



Accepting a chronic kidney disease patient for perioperative management: a narrative review of key aspects

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ABSTRACT

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Chronic kidney disease is one of the leading co-morbidity at present. With the increasing prevalence of diabetes mellitus and hypertension, more and more peoples are developing diabetic and hypertensive nephropathy. As chronic kidney disease patient can present as an asymptomatic stable patient in one end and a multi-organ involved complicated end-stage disease in other ends, their management plan also varies. The serum creatinine levels of as low as 1.5 mg% have been linked to perioperative major cardiac events like myocardial infarction and arrest; these patients poses a challenge to the perioperative team. Moreover, a chance of developing acute kidney injury on the chronic kidney disease is also higher. These patients are also often elderly, with diabetes mellitus and/or hypertension. Therefore, accepting such patient for perioperative care needs systematic and meticulous approach. Preoperative assessment, risk stratification, and optimization play a great role. Both intraoperative and postoperative management needs a tailored approach. The present narrative review is prepared to give the current insight on these aspects.

Key words: Chronic Kidney Disease; Preoperative Assessment; Risk Stratification; Hemodialysis; Anesthesia; Intensive Care Unit

Abbreviations used: AKI – Acute kidney injury; CKD - Chronic kidney disease; ESRD - End stage renal disease; eGFR: estimated Glomerular Filtration Rate; HD – Hemodialysis; GFR - Glomerular filtration rate; KDIGO - The Kidney Disease: Improving Global Outcomes, RCRI - Revised Cardiac Risk Index; RRT- Renal Replacement Therapy

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INTRODUCTION

Chronic kidney disease (CKD) has a high prevalence worldwide.¹ These patients will undergo surgical procedures many a time related to dialysis or surgeries related to their co-morbidities. Major surgeries like joint replacements, renal transplants are also increasingly done now a day. A patient with CKD may present to a hospital as an asymptomatic, stable patient; symptomatic, stable on medical management; symptomatic, stable on renal replacement therapy or even directly in the advanced / end-stage renal disease

with acute life-threatening complications.^{2,3} As the patient may present in any stage of disease and with varied clinical manifestations; their management plan also varies. The approach of such patient often needs to be multidisciplinary, yet, for better planning and management, the anesthesiologist needs to be versed with the pathophysiology and implications of these changes during perioperative care, especially for anesthesia. A proper preoperative evaluation of the CKD patient is required for formulating perioperative care. Although guidelines and literature on the diagnosis and management of CKD patients

are there,⁴ specific guidelines for perioperative management and approach is limited. The present review is prepared to give the current insight on these aspects.

PATHOPHYSIOLOGY AND STAGES OF CKD

Chronic kidney disease is a multitude of systemic disorders primarily arising with the involvement of the kidney. The mechanism of development of this disorder basically depends on two phenomena; a) loss of a significant number of functional nephrons, and b) compensatory reversible / irreversible pathological changes in the remaining nephrons. It is the end result of various kidney diseases. Reduction in the number of nephrons lead to hyperfiltration by the rest of the nephrons; Estimates of single nephron glomerular filtration rate (GFR) in humans support hyperfiltration as a relevant pathophysiologic mechanism;⁵ on a long run, distortion of glomerular architecture, abnormal podocyte function, and disruption of the filtration barrier lead to sclerosis. Renin-angiotensin system has a major role in the adaptive hyperfiltration as well as subsequent sclerosis (flow diagram 1). Reduction in GFR is the first reliable parameter and is used to stage the CKD. Staging of CKD was done based on GFR (G-stages) by the National Kidney Foundation,⁶ and also adopted by the Kidney Disease: Improving Global Outcomes (KDIGO) as below (Table 1);⁴

The KDIGO guidelines also recommend using albuminuria levels along with GFR to improve prognostic accuracy in the assessment of CKD.⁴ Patients with stage G4 and G5 disease, involve multiple organ systems, showing a state of dyssynchronous cross talk among them. Uremia in an advanced stage gives

rise to many metabolic and endocrine abnormalities leading to the deranged metabolism of carbohydrates, protein and fat, decreased erythropoietin production, malnutrition. Metabolisms of parathyroid hormone (PTH), fibroblastic growth factor-23, insulin, glucagon, sex hormones are getting disturbed as CKD progresses to stage G4. The disharmony of the internal milieu produces systemic inflammatory changes, atherosclerotic and calcific changes in vessels, dysplastic bones, especially in children. Knowledge of the above malfunctions holds the key for delivering a safe anesthesia to a patient of CKD posted for various surgeries.

