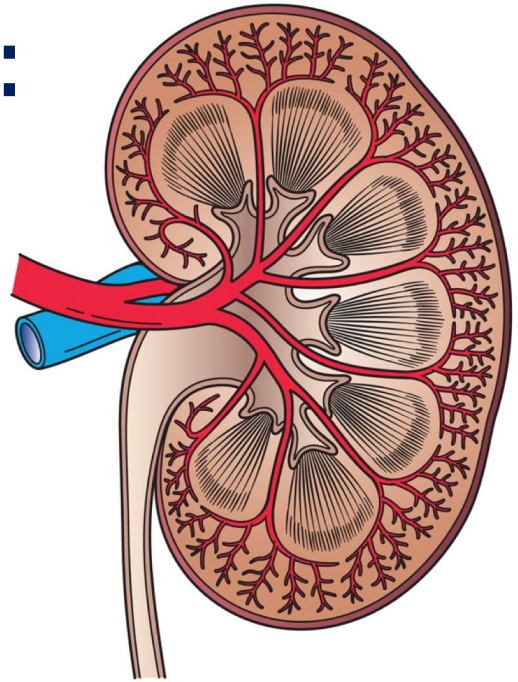
Avoiding Kidney Injury:

Recommendations for Adult Surgical Patients



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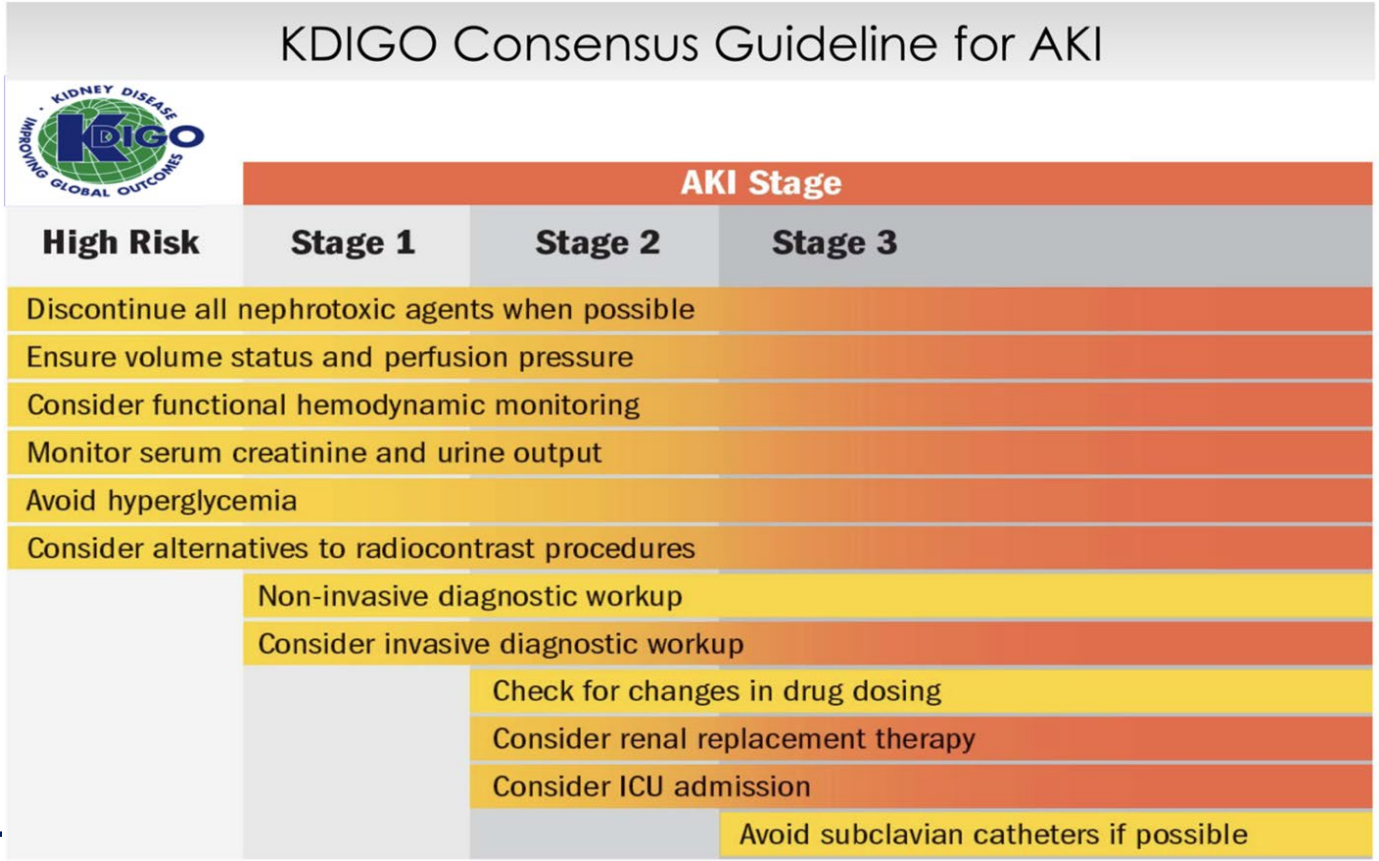
Objectives

