	100



25% of patients had diagnosis of triple vessel disease leading to more referral for coronary artery bypass graft. So these represent more extensive disease. 42% that is the majority of patients were single vessel disease so they are made to undergo either optimal medical treatment or CABG.

TABLE 7: EJECTION FRACTION AMONG STUDY POPULATION:

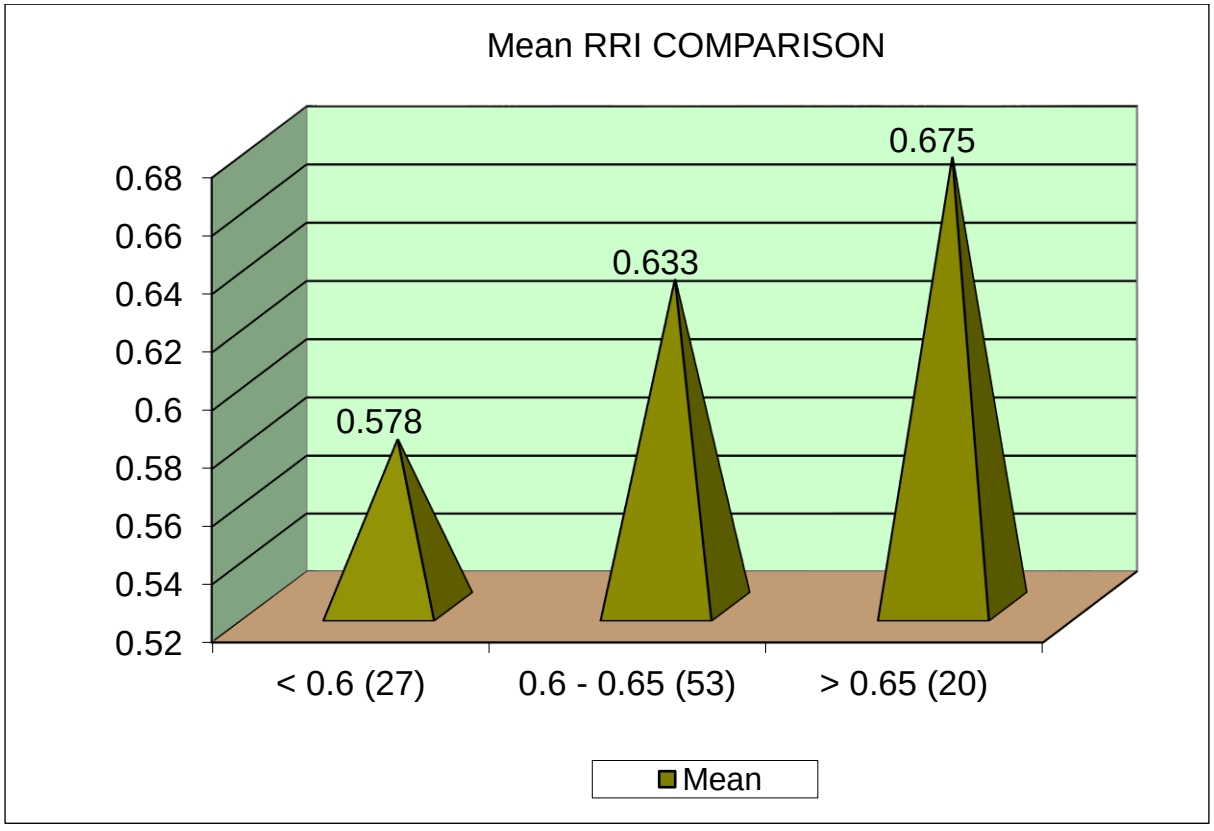
EF	Mean	S.D
< 45 (17)	41.8	1.147
45 - 55 (52)	49.8	3.485
> 55 (31)	58.5	2.014



It has been observed in our study that most of the patients in study population belong to ejection fraction of >45%. Those with ejection fraction of <35% are excluded from our study as it may lead to false elevation of RFT due to hypoperfusion of kidney.

TABLE 8: PRE PROCEDURAL RENAL RESISTIVE INDEX:

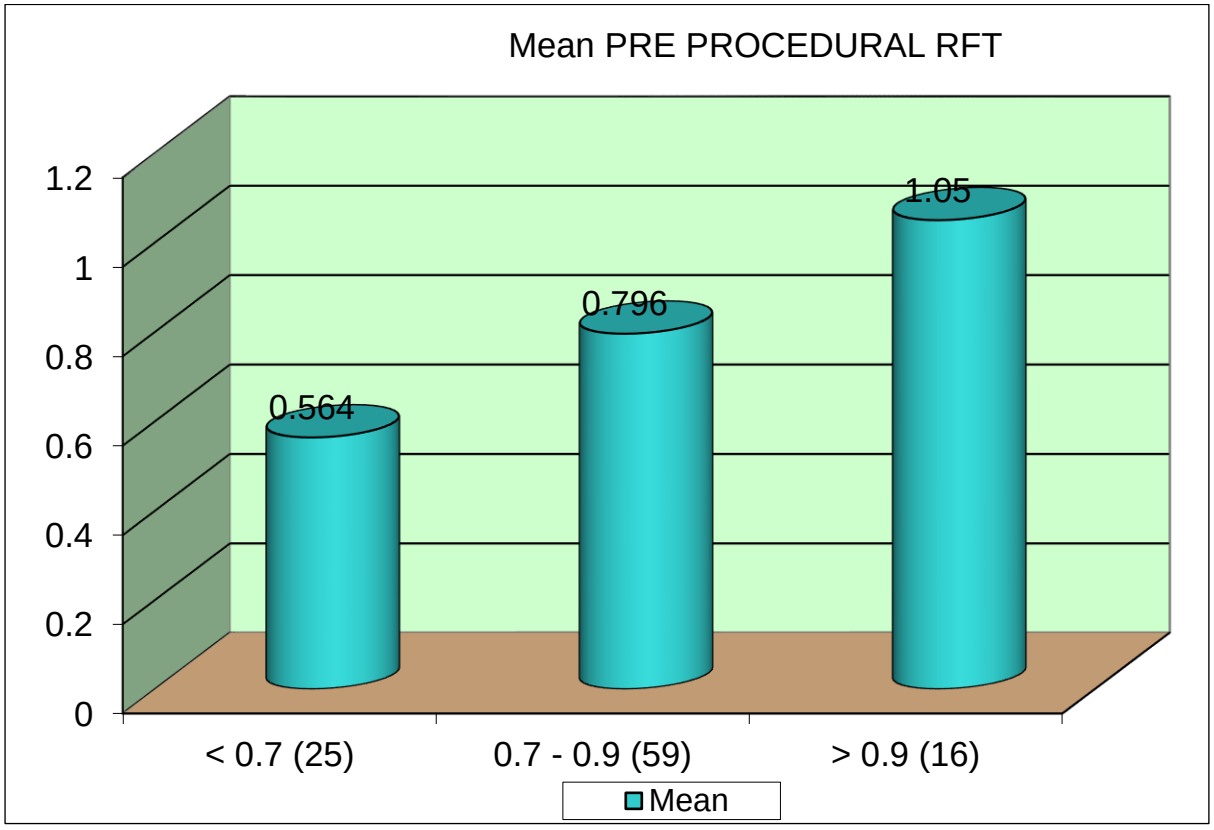
RRI	Mean	S.D
< 0.6 (27)	0.578	0.015
0.6 - 0.65 (53)	0.633	0.0171
> 0.65 (20)	0.675	0.0228



The mean value of renal resistive index found in our study was 0.633±0.0171 comprising about 53 patients. But those whose had RRI value more than 6.5 was about 20. And among them 6 had values more than 0.69 which is the cut off for our study.

TABLE 9: PRE PROCEDURAL RFT VALUES:

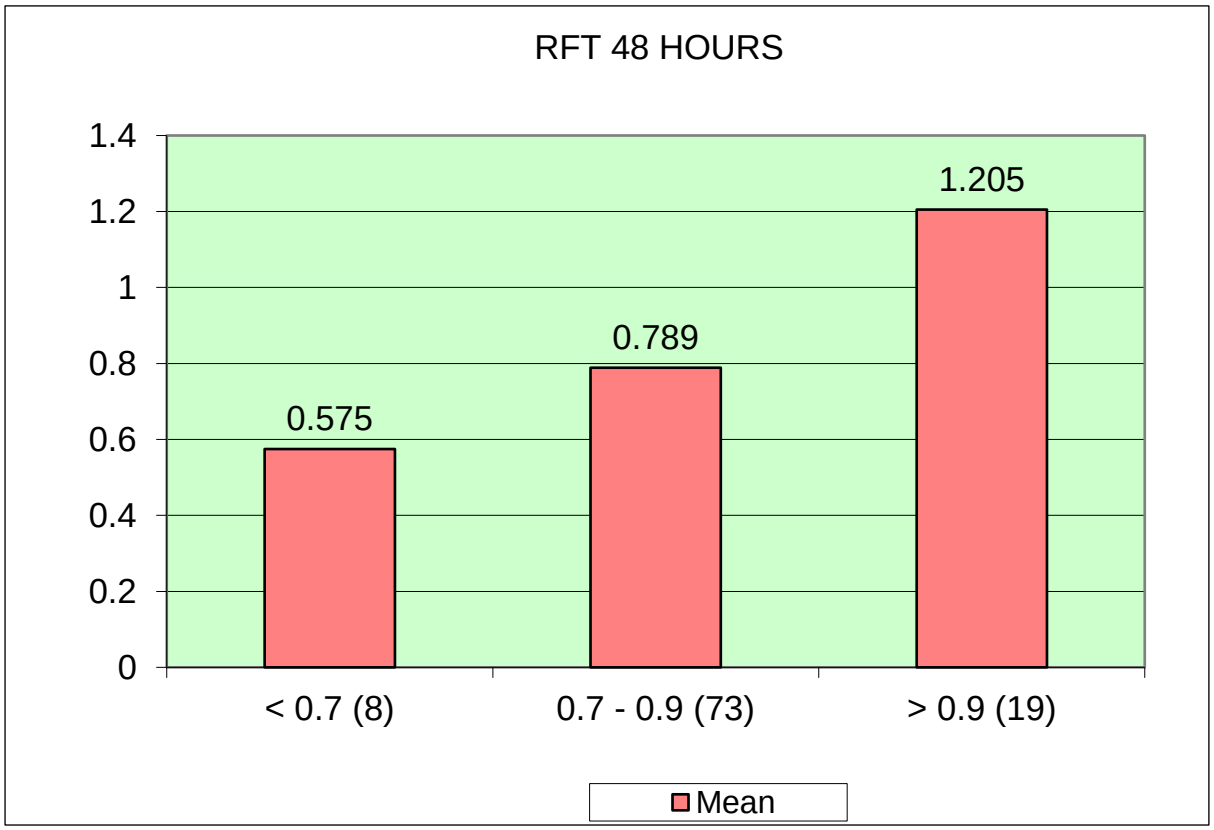
PRE PROCEDURAL RFT	Mean	S.D
< 0.7 (25)	0.564	0.0569
0.7 - 0.9 (59)	0.796	0.0809
> 0.9 (16)	1.05	0.0516