ORGAN-SPECIFIC CHANGES WITH POTENTIAL PERIOPERATIVE IMPLICATIONS

Cardiovascular System: Cardiovascular diseases in CKD are the major cause of mortality with higher relative risk in young patients. Calcific changes and sodium and water imbalance contribute significantly towards congestive heart failure, left ventricular hypertrophy (LVH), ischemic heart disease, sudden death, cerebrovascular accidents, and peripheral artery diseases.^{7,8} LVH is an independent risk factor for producing arrhythmia, myocardial infarction, and heart failure. Diuretics can be used to reduce fluid overload. Patient with the diuretic resistant disease may need dialysis before a scheduled surgery. Permanent arterio-venous fistula also produces fluid overload and status has to be confirmed before surgery. Furthermore, raised renin-angiotensin levels cause endothelial hypertrophy and sclerosis.⁸ Administered erythropoietin can also cause hypertension. The Angiotensin-converting enzyme (ACE) inhibitor or an Angiotensin II receptor blocker (ARB), may slow the disease process and even preserve renal function, and is recommended for controlling the blood pressure (BP).⁹ The intraoperative increased incidence of hypotension in such patients who are receiving ACE/ARB drugs needs to be considered.¹⁰

Respiratory System: CKD can complicate respiratory system in multiple ways, including pulmonary edema, fibrinous pleuritis, pulmonary calcification, etc.¹¹ Sleep disturbances and sleep apnea are extremely common in patients with ESRD.¹¹ Patients may present with hypoxemia, hypercapnia and ventilation-perfusion mismatch due to fluid overload. Fluid overload is closely associated with restrictive and obstructive respiratory abnormalities in patients receiving renal replacement therapy (RRT).¹² Measures to restrict salt and fluid, diuretics are the mainstay for symptom alleviation.

Table 1: Staging of CKD based on GFR (G-stages) by the National Kidney Foundation

category	eGFR (ml/min/1.73 m ²)	Terms used to describe
G1	≥ 90	Normal or high
G2	60-89	Mildly decreased*
G3a	45-59	Mildly to moderately decreased
G3b	30-44	Moderately to severely decreased
G4	15-29	Severely decreased (advanced renal disease)
G5	<15	End stage renal disease (ESRD)

*Relative to young adult level. (eGFR- estimated glomerular filtration rate, ESRD- End-stage renal disease). In the absence of evidence of kidney damage, neither GFR category G1 nor G2 fulfils the criteria for chronic kidney disease.

If symptoms persist despite conservative measures, RRT like hemodialysis (HD) can be used as required and it has been shown to improve pulmonary function test results.¹²

Central Nervous System: Generalized fatigue, malaise, lack of concentration, impaired cognition gradually leading to mental obtundation, seizure, coma, and death.¹³ Patients on HD may present with dehydration, vomiting, and hypotension and rarely dialysis disequilibrium syndrome due to changes in extracellular fluid volume and subsequent cerebral edema.¹⁴ These facts need to be remembered while obtaining the consent of evaluating postoperative recovery and progression of such patients.

Hematological and Coagulation System: In CKD, erythropoietin-producing cells in the kidney i.e. peritubular and endothelial cells of the cortex and outer medulla are damaged resulting in reduced erythrocyte production and differentiation. Decreased red cell lifespan, increased hemolysis and bleeding, repeated loss during HD, uremia induced bone marrow suppression and iron, folate, and vitamin B₆ and B₁₂ deficiencies altogether produces anemia. Increased cardiac output compensates the tissue oxygenation but gradually land up in high output failure. Erythropoiesis-stimulating agents are preferred over blood transfusion for the treatment of severe anemia in these patients.¹⁵ KDIGO and the Renal Association guideline recommend not using blood transfusion if a patient is waiting for renal transplant unless and until it becomes essential.^{15,16} The CKD patients are having a bleeding tendency because of dysfunctional platelets attributing to uremic thrombocytopeny. Defective interaction of von-Willebrand factor with platelet glycoprotein IIb-IIIa receptors, reduced platelet adenosine diphosphate content, and reduced thromboxane A₂ cause an abnormal platelet function.¹⁷ These aspects need to be considered while evaluating such patients and planning management, especially regional anesthesia.