- Provide an overview of the literature regarding the prevention and recognition of kidney injury
- Summarize recommendations to prevent & identify AKI as outlined in the literature
- For an overview of kidney disease, reference:
  - MPOG Avoiding Kidney Injury - Overview, Pathophysiology, Definitions
- For specialty specific recommendations, reference the following sections of the toolkit:
  - Avoiding Kidney Injury - Pediatrics
  - Avoiding Kidney Injury - Obstetrics
  - Avoiding Kidney Injury - Cardiac Surgery

Recommendations for Avoiding AKI

KDIGO Stage Based Recommendations



KDIGO Guideline Bundles

- Single center trial
- Implemented “bundle” of KDIGO guidelines[3]
  - Optimization of volume state and hemodynamics
  - Avoidance of nephrotoxic drugs
  - Normoglycemic management
- Randomized high risk patients undergoing cardiac surgery
- ↓AKI in patients receiving the bundled protocol
- Need for further multi-center adequately powered studies

Intensive Care Med (2017) 43:1551–1561
DOI 10.1007/s00134-016-4670-3

SEVEN-DAY PROFILE PUBLICATION

Prevention of cardiac surgery-associated AKI by implementing the KDIGO guidelines in high risk patients identified by biomarkers: the PrevAKI randomized controlled trial

Melanie Meersch[1], Christoph Schmidt[1], Andreas Hoffmeier[2], Hugo Van Aken[1], Carola Wempe[1], Joachim Gerss[3] and Alexander Zarbock[1*]

KDIGO Guideline Bundles

- Single center study, adult patients >18 years[4]
- Utilized an AKI care bundle, an electronic recognition of AKI based on KDIGO Criteria, and an EHR alert
- Compared patients who received the AKI care bundle vs. those who did not" to save some space
  - 10 fold increase in care bundle usage after integration of EHR alert
  - Completion of an AKI CB within 24 hours of abnormal blood test was associated with less progression to higher AKI stages and significantly lower in-hospital, 30-day and 60-day case fatality.
- Used “AUDITS” bundle

RESEARCH ARTICLE

Impact of Compliance with a Care Bundle on Acute Kidney Injury Outcomes: A Prospective Observational Study

Nitin V. Kolhe[1]*, David Staples[2], Timothy Reilly[3], Daniel Merrison[3], Christopher W. Mcintyre[1,4a], Richard J. Fluck[1], Nicholas M. Selby[1,4], Maarten W. Taal[1,4]

AKI Resolved?
AUDITS
Assess history & examine
Volume depletion
Detailed history
. 3H Haemoptysis, Haemolysis, Hypercalcemia
. 3R Rash, Recent vascular intervention, Raised CK
Nephrotoxins - Check medications
. (Contrast Media, ACEI, ARB, NSAIDs, Diuretic)
Urinary symptoms - Obstruction, oliguria, haematuria, colic
Sepsis
Urine Dipstick
. Blood
. Protein
. Leucocytes
Diagnosis **Think cause of AKI**
. Pre Renal
. Renal
. Post Renal
Investigations
. UE, Bicarb, Glucose, ECG, CXR, Cultures
. Renal Ultrasound (if Stage 2 or 3, or obstruction suspected)
Treatment (PUMP)
Perfusion - ensure euvolemic status
Underlying cause - stop nephrotoxins, antibiotics for sepsis, relive obstruction
Monitor - EWS, volume status, Daily U+Es, fluid balance
Prevent & treat complications - fluid overdload, adjust doses of meds, hyperkalemia, and acidosis
Seek advice
Seek renal advice (bleep 8121) for all AKI stage 3 and,
if specific cause for AKI is suspected. refer ro TRUST AKI Website