Here the pre procedural renal function test values are compared with the maximum patients belong to value of 0.7 to 0.9mg/dl. More than 1.5mg/dl were excluded as it may have a confounding effect. And only 16 patients had values more than 0.9 mg/dl.

TABLE 10: RFT AT 48 HOURS (POST PROCEDURE):

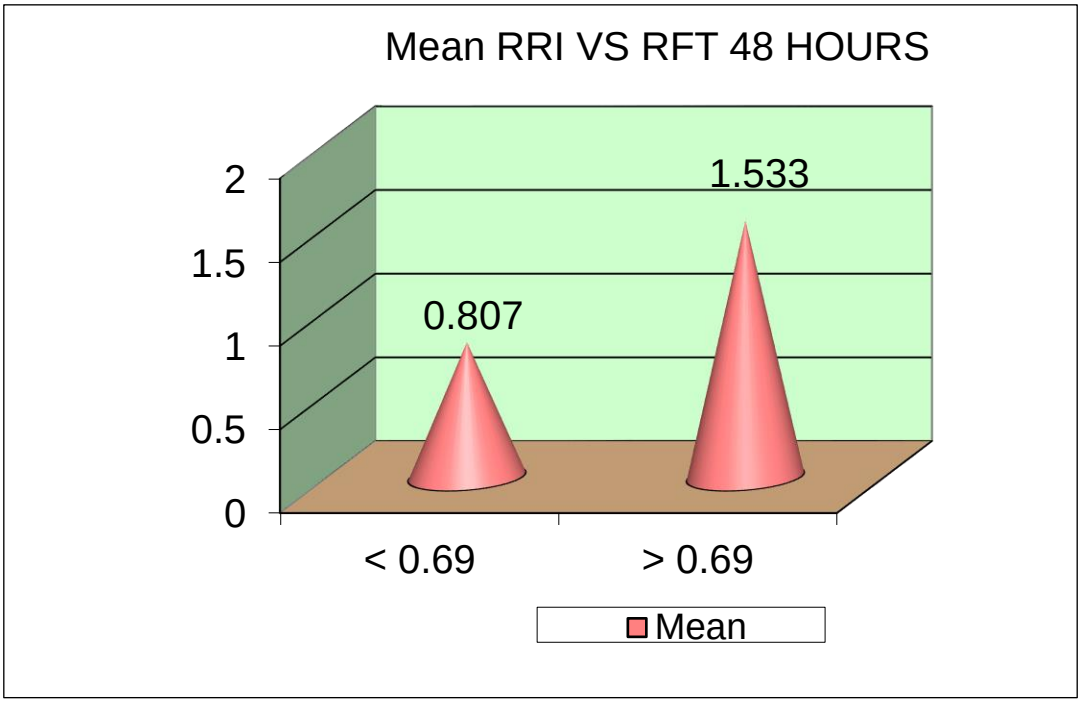
RFT48 HOURS	Mean	S.D
< 0.7 (8)	0.575	0.0463
0.7 - 0.9 (73)	0.789	0.0891
> 0.9 (19)	1.205	0.234



After administration of contrast for coronary angiography, the renal function test is done at 48 hours and it is the main comparison for our study.73 patients had no significant elevation of RFT that is they are maintained within the limits of 0.7 to 0.9 mg/dl. And more than 0.9 mg/dl is found in 19 patients.

TABLE 11: COMPARISON BETWEEN PRE PROCEDURAL RRI AND 48 HOUR RFT(POST PROCEDURE):

RRI vs RFT48 HOURS		
RRI vs RFT48 HOURS	< 0.69	> 0.69
Mean	0.807	1.533
S.D	0.142	0.0516
p' value	<0.001	Significant



The main result that we infer from our study is that on comparing the pre procedural renal resistive index with renal function test done at 48 hours is seen significant as compared with all studies from all over world. The mean serum creatine at 48 hours after contrast study is found to be 1.533 mg/dl ($p<0.001$). This makes our study significant.

DISCUSSION

The frequency of contrast induced acute kidney injury varies from 3 to 13% of patients posted for coronary angiographies, which has increased mortality and morbidity.