Bone mineral disease: Hyperphosphatemia is a common complication of CKD but a relatively late event. Initially, the hypersecretion of PTH maintains calcium and phosphate balance. But gradually secondary hyperparathyroidism lead to the development of renal osteodystrophy and multiple major bone disorders.¹⁸ Calcitriol is secreted from the kidney to directly suppress the secretion of PTH. However, as the disease progresses to stage G4, circulating calcitriol levels begin to fall resulting in a decompensated bone disease. Clinically patient presents with bone pain deformed long bones in

weight-bearing age and subsequent fracture. Care should be taken during positioning before surgery. Intubation process should be gentle, keeping in mind of minimal movement at the atlantoaxial junction.

Fluid, Electrolyte and Acid-Base Balance: When the GFR falls below 10-15 ml/min/1.73 m², the homeostasis of sodium and water and free acids get compromised severely leading to volume overload. This results in relative hyponatremia, hyperchloremia, hyperkalemia, and metabolic acidosis. Some authors claimed that a reduction in sodium intake halts the disease progression by increasing intra-glomerular pressure over a period of time.¹⁹ Water restriction is indicated only when hyponatremia is clinically relevant. Retention of potassium is not directly proportional to reduced GFR. Rather it is affected by impaired aldosterone secretion in distal nephron and impaired gastrointestinal tract function. Failure of both the defences produces hyperkalemia and in the late course led to cardiac abnormalities. Increased dietary potassium intake, protein catabolism, hemolysis, hemorrhage, transfusion of stored red blood cells, and metabolic acidosis etc. make the situation even worse. In addition, some medications (e.g. Renin-Angiotensin-Aldosterone system inhibitors and spironolactone and other potassium-sparing diuretics) also produce hyperkalemia. Optimum potassium level usually can be obtained by dietary restriction, avoidance of certain medications and medical management.

Metabolic acidosis is frequently seen early in the course of the disease. Although kidney is able to acidify the urine, the ability to produce ammonia decreases which are further aggravated by hyperkalemia. Hyperkalemia and hyperchloremic acidosis together produce a state of non-anion gap metabolic acidosis. As the kidney function deteriorates, daily excretion of acids falls down to 30-40 mmol. The pH < 7.35 is rare and treatment with sodium bicarbonate generally maintains the homeostasis when the serum bicarbonate concentration falls below 20-23 mmol/L.²⁰

Gastrointestinal System: The gastric and small intestinal epithelial tight junctions get disrupted in CKD.²¹ Erosive gastritis and duodenitis are common,²² leading to anorexia, nausea, vomiting, gastrointestinal bleeding, diarrhea, delayed gastric emptying time, increased acidity and gastric volume necessitate the use of H₂ blockers and proton pump inhibitors. Rapid sequence intubation has to be considered for these patients if general anesthesia is planned.

PREOPERATIVE EVALUATION

The pre-anesthesia evaluation is done for comprehensive assessment of the patient's health; including the functional reserves in context to a surgery/intervention planned and risk stratify for any potential complications during the perioperative period. This also includes optimization of the patient if indicated and planning for anesthesia and postoperative care.

Pre anesthesia Assessment: It should include, at a minimum, patient interview, a focused examination of the airway, lungs, and heart, review of pertinent medical records, indicated preoperative tests and consultations with specialists if necessary.^{23,24} Patients' interview for the evaluation of patients with chronic renal disease planned for a surgery should be focusing on knowing the etiology and the severity (level of renal function) of renal failure; to find the clue on complications due to chronic renal disease, etc. The interview should also include a history of comorbidities and functional status of the patient. The severity of the disease will be indicated from the history of urine output, need of dialysis and frequency of dialysis, history of admission to hospital with fluid and electrolyte imbalance etc. GFR can be estimated from serum creatinine level by using the Cockcroft-Gault equation and can aid us in classifying the stage of renal failure.²⁵ A focused yet detailed clinical examination of the cardiovascular and respiratory system is necessary which may give clue to fluid overload, heart failure, uncontrolled hypertension, etc.