Implementation of AKI Care Bundle in NHS hospital[5]

- London hospital implemented daily audit process to assess care for patients with AKI
  - 2011: Pre-intervention audit of 100 patients with AKI (KDIGO definition used)
  - 2012: Intervention applied- AKI Care Bundle implemented
  - 2013: Post-intervention audit of 92 patients with AKI
- Outcomes:
  - Hospital mortality decreased in the post-intervention group (10% post vs. 12% pre)
  - AKI was recognized more often in the post-intervention group (68% post vs 51% pre)
  - Higher rates of nephrotoxic medication discontinuation post-intervention (73% post vs. 29% pre)

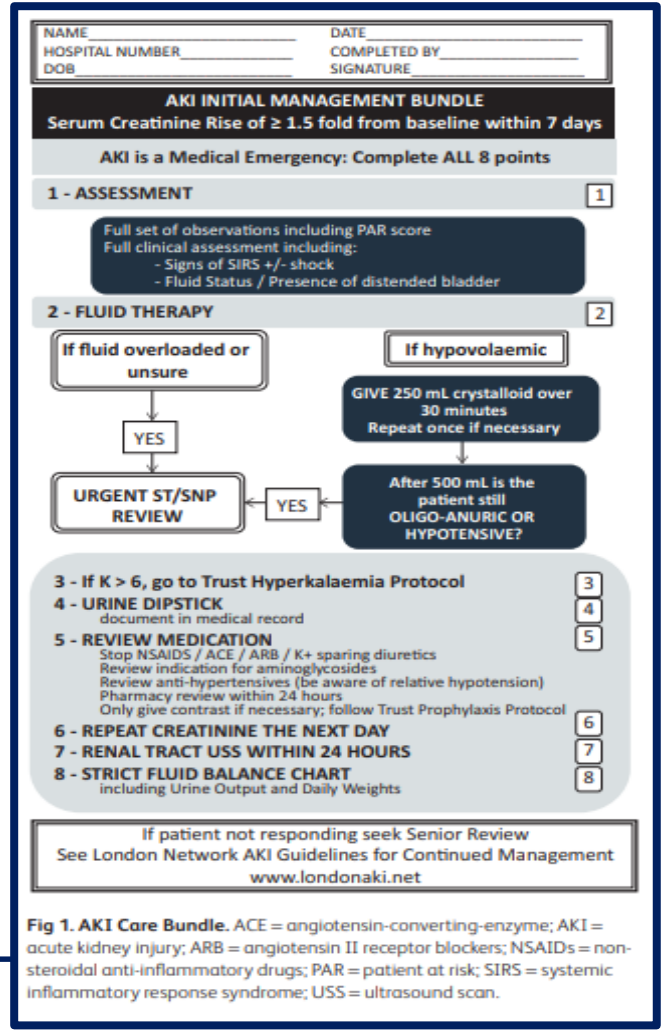


Fig 1. AKI Care Bundle. ACE = angiotensin-converting-enzyme; AKI = acute kidney injury; ARB = angiotensin II receptor blockers; NSAIDs = non-steroidal anti-inflammatory drugs; PAR = patient at risk; SIRS = systemic inflammatory response syndrome; USS = ultrasound scan.

More AKI Bundles for Review

Please contact MPOG to share your AKI Prevention Bundle & Quality Improvement story!

Aintree University Hospital

SP268

REDUCTION IN ACUTE KIDNEY INJURY (AKI) MORTALITY DATA WITH THE DEVELOPMENT OF A NOVEL AKI MANAGEMENT BUNDLE

James Master, Salim Hammad, Peter Chamberlain, Thangavelu Chandrasekar, Christopher Wong

Nephrology Dialysis Transplantation, Volume 30, Issue suppl_3, 1 May 2015, Page iii467, https://doi.org/10.1093/ndt/gfv190.80

Published: 21 May 2015

NHS Think Kidneys

Recommended minimum requirements of a care bundle for patients with AKI in hospital