Intra renal vascular resistance may act as an additive factor for tubular injury caused by contrast media in renal medulla- due to action of contrast media causing imbalance of intra renal vasoconstriction and vasodilator agents.

Vasoconstriction of afferent arteriole, due to adenosine, triggered by the contrast causing overstimulation of tubular glomerular feedback- may lead to increased renal vascular resistance.

Renal resistive index(RRI) acts as a predictor of intra renal arterial stiffness, indirectly indicating renal vascular resistance.

So renal resistive index(RRI) is indicative for susceptibility to acute kidney injury and contrast mediated renal injury.

A total of 100 patients who were admitted in GRH with STEMI and NSTEMI for favour of coronary angiography. In our study we found that most of the patients were of the age group between 35 to 55 years of age, 52%. The least number of cases were of age group <35 years of age, 4%. In our study we found that most of the patients were male patients comprising of about 79% and the

other sex female is of 21%. Thus this Makes male sex a risk factor for MI and for CIN AKI. STEMI comprised most of the cases in our study, about 63%. This has significance because the presentation is earlier and the complications are comparatively more in STEMI. The other 37% is made by NSTEMI. 74% of patients in this study are diabetic and rest are non diabetic. This is significant because this being a cause for atherosclerosis has more effect on intra renal vasculature. Leading to increased risk of AKI after contrast study. 62% of the patients are hypertensive making hypertension an important etiology for myocardial infarction and atherosclerosis. This makes the intra renal arteries and arterioles stiff and less pliable, making these patients more prone for CIN AKI. 25% of patients had diagnosis of triple vessel disease leading to more referral for coronary artery bypass graft. So these represent more extensive disease. 42% that is the majority of patients were single vessel disease so they are made to undergo either optimal medical treatment or CABG. It has been observed in our study that most of the patients in study population belong to ejection fraction of >45%. Those with ejection fraction of <35% are excluded from our study as it may lead to false elevation of RFT due to hypoperfusion of kidney. The mean value of renal resistive index found in our study was 0.633±0.0171 comprising about 53 patients. But those whoe had RRI value more than 6.5 was about 20. And among them 6 had values more than 0.69 which is the cut off for our study. Here the pre procedural renal function test values are compared with the maximum patients belong to value of 0.7 to 0.9mg/dl. More than 1.5mg/dl were excluded as it may

have a confounding effect. And only 16 patients had values more than 0.9 mg/dl. Here the pre procedural renal function test values are compared with the maximum patients belong to value of 0.7 to 0.9mg/dl. More than 1.5mg/dl were excluded as it may have a confounding effect. And only 16 patients had values more than 0.9 mg/dl. After administration of contrast for coronary angiography, the renal function test is done at 48 hours and it is the main comparison for our study.73 patients had no significant elevation of RFT that is they are maintained within the limits of 0.7 to 0.9 mg/dl. And more than 0.9 mg/dl is found in 19 patients. The main result that we infer from our study is that on comparing the pre procedural renal resistive index with renal function test done at 48 hours is seen significant as compared with all studies from all over world. The mean serum creatine at 48 hours after contrast study is found to be 1.533 mg/dl ($p<0.001$). This makes our study significant.

Baseline renal resistive index is higher in patients who developed contrast induced acute kidney injury following elective coronary angiography, suggesting the superior predictive value of renal resistive index for predicting acute kidney injury due to contrast administration.

SUMMARY

From our study we can conclude that baseline GFR and serum creatinine cannot predict the onset of CIN AKI. Moreover there is only limited treatment possibilities for CIN AKI, as it may also progress to ESRD in future. The major findings in our study is that,

- Out of 100 patients considered in our study, 79% of them are male, and most of them belong to age group of 35 to 55 years comprising of about 55%.
- 74% of the observed patients were diabetic and 62% of the observed patients were hypertensive. This makes these two as main risk factor for intra renal atherosclerosis and increased risk for AKI.
- 25% patients had triple vessel disease and 42% had single vessel disease. The maximum patients had ejection fraction of about >45%.
- The mean value of renal resistive index found in our study was 0.633±0.0171 comprising about 53 patients. But those who had RRI value more than 6.5 was about 20.
- The pre procedural renal resistive index with renal function test done at 48 hours is seen significant as compared with all studies from all over world. The mean serum creatine at 48 hours after contrast study is found to be 1.533 mg/dl ($p<0.001$).

LIMITATION

The current study was a single centre study. Furthermore, renal biopsy was not done for these patients for confirming the diagnosis. Confounding factor like delayed presentation and delayed or irregular treatment , poor glycemic control and poor adherence to anti hypertensives and anti hyperglycemia drugs and anginal drugs which may accelerate atherosclerosis and also lead to AKI which are not considered in this study.

.

CONCLUSION

Baseline GFR and serum creatinine cannot predict contrast induced acute kidney injury onset in patients with preserved renal function. But higher pre procedural renal resistive index(RRI) can be used as a novel risk factor for the above population.

It has better result in elderly, advanced peripheral and coronary atherosclerosis and type 2 diabetic patients.

So with RRI we can select individuals requiring more intense peri procedural hydration regimen, forced diuresis, cessation of nephrotoxic drug, statin loading dose prior to procedure, limiting the dose and duration of contrast administration and prolonged post procedure renal function monitoring.