Laboratory investigations aids in both preoperative evaluation and risk stratification. It can also guide the team towards optimization needed. However, routine laboratory testing is not recommended.^{24,26} The routine practice has been shown to be subjecting the patient to both unnecessary testing and delay.²⁷ It has been also noted that routine testing may not be adequate for severely ill (i.e. ASA- IV) patients.²⁸ The impact of routine testing in changing perioperative anesthetic management is also shown to be unfavorable for the patients.²⁹ Rather, laboratory testing should be patients' disease and surgery-specific.³⁰ Comorbidity based preoperative laboratory testing is likely to be more impactful in changing perioperative anesthetic management.³¹

CKD patients often have comorbidities and fluid and electrolyte imbalance. Therefore, preoperative testing should target towards knowing/establishing the severity, presence of electrolyte imbalance and establishing comorbid condition if suspected from

history and clinical examinations. As such patients can have anemia and platelet abnormality, complete blood count in such patient is advisable. The National Institute of Healthcare and Clinical Excellence (NICE) and the Association of Anaesthetists of Great Britain and Ireland recommend that the patients with the severe renal disease should undergo full blood count and electrocardiography.^{26,32} Patients with any kind of renal disease should also undergo serum electrolytes, blood urea and creatinine estimation.^{26,27,32} A preoperative chest x-ray may be done if clinical and history suggests any abnormality or the patient is planned to undergo critical care management in the postoperative period.^{26,27,32} Often, CKD is due to diabetes mellitus and if so, blood glucose level estimation is recommended. ESRD patients are likely to have hyperkalemia, hyponatremia, hypertension, ischemic heart disease, congestive heart failure, metabolic acidosis, and even circulatory collapse. Although, routine echocardiography is not indicated for non-cardiac surgeries,^{24,26} in ESRD patients with cardiorespiratory symptoms planned for NICE major plus grade surgery, it may be necessary or justifiable. Routine urine examination is likely to find albuminuria and sediments which may be helpful for confirming the diagnosis. In this context, it is to be remembered that the patient usually attends pre-anesthesia clinics with known of diagnosed condition; therefore, asking again a routine urine examination is usually not required. Moreover, urinary sediments or albuminuria findings in known chronic renal disease patient is unlikely to change or modify anesthetic management. However, quantitative estimation of urinary albumin and creatinine in spot urine may help us in establishing the severity of CKD by using urinary albumin to creatinine ratio (ACR). ACR >300 refers to severe disease. This is again cannot be regarded as a preoperative test for undergoing surgery, rather, it is a diagnostic and stratification test. As these patients are having albuminuria and serum albumin can affect anesthetic drug pharmacokinetic; serum albumin level determination becomes necessary. However, a complete panel of liver function test can be only justified if congestive heart failure is suspected from history and clinical examination.

Risk Stratification: It is required for informed and shared decision making and planning alternative / additional management if required. Risk stratification of CKD patient undergoing a surgery also depends on the surgery planned. Both renal and cardiovascular risk during the perioperative period should be assessed and noted. Serum creatinine level of >

2mg% is regarded as one of the risk factors to predict perioperative cardiac morbidity and mortality as described in the revised cardiac risk index (RCRI).³³ Although RCRI is regarded as gold standard, other risk predictors like reconstructed cardiac risk index (R-RCRI),³⁴ myocardial infarction or cardiac arrest (MICA) calculator,³⁵ or the American College of Surgeons surgical risk calculator (ACS-SRC),³⁶ can also be used. Comparison of these risk calculators has shown that all these calculators are equally effective in defining low-risk patients.³⁷ However, the MICA was found to be better in defining high-risk patients.³⁷ The guidelines for preoperative cardiovascular evaluation of non-cardiac surgical patients by American College of Cardiology/American Heart Association and European Society of Cardiology and the European Society of Anaesthesiology also recommend the use of any clinical risk indices including RCRI to risk stratify the patient and decision making for the need of the further cardiac evaluation.^{38,39} It is to be noted that the MICA includes serum creatinine of > 1.5 mg/dl as one of the risk factors.³⁵ However, mere presence of a serum creatinine level of > 1.5 or 2 mg/dl does not indicate that the patient may be at high risk if the patient is relatively young and not having other comorbidity or complications, and these patients can safely proceed for non-cardiac surgeries without further cardiac evaluation.^{38,40} However, the scenario is not so rosy, especially in the low socioeconomic and developing countries where a good number of CKD patients present for the first time to the hospital with advanced grade/end stage renal disease. If the cause of the CKD is diabetes and the patient is either elderly or presenting with heart failure features, they will need further cardiac evaluation and optimization.³⁸ The decision to further evaluate also depends on the invasiveness of the surgery planned.^{26,38}