Original Publication date December 2015
Reviewed March 2020
Review March 2022

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Recommendations

01	Identify patients at risk of developing AKI	• Patient risk factors • Procedure risk factors • Anesthesia related risk factors
02	Avoid hypotension	• Relative vs. absolute hypotension • Restrictive vs. Liberal Fluid Therapy • Vasopressor use • Sepsis Implications
03	Avoid hyperglycemia	• Patient Risk Factors • Glycemic Range Targets • Insulin Therapy
04	Avoid nephrotoxins	• Antimicrobials • Contrast • NSAIDs
05	Early recognition of AKI	• Optimizes treatment and prevents progression • EHR alerts/AI/Diagnostic Tools • Provider education

Recommendation #1: Identify patients at risk for AKI

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Categories of AKI Risk Factors

- Patient-related, such as:
  - Diabetes
  - Hypertension
  - Sepsis
- Procedure-related, such as:
  - Cardiopulmonary bypass & duration
  - Emergency Surgery
  - Organ Transplant
- Anesthesia-specific, such as:
  - Vasopressor use
  - Diuretic use
  - Hypotension

Patient Risk Factors[6-8]

- Preoperative level of kidney function
- Chronic Vascular Disease
- Arterial Hypertension
- Cardiac Failure/Cardiac Decompensation
- Diabetes (insulin or oral therapy requirements)
- Acute medical conditions (sepsis, major surgery, mechanical ventilation, hemodynamic instability)
- Hypertension
- Peripheral Vascular Disease
- Congestive Heart Failure
- Sepsis
- Ascites
- Cerebrovascular disease
- Mild to Moderate preoperative renal insufficiency
- Age >65
- COPD
- Chronic Kidney Disease
- BMI ≥ 25 (Overweight) (Ju 2018)

Patient-related risk factors are more strongly associated with mortality than the type of procedure.[6]

Procedure Related Risk Factors[6,8-9]

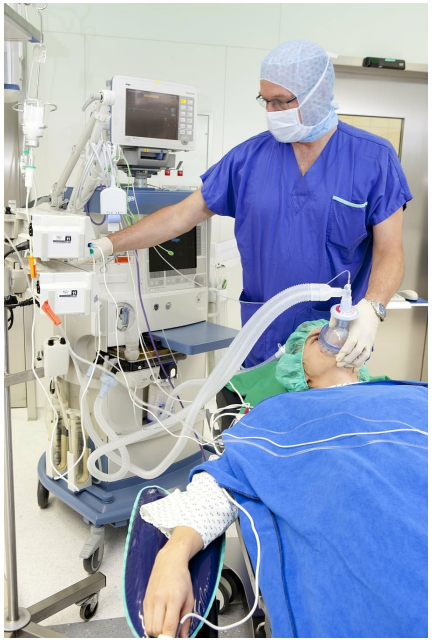
- Gastric bypass surgery for morbid obesity- 8.5% incidence AKI
- Cardiopulmonary bypass (CPB) & duration
- Aortic cross clamping & duration
- Hemodilution (cardiac surgery)
- Duration of surgery
- Intraperitoneal surgery
- Repair of AAA

- Organ Transplant (non-renal also)
  - Liver transplant:
    - 33% AKI
    - 17% require renal replacement therapy
- Use of intra-aortic balloon pump
- Type of cardiac surgical procedure
- Intra-abdominal hypertension
- Emergency surgery
- Bleeding complications

Anesthesia-related Risk Factors[6,8-9]

Potentially modifiable AKI risk factors in both cardiac and noncardiac surgery

- Hemodilution
- Hemoglobin level
- Intraoperative transfusion
- Hypotension
- Inadequate oxygen delivery
- Use of diuretics
- Selective renal ischemia
- Ischemia reperfusion injury
- Bleeding complications
- Intraoperative Hypertension
- Nephrotoxic agents (eg abx, contrast agents)



Novel Predictive Techniques

- Use of predictive analytics and machine learning techniques present new opportunities to identify risk and potentially prevent AKI:[11]
  - Thottakara et al recently used a machine-learning computational approach to develop a KDIGO AKI preoperative forecasting model
    - Used 59 variables from the electronic health record
    - Included patients undergoing any type of major surgery
    - Reported an AUC of 0.86 in the internal validation cohort

Recommendation #2: Avoid Hypotension

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Pathophysiology: How Hypotension contributes to AKI

- Kidneys able to compensate for hypoperfusion to a certain extent
- ↓ renal perfusion → ↓GFR (without damage to parenchyma) as adaptive response[12]
  - Prostaglandin signaling → ↓ afferent arteriole resistance and ↑ blood flow to glomeruli and maintains capillary pressure[2]
  - Renin-angiotensin-aldosterone system and release of angiotensin II → ↑efferent arteriole resistance[2]
- Once hypoperfusion drops below compensatory range, vasoconstrictors released by renal sympathetic nerves →↑afferent arteriole resistance→↓in GFR and renal blood flow→tubular cell damage and cell death[2]