BIBLIOGRAPHY

1. Rihal CS, Textor SC, Grill DE et al (2002) Incidence and prognostic importance of acute renal failure after percutaneous coronary intervention. Circulation 105:2259–2264

2. 2. Mehran R, Aymong ED, Nikolsky E et al (2004) A simple risk score for prediction of contrast-induced nephropathy after percutaneous coronary intervention: development and initial validation. J Am Coll Cardiol 44:1393–1399

3. Gurm HS, Seth M, Kooiman J, Share D (2013) A novel tool for reliable and accurate prediction of renal complications in patients undergoing percutaneous coronary intervention. J Am Coll Cardiol 61:2242–2248

4. Solomon RJ, Mehran R, Natarajan MK et al (2009) Contrastinduced nephropathy and long-term adverse events: cause and effect? Clin J Am Soc Nephrol 4:1162–1169

5. Vanmassenhove J, Vanholder R, Nagler E, Van Biesen W (2013) Urinary and serum biomarkers for the diagnosis of acute kidney injury: an in-depth review of the literature. Nephrol Dial Transplant 28:254–273

6. Tziakas D, Chalikias G, Stakos D et al (2014) Validation of a new risk score to predict contrast-induced nephropathy after percutaneous coronary intervention. Am J Cardiol 113:1487–1493

7. Kurihara O, Takano M, Uchiyama S et al (2015) Microvascular resistance in response to iodinated contrast media in normal and functionally impaired kidneys. Clin Exp Pharmacol Physiol 42:1245–1250
8. Sendeski M, Patzak A, Persson PB (2010) Constriction of the vasa recta, the vessels supplying the area at risk for acute kidney injury, by four different iodinated contrast media, evaluating ionic, nonionic, monomeric and dimeric agents. Invest Radiol 45:453–457
9. Huang SS, Huang PH, Leu HB, Wu TC, Lin SJ, Chen JW (2013) Association of central pulse pressure with contrast-induced nephropathy and clinical outcomes in patients undergoing coronary intervention. J Hypertens 31:2187–2194
10. Radermacher J, Chavan A, Bleck J et al (2001) Use of Doppler ultrasonography to predict the outcome of therapy for renalartery stenosis. N Engl J Med 344:410–417
11. Winther SO, Thiesson HC, Poulsen LN, Chehri M, Agerskov H, Tepel M (2012) The renal arterial resistive index and stage of chronic kidney disease in patients with renal allograft. PLoS One 7:e51772
12. Ninet S, Schnell D, Dewitte A, Zeni F, Meziani F, Darmon M (2015) Doppler-based renal resistive index for prediction of renal dysfunction reversibility: a systematic review and meta-analysis. J Crit Care 30:629–635

13. Schnell D, Deruddre S, Harrois A et al (2012) Renal resistive index better predicts the occurrence of acute kidney injury than cystatin C. Shock 38:592–597

14. Kuznetsova T, Cauwenberghs N, Knez J et al (2015) Doppler indexes of left ventricular systolic and diastolic flow and central pulse pressure in relation to renal resistive index. Am J Hypertens 28:535–545

15. Pearce JD, Craven TE, Edwards MS et al (2010) Associations between renal duplex parameters and adverse cardiovascular events in the elderly: a prospective cohort study. Am J Kidney Dis 55:281–290

16. Lerolle N (2012) Please don’t call me RI anymore; I may not be the one you think I am! Crit Care 16:174

17. Mehta RL, Kellum JA, Shah SV, Acute Kidney Injury Network et al (2007) Acute kidney injury network: report of an initiative to improve outcomes in acute kidney injury. Crit Care 11:R31

18. Seeliger E, Becker K, Ladwig M, Wronski T, Persson PB, Flemming B (2010) Up to 50-fold increase in urine viscosity with isoosmolar contrast media in the rat. Radiology 256:406–414

19. Ribeiro L, de Assunção e Silva F, Kurihara RS, Schor N, Mieko E, Higa S (2004) Evaluation of the nitric oxide production in rat renal artery smooth muscle cells culture exposed to radiocontrast agents. Kidney Int 65:589–596

20. Cantley LG, Spokes K, Clark B, McMahon EG, Carter J, Epstein FH (1993) Role of endothelin and prostaglandins in radiocontrast- induced renal artery constriction. Kidney Int 44:1217–1223

21. Liu ZZ, Schmerbach K, Lu Y et al. (2014) Iodinated contrast media cause direct tubular cell damage, leading to oxidative stress, low nitric oxide, and impairment of tubuloglomerular feedback. Am J Physiol Renal Physiol 306:F864–F872

22. Lerolle N, Guérot E, Faisy C, Bornstain C, Diehl JL, Fagon JY (2006) Renal failure in septic shock: predictive value of Doppler- based renal arterial resistive index. Intensive Care Med 32:1553–1559

23. Tublin ME, Bude RO, Platt JF (2003) Review. The resistive index in renal Doppler sonography: where do we stand? Am J Roentgenol 180:885–892