The American Society of Anesthesiologists – physical status,⁴¹ also risk stratifies and predicts the medical morbidity and mortality reliably and independently following surgery.⁴² The MICA risk calculator also includes it as one of the risk factors to predict 30-day morbidity and mortality from myocardial infarction and cardiac arrest in patients undergoing non-cardiac surgeries.³⁵ Evidence suggests that the risk of early mortality after surgery begins to rise more steeply once eGFR falls below 60 mL/min/1.73 m².⁴³ Severe stage stratified by preoperative eGFR levels was found to be effectively predicting postoperative renal replacement therapy in type-A aortic dissection patients.⁴⁴ On admission eGFR provides prognostic information in acute surgical settings too; eGFR < 60 mL/min/1.73 m² was associated with increased 30

and 90-day mortality.⁴⁵ A preoperative poor renal function has been shown to be associated with increased postoperative length of stay in the hospital after coronary artery bypass graft.⁴⁶ Preoperative renal impairment and hypoalbuminemia were associated with a requirement for postoperative HD in cardiac surgical patients.⁴⁷

PREOPERATIVE OPTIMIZATION

If the surgery planned is not an urgent or emergency and patients renal and comorbid status is likely to improve with preoperative medical management, the patient should be optimized before taking up for elective surgery. This is, however, dependant of the invasiveness and nature of the surgery planned too. A CKD patient posted for vascular access surgery for starting HD is unlikely to require optimization unless the patient is very much unstable from a hemodynamic point of view. On the other hand, if the patient is posted for major surgeries, cardiovascular surgeries, renal transplant, etc., patients with ESRD or advanced renal failure will require preoperative optimization.⁴⁸ As ESRD involves multi-organ systems; preoperative optimization may even need a cardiologist and nephrologists' consultation and inter-disciplinary management. However, a stable CKD patient on RRT or not yet started on RRT, posted for minor or intermediate class surgery without any clue of cardiac abnormality from history, physical examination, and electrocardiogram, do not require a cardiologist consultation or intervention.⁴⁸ The cardiologist referral should be based on the patient and disease-specific.⁴⁹ These patients often have an electrolyte imbalance, especially hyperkalemia, and hypocalcemia; which needs to be optimized to an acceptable level before proceeding for elective surgeries. Although hyperkalemia in CKD patients is well tolerated and poses less threat to the patient as compared to the patient with normal renal function,⁵⁰ it is advisable to keep K⁺ level < 5.5meq/L before taking up for elective surgeries.⁵¹ In intractable metabolic and electrolyte disturbances, fluid overload; consultation from a nephrologist and intervention like HD may be needed for optimization. Preoperative HD may be needed in ESRD patients if there is a problem with fluid or K⁺ control, planned for major surgery and on maintenance HD. It is usually done the day before the scheduled surgery.⁴⁸ These patients are often having hypertension and diabetes, which may also need optimization before surgery. They are also often on antiplatelet and deep vein thrombosis prophylaxis, which also needs to be managed and optimized as per guidelines.⁵² A patient with multiple abnormalities often needs to be shifted

to intensive care one to two days prior for optimization and closed monitoring and management.

MANAGEMENT OVERVIEW

In a very large observational study, including more than 75,000 patients undergoing general surgery, preoperative kidney malfunction was strongly associated with the development of postoperative acute kidney injury (AKI) (i.e. 27% AKI).⁵³ On the similar plight, The CKD guidelines recommend that all patients with CKD are considered to be at risk for AKI.⁴ Therefore, the importance of meticulously preserving kidney functions throughout the perioperative period is very important and this should be done both during the intraoperative and postoperative period.