Glomerular Filtration as a Function of Glomerular Blood Flow

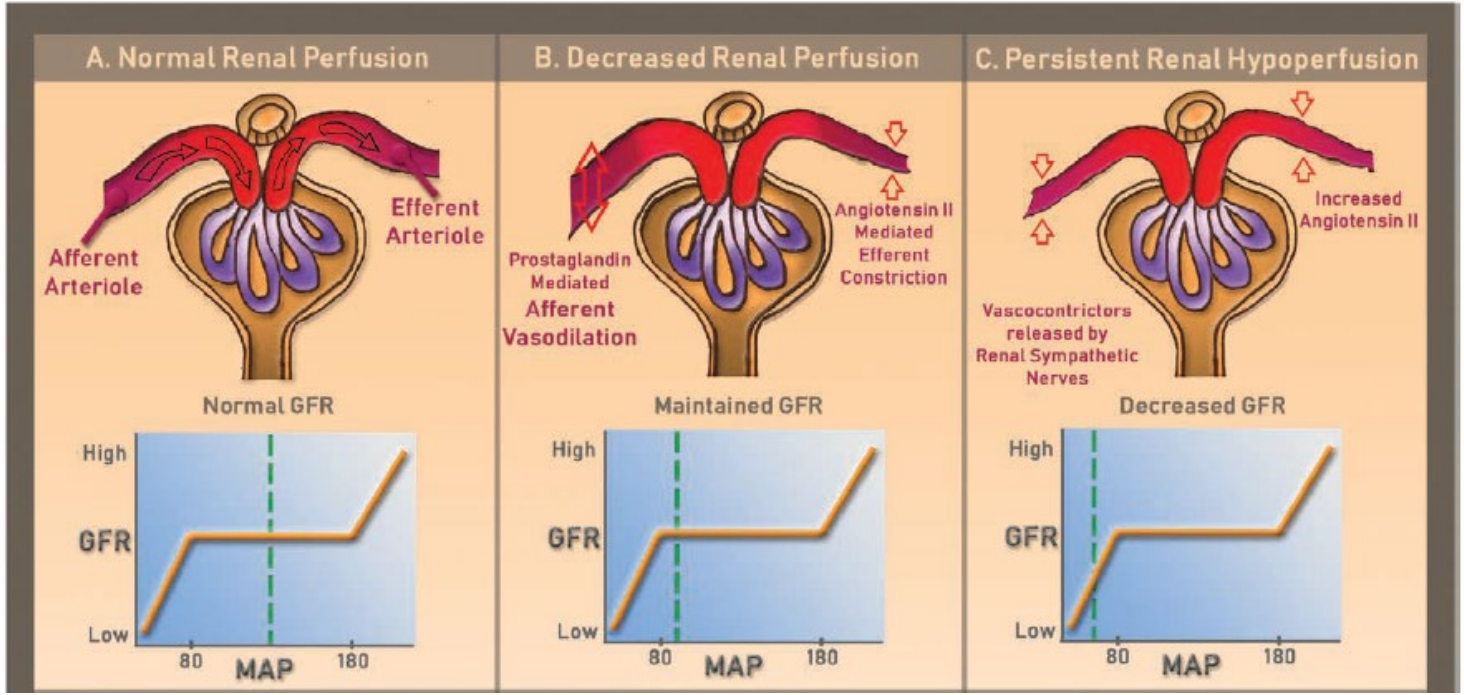

Image Source: Gumbert et al. *Anesthesiology* 2020

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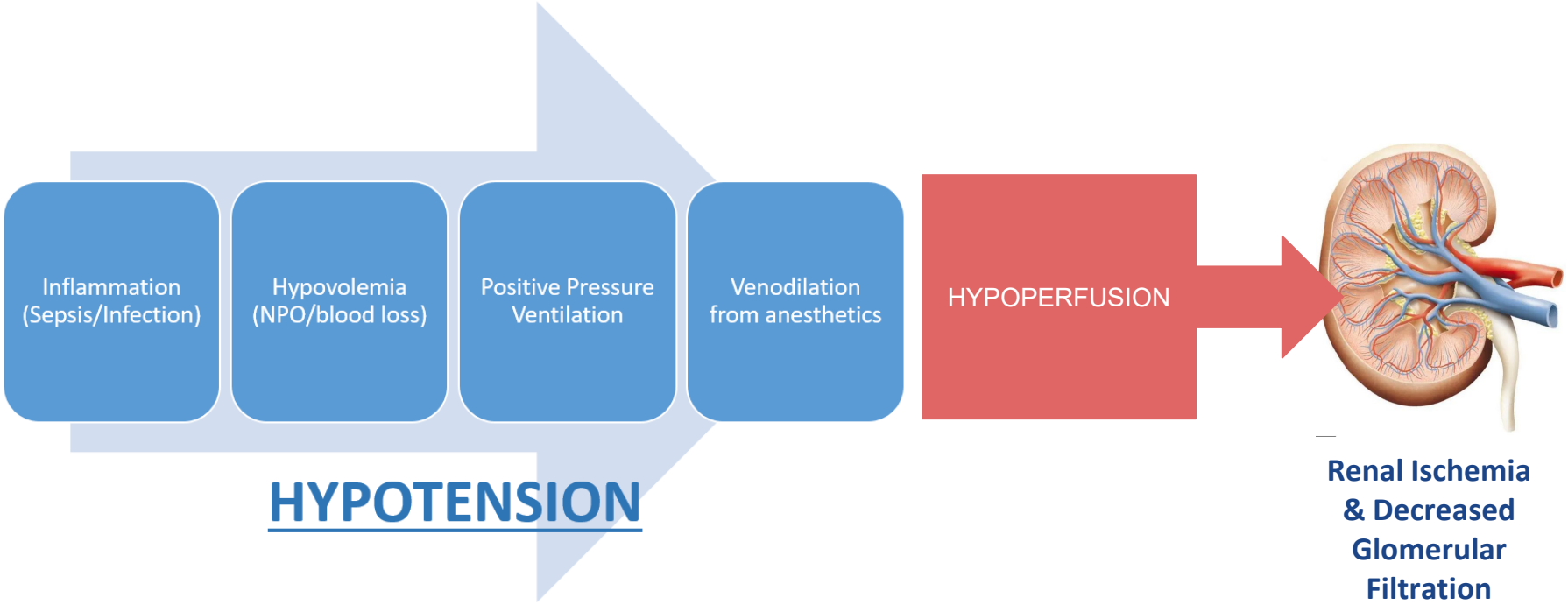
Intraoperative Hypotension: Contributing Factors[13]



Hypotension and AKI

- Intraoperative hypotension, even for short durations is associated with postoperative acute kidney injury[14-18]

- Individualized management strategy aimed at achieving SBP within 10% of baseline resulted in lower incidence of AKI as compared to the control group (treat SBP<80 mmHg OR lower than 40% from baseline)[19]

- Associations based on relative hypotension and AKI are no stronger than associations based on absolute hypotension- **anesthetic management of hypotension can be based on intraop values alone**[16]

Hypotension and AKI

Associations between intraoperative hypotension and AKI are dependent upon patient's baseline risk for AKI[18]

- Patients with **low** baseline risk demonstrated no associations between intraop hypotension and AKI
- Patients with **medium** risk demonstrated associations between hypotension (MAP<50) and AKI
- Patients with **high** risk demonstrated associations between hypotension (MAP<60) and AKI