ABBREVIATIONS

- RFT - RENAL FUNCTION TEST
- AKI - ACUTE KIDNEY INJURY
- CABG - CORONARY ARTERY BYPASS GRAFT
- CAD - CORONARY ARTERY DISEASE
- CCF - CONGESTIVE CARDIAC FAILURE
- CK- MB - CREATINE KINASE – MB
- Scr - SERUM CREATININE
- ECG - ELECTROCARDIOGRAM
- CIN - CONTRAST INDUCED NEPHROPATHY
- ATN - ACUTE TUBULSR NECROSIS
- MI - MYOCARDIAL INFARCTION
- RRI - RENAL RESISTIVE INDEX
- PCI - PERCUTANEOUS CORONARY INTERVENTION
- STEMI - ST ELEVATION MYOCARDIAL INFARCTION
- NSTEMI - NON ST ELEVATION MYOCARDIAL INFARCTION
- CKD - CHRONIC KIDNEY DISEASE
- ESRD - END STAGE RENAL DISEASE

CONSENT FORM

ஆராய்ச்சிஒப்புதல்படிவம்

பெயர்: தேதி:
வயது: நோயாளிஎண்:
ஆராய்ச்சிசேர்க்கைஎண்:

இந்தஆராய்ச்சியின்விவரங்களும்அதன்நோக்கங்களும்முழுமையாகஎனக்குவிளக்கபட்டது.

எனக்குவிளக்கபட்டவிஷயங்களைநான்புரிந்துகொண்டுஎனதுமுழுமனதுடன்சம்மதிக்கிறேன்.

இந்தஆராய்ச்சியில்பிறரின்நிர்பந்தமின்றிஎன்சொந்தவிருப்பத்தின்பேரில்தான்பங்குபெறுகிறேன்மற்றும்நான்இந்தஆராய்ச்சியில்இருந்துஎந்தநேரமும்பின்வாங்கலாம்என்றும்அதனால்எந்தபாதிப்பும்எனக்குஏற்படாதுஎன்பதையும்புரிந்துகொண்டேன்.

நான்என்னுடையசுயநினைவுடன்மற்றும்முழுசுதந்திரத்துடன்இந்தமருத்துவஆராய்ச்சியில்பங்குகொள்ளசம்மதிக்கிறேன்.

S.No	Age	Sex	Diagnosis	Diabetes	SHTN	CAG	EF	Pre Procedural RRI	Pre Procedural RFT	RFT at 24hrs	RFT at 48 Hrs
1	55	F	STEMI	YES	YES	DVD	58	0.62	0.7	1.1	0.9
2	48	M	NSTEMI	YES	NO	SVD	57	0.7	0.7	1.2	1.5
3	28	M	STEMI	YES	YES	SVD	59	0.63	0.5	0.6	0.9
4	77	M	STEMI	YES	YES	DVD	58	0.66	0.8	1.1	0.9
5	47	M	STEMI	YES	YES	DVD	61	0.66	0.8	0.9	0.7
6	55	M	STEMI	YES	NO	SVD	45	0.64	1.1	0.9	0.9
7	55	M	STEMI	YES	YES	DVD	46	0.71	0.5	0.9	1.6
8	58	M	STEMI	NO	YES	DVD	48	0.6	0.77	0.9	0.9
9	50	M	STEMI	YES	NO	SVD	57	0.6	1.1	1	0.9
10	64	M	STEMI	YES	YES	TVD	43	0.64	0.6	0.4	0.8
11	35	M	NSTEMI	YES	YES	SVD	56	0.72	0.5	0.9	1.5
12	41	M	NSTEMI	YES	NO	DVD	59	0.61	0.4	0.6	0.7
13	64	M	NSTEMI	NO	YES	SVD	43	0.61	0.9	0.8	0.9
14	43	M	NSTEMI	YES	NO	DVD	47	0.6	0.7	0.8	0.7
15	40	M	STEMI	YES	NO	TVD	55	0.59	1	1	1.1
16	45	M	STEMI	NO	YES	DVD	58	0.58	0.7	0.8	0.7
17	52	M	STEMI	YES	YES	DVD	60	0.63	0.9	0.5	0.8
18	60	M	NSTEMI	YES	YES	DVD	54	0.65	0.9	1.1	1.1
19	70	M	NSTEMI	NO	NO	SVD	54	0.65	0.7	0.6	0.8
20	56	M	STEMI	NO	YES	SVD	56	0.7	0.5	1.1	1.5
21	60	M	NSTEMI	NO	YES	SVD	42	0.58	0.7	0.8	0.7
22	62	M	NSTEMI	NO	YES	SVD	46	0.59	0.6	0.7	0.7
23	41	M	NSTEMI	YES	NO	SVD	40	0.59	0.9	0.7	0.6
24	43	M	STEMI	YES	NO	SVD	47	0.6	0.8	0.8	0.7
25	47	M	STEMI	NO	YES	SVD	54	0.64	0.7	0.8	0.7
26	74	M	STEMI	YES	YES	TVD	53	0.66	0.6	0.7	0.7
27	53	F	STEMI	YES	NO	SVD	52	0.64	0.8	0.7	0.8
28	60	F	NSTEMI	NO	YES	SVD	51	0.59	1	1.2	1
29	58	M	NSTEMI	YES	NO	SVD	49	0.59	0.7	0.7	0.7
30	33	M	STEMI	YES	YES	SVD	47	0.61	0.8	0.7	0.9
31	53	M	STEMI	YES	YES	DVD	46	0.62	0.9	0.7	0.7
32	44	M	NSTEMI	NO	YES	SVD	47	0.64	0.5	0.8	0.7
33	60	F	NSTEMI	YES	NO	DVD	58	0.59	1	0.9	0.8
34	70	M	STEMI	NO	YES	DVD	53	0.6	0.7	0.8	0.7
35	45	F	STEMI	NO	NO	SVD	55	0.65	1.1	1	0.9
36	55	M	STEMI	YES	YES	DVD	62	0.64	0.5	0.7	0.7
37	46	M	NSTEMI	YES	NO	SVD	60	0.65	0.6	0.7	0.7