Vascular access: These patients may have difficult venous access due to edema. Current or potential future fistula sites should be avoided for cannulation. The forearm and antecubital veins if possible should also be avoided. Central venous access may also be difficult because of previous dialysis sheath, ultrasound assistance is necessary for placement of catheter.⁵⁴ HD catheter should not be used to deliver fluid/drugs as far as possible.

Interventions to prevent the decline of pre-existing renal dysfunction: Over the past decades, several interventions have been studied that provide some help to alleviate the pre-existing kidney dysfunction. The kidney protective measures like avoiding hydroxyethyl starch (HES), nephrotoxic medications, and contrast, targeted hemodynamics management, maintenance of global and microperfusion, etc.,⁵⁵ should be considered throughout. Evidence-Based Guideline for the management of high BP in adults, suggests a BP goal of < 140/90 mmHg in patients with CKD.⁵⁶ However, this recommendation and goal are for long-term management. Although, a specific guideline for an upper acceptable limit of preoperative BP in CKD patient is not available, yet, a patient can be accepted for elective surgery if the preoperative BP is < 180/105 mmHg.⁵⁷ Moreover, these patients often have higher BP and their auto regulations are also set at higher levels. Still, it will be prudent to reduce the blood pressure (if presented with high BP, e.g. 180/100) by 20% during the intraoperative period,⁵⁸ and then slowly targeting towards the goal in the postoperative period over the next few days. If the patient has an acute cardiovascular emergency, neurologic signs or symptoms, acute renal failure, or a postoperative complication that is exacerbated by the elevated BP, immediate treatment of severe perioperative hypertension is warranted using intravenous

antihypertensive.⁵⁸ A mean arterial pressure of 65 mmHg may be suboptimal and predispose the patient to AKI in chronic hypertensive patients.⁵⁹ As intraoperative hypotension adversely affects the renal microvasculature and has been shown to be associated with increased 30-day operative mortality in non-cardiac surgery,⁶⁰ maintenance of BP within 20% of baseline can be regarded as paramount especially for those who are at risk of developing AKI.

Although it is established that deranged glycemetic control is an independent risk factor for the development of CKD, it yet unknown whether acute hyperglycemia predisposes a patient to AKI. A study enrolling 474 diabetic patients with acute myocardial infarction, evaluated the role of acute and chronic hyperglycemia on AKI and found that on admission hyperglycemia alone cannot predict AKI.⁶¹ Chronic hyperglycemia is an important determinant. There is still a lack of clarity over the blood glucose level that has to be maintained and until further concrete clarifications glycemetic control with blood glucose levels of 110-150 mg/dl seems to be reasonable and is recommended by the KDIGO for AKI.⁴ However, elective non-cardiac surgery is usually not postponed if blood sugar (BS) is < 400 mg%.^{62,63} Insulin therapy can be adjusted/started if required for preoperative optimization if blood sugar is not within the goal, and a BS of 180-220 mg% is well accepted during the perioperative period. It has been noted that preoperative BP between 160/100 – 179/109 mmHg and BS > 250 - 399 mg% frequently needs medication change with consultations, but the changes in the anesthetic management were not much.⁶⁴ Invasive hemodynamic monitoring may be required during both intraoperative and postoperative ICU care depending on the patients' condition.

The use of intravenous fluids in the perioperative period is a routine practice which compensated for blood, fluid and third space losses. The CKD patients too have an impaired ability to concentrate or dilute urine. Studies on critically ill patients have shown that any weight gain together with the formation of organ edema leads to AKI.⁶⁵ However, the intraoperative use of diuretics is not recommended except for the management of severe fluid overload.⁴ Moreover, not only the amount of fluid but also the kind of fluid to be used are also controversial and have to be considered carefully. Crystalloids, in particular, 0.9% saline solution is known to cause hyperchloremic acidosis and renal vasoconstriction when infused in large quantities. This contributes to the sharp rise in the risk of developing AKI.⁶⁶ HES is known for its harmful effect on renal function and coagulation.^{67,68}

perioperative management in chronic kidney disease

In the 6S trial,⁶⁸ the need for renal replacement therapy was significantly higher in the HES group compared to the Ringer acetate group, particularly in patient pre-existing renal dysfunction. But, there exists some uncertainty and clarity regarding the use of HES in CKD patients routinely. All the information is taken together, an adequate perioperative control to ensure hemodynamic stability is crucial. Guidelines recommend using isotonic crystalloids rather than colloids in the absence of hemorrhagic shock and avoiding the use of diuretics and other nephrotoxic agents in such subset of patients.⁴ Analgesia should be taken care well and multimodal analgesia with regional anesthesia as one modality will be better, NSAIDs should be avoided.