38	66	M	STEMI	NO	YES	DVD	58	0.66	0.8	0.7	0.6
39	55	M	NSTEMI	YES	NO	SVD	52	0.64	0.7	0.8	0.7
40	42	M	STEMI	YES	NO	DVD	42	0.59	0.6	0.6	0.5
41	50	M	NSTEMI	YES	NO	SVD	49	0.54	0.7	0.8	0.7
42	59	M	STEMI	YES	NO	SVD	46	0.56	0.6	0.6	0.7
43	50	M	NSTEMI	YES	YES	DVD	57	0.57	0.9	0.6	0.7
44	50	M	STEMI	YES	YES	DVD	55	0.6	1	0.9	0.9
45	39	M	NSTEMI	YES	NO	SVD	64	0.63	0.7	0.7	0.8
46	53	M	NSTEMI	YES	NO	DVD	41	0.65	0.8	0.6	0.7
47	59	M	NSTEMI	YES	NO	DVD	43	0.64	0.7	0.9	0.7
48	42	M	NSTEMI	YES	YES	TVD	47	0.65	0.6	0.7	0.9
49	59	M	NSTEMI	YES	NO	SVD	46	0.66	0.7	0.8	0.5
50	57	M	STEMI	NO	YES	SVD	57	0.59	0.6	0.5	0.6
51	55	F	STEMI	YES	NO	DVD	51	0.59	0.9	0.8	0.9
52	58	F	STEMI	YES	YES	DVD	58	0.62	0.7	0.8	0.7
53	60	F	STEMI	NO	YES	DVD	54	0.65	0.6	0.8	0.7
54	58	F	STEMI	NO	YES	DVD	55	0.72	1.1	1.3	1.6
55	50	M	STEMI	YES	YES	DVD	60	0.64	0.7	0.8	0.8
56	56	M	STEMI	YES	YES	TVD	40	0.66	0.6	0.6	0.6
57	62	M	STEMI	NO	NO	DVD	43	0.64	0.9	0.8	0.9
58	60	M	STEMI	YES	YES	TVD	47	0.56	0.9	0.9	0.9
59	60	F	NSTEMI	YES	NO	SVD	49	0.59	0.5	0.7	0.9
60	60	F	STEMI	NO	YES	SVD	59	0.58	0.8	0.9	0.9
61	50	M	STEMI	YES	YES	TVD	56	0.56	0.6	0.8	0.9
62	67	F	STEMI	NO	NO	SVD	46	0.66	0.8	0.7	0.9
63	49	M	NSTEMI	YES	YES	TVD	53	0.65	0.6	0.6	0.6
64	60	F	NSTEMI	YES	NO	SVD	47	0.64	0.7	0.6	0.8
65	40	M	STEMI	YES	YES	DVD	57	0.65	0.9	0.9	0.7
66	55	F	NSTEMI	YES	NO	DVD	55	0.64	0.6	0.6	0.8
67	47	F	STEMI	YES	NO	DVD	52	0.65	0.8	0.8	1
68	47	M	STEMI	NO	YES	SVD	60	0.66	0.8	0.7	0.7
69	68	F	STEMI	YES	YES	DVD	63	0.63	0.8	0.8	0.8
70	49	M	STEMI	YES	YES	TVD	40	0.64	0.6	0.9	1
71	58	M	STEMI	YES	YES	TVD	45	0.59	1.1	0.9	0.9
72	70	M	NSTEMI	YES	YES	TVD	57	0.66	1	0.9	0.8
73	52	M	NSTEMI	YES	YES	TVD	56	0.56	0.8	0.8	0.9
74	60	M	NSTEMI	NO	YES	SVD	53	0.57	0.9	0.8	1
75	63	F	STEMI	NO	YES	SVD	51	0.62	0.9	0.6	0.7

76	57	M	NSTEMI	YES	YES	DVD	54	0.66	0.7	1	1.1
77	29	M	STEMI	YES	NO	SVD	58	0.65	1	0.9	0.7
78	55	M	STEMI	YES	NO	TVD	52	0.64	0.8	0.6	0.7
79	52	M	STEMI	NO	YES	SVD	59	0.64	0.6	0.9	0.9
80	44	F	NSTEMI	YES	NO	SVD	48	0.63	1.1	1.1	0.9
81	72	M	NSTEMI	YES	YES	TVD	46	0.58	0.9	0.8	0.9
82	31	M	STEMI	YES	YES	TVD	43	0.56	0.7	0.6	0.6
83	42	M	NSTEMI	YES	YES	TVD	42	0.59	1.1	1	1
84	52	M	NSTEMI	YES	YES	TVD	47	0.58	1	0.9	1.1
85	40	M	STEMI	YES	NO	DVD	41	0.65	1	1.1	1.1
86	60	M	NSTEMI	NO	YES	TVD	48	0.7	0.9	1.1	1.5
87	58	M	STEMI	YES	YES	DVD	47	0.63	0.9	0.8	0.7
88	57	M	STEMI	NO	YES	SVD	46	0.64	0.7	0.6	0.7
89	58	M	STEMI	YES	YES	TVD	43	0.66	0.8	0.8	0.9
90	70	M	STEMI	YES	YES	TVD	41	0.64	0.9	0.9	1.1
91	55	M	STEMI	NO	YES	SVD	52	0.65	0.8	0.8	0.7
92	68	M	STEMI	YES	YES	TVD	57	0.55	0.6	0.9	1.1
93	52	M	STEMI	YES	NO	SVD	46	0.59	0.8	0.9	0.7
94	54	M	STEMI	YES	YES	TVD	49	0.65	0.9	0.8	0.8
95	42	F	STEMI	YES	NO	SVD	41	0.67	0.8	0.7	0.9
96	52	F	STEMI	YES	YES	TVD	42	0.64	0.8	1.1	1
97	60	M	STEMI	YES	YES	DVD	45	0.6	0.9	0.6	0.8
98	65	F	STEMI	YES	NO	SVD	54	0.67	0.8	0.7	0.8
99	42	M	STEMI	YES	NO	TVD	55	0.65	1.1	0.9	0.8
100	42	M	NSTEMI	YES	NO	TVD	59	0.66	0.6	0.8	0.7

MADURAI MEDICAL COLLEGE
MADURAI, TAMILNADU, INDIA -625 020
(Affiliated to The Tamilnadu Dr.MGR Medical University, Chennai, Tamil Nadu)

ETHICS COMMITTEE CERTIFICATE

Name of the Candidate : Dr.S.R.Ramprasanth

Course : PG in MD., General Medicine

Period of Study : 2016-2019

College : MADURAI MEDICAL COLLEGE

Research Topic :

Accuracy of pre-procedural renal resistive index in predicting contrast induced acute kidney injury in patients with preserved renal function submitted to elective coronary angiography

Ethical Committee as on : 16.05.2018

The Ethics Committee, Madurai Medical College has decided to inform that your Research proposal is accepted.

Member Secretary Chairman Dean / Convenor

DEAN
Madurai Medical College
Madurai-20

Prof Dr V Nagaraajan
M.D., MNAMS, D.M., Dsc.,(Neuro), Dsc (Hon)
Professor Emeritus Neuroscience
Sr. Consultant Neurologist
Director, VN Neuro Care Centre
Vakil New Street, Madurai-625 001

17 JUL 2018

625020

Gmail Ram Prasanth <srram1991@gmail.com>

[Urkund] 1% similarity - srram1991@gmail.com

2 messages

report@analysis.urkund.com <report@analysis.urkund.com> Thu, Oct 11, 2018 at 2:14 AM
To: srram1991@gmail.com

Document sent by: srram1991@gmail.com
Document received: 10/10/2018 10:43:00 PM
Report generated 10/10/2018 10:44:48 PM by Urkund's system for automatic control.

Student message:

Document : plagirism.docx [D42394474]

IMPORTANT! The analysis contains 1 warning(s).

About 1% of this document consists of text similar to text found in 103 sources. The largest marking is 61 words long and is 87% similar to its primary source.

PLEASE NOTE that the above figures do not automatically mean that there is plagiarism in the document. There may be good reasons as to why parts of a text also appear in other sources. For a reasonable suspicion of academic dishonesty to present itself, the analysis, possibly found sources and the original document need to be examined closely.

Click here to open the analysis:
https://secure.urkund.com/view/41431750-327556-814329

Click here to download the document:
https://secure.urkund.com/archive/download/42394474-321111-613783

Ram Prasanth <srram1991@gmail.com> Thu, Oct 11, 2018 at 2:46 PM
To: dineshravichandran@yahoo.co.in

[Quoted text hidden]

CERTIFICATE

This is to certify that this dissertation titled "**ACCURACY OF PRE-PROCEDURAL RENAL RESISTIVE INDEX IN PREDICTING CONTRAST INDUCED ACUTE KIDNEY INJURY IN PATIENTS WITH PRESERVED RENAL FUNCTION SUBMITTED TO ELECTIVE CORONARY ANGIOGRAPHY**" of the candidate **Dr.S.R.RAM PRASANTH** with registration number 201611115 for the award of **M.D** degree in the branch of GENERAL MEDICINE. I personally verified the urkund.com website for the purpose of plagiarism check. I found that the uploaded thesis file containing from introduction to conclusion pages and result shows **1** percentage of plagiarism in the dissertation.

Dr. J. SANGUMANI M.D.,
Professor of Medicine,
Department of General Medicine,
Government Rajaji Hospital,
Madurai Medical College, Madurai