Most of the patient who are having advanced or ESRD, have to undergo major or major plus grade of surgeries will require postoperative management in intensive care. The management principle is similar to the intraoperative period. Close monitoring and management of fluid, hemodynamics, metabolic derangement, anemia, nutrition, etc is important.⁶⁹ Drugs selection to prevent nephrotoxic drugs; monitoring of kidney function by estimating serial serum creatinine and creatinine clearance is required and drug dose should be adjusted accordingly.⁶⁹ If the patient develops AKI on stable CKD, or if the patient was on maintenance HD, the patient will require postoperative HD. At present there is no clear consensus on when to start HD in AKI, but the accepted urgent indications for HD in such

patients generally include; refractory fluid overload, severe hyperkalemia (>6.5 mEq/L) or rapidly rising potassium levels refractory to medical management, signs of uremia, (i.e. pericarditis, encephalopathy, or an otherwise unexplained decline in mental status), severe metabolic acidosis (pH <7.1) etc.⁷⁰ If a patient undergoes HD, drug dose should be adjusted accordingly.

CONCLUSION

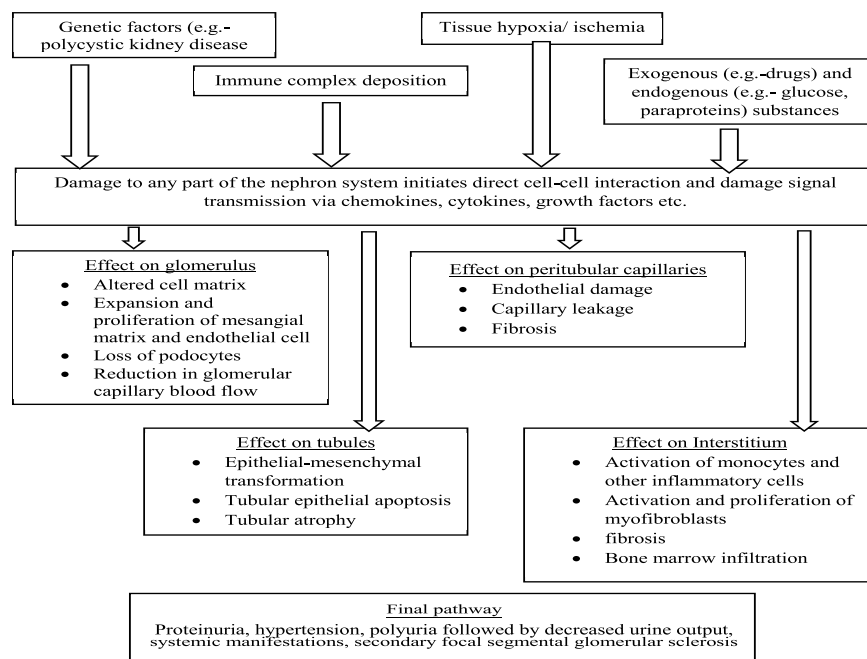
An increasing number of patients with CKD are requiring surgery. The presentation of CKD patient is very much variable including asymptomatic existence. These patients require proper risk stratification before undergoing surgery. Non-emergent cases may be postponed till such patients are optimized. Nephrotoxic drugs or the drugs taking the renal route for elimination need to be avoided or discontinued or adjusted. Optimal hemodynamic to ensure adequate renal perfusion appears to be preventive for precipitation of AKI. Fluid and electrolyte imbalance needs special attention. The level of care and monitoring required vary with the severity of the CKD and invasiveness of surgery planned. Stage G4 and G5 should be managed in a setup with HD and intensive care facility in a multidisciplinary approach.

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Flow diagram 1: Pathophysiology of chronic kidney

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