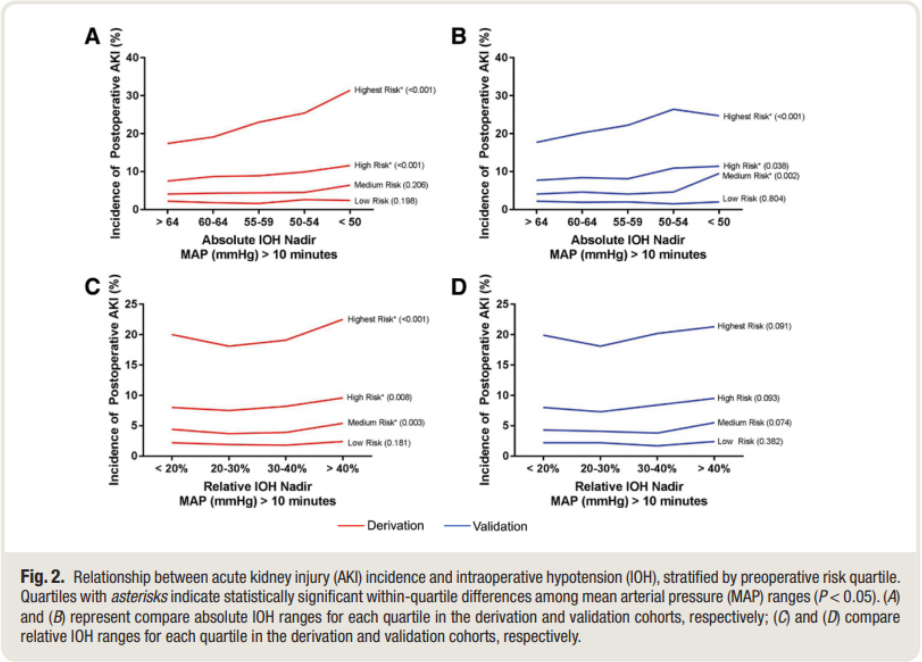


Fig. 2. Relationship between acute kidney injury (AKI) incidence and intraoperative hypotension (IOH), stratified by preoperative risk quartile. Quartiles with *asterisks* indicate statistically significant within-quartile differences among mean arterial pressure (MAP) ranges ($P < 0.05$). (*A*) and (*B*) represent compare absolute IOH ranges for each quartile in the derivation and validation cohorts, respectively; (*C*) and (*D*) compare relative IOH ranges for each quartile in the derivation and validation cohorts, respectively.

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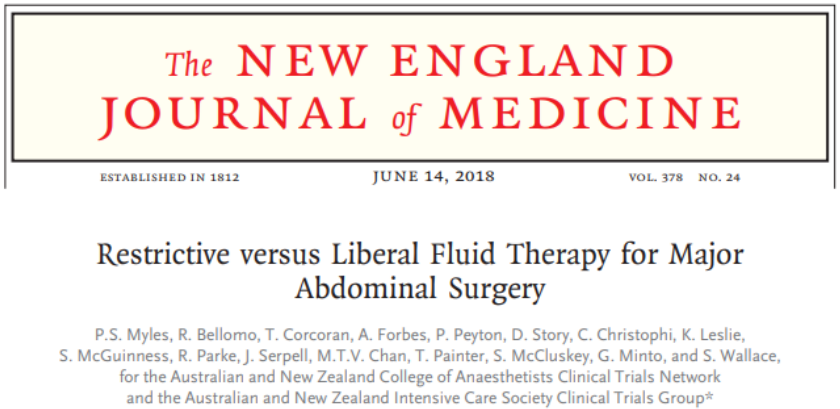
Restrictive Fluid Protocols may lead to AKI



The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 JUNE 14, 2018 VOL. 378 NO. 24

Restrictive versus Liberal Fluid Therapy for Major Abdominal Surgery

P.S. Myles, R. Bellomo, T. Corcoran, A. Forbes, P. Peyton, D. Story, C. Christophi, K. Leslie, S. McGuinness, R. Parke, J. Serpell, M.T.V. Chan, T. Painter, S. McCluskey, G. Minto, and S. Wallace, for the Australian and New Zealand College of Anaesthetists Clinical Trials Network and the Australian and New Zealand Intensive Care Society Clinical Trials Group*

RELIEF Study[20]

- 3000 patients undergoing abdominal surgery
- 1490 patients in restrictive fluid therapy group (median 3.7L in 24 hours postop)
- 1493 patients in liberal fluid therapy group (median 6.1L in 24 hours postop)
- AKI incidence of 8.6% in restrictive vs. 5.0% in liberal
- **Restrictive fluid protocols in abdominal surgery → higher chance for AKI with no benefit to survival**

Cardiac Output directed fluid therapy: Controversial

- Use cardiac output to guide fluid resuscitation efforts → improve perfusion without fluid overload
  - Supported by meta-analysis of 65 studies including 9308 patients in total[21]
    - Found GDFT using fluid and inotropes & targeting cardiac output and oxygen delivery (DO_2) was most effective in reducing AKI incidence
    - Benefits more significant for high risk patients undergoing orthopedic or major abdominal surgery
  - OPTIMISE Trial: Did not find significant difference in outcomes for GDFT group[22]
    - Pragmatic, multicenter, randomized, observer-blinded
    - 734 high-risk patients undergoing major abdominal surgery
  - Need for further research as GDFT protocols vary widely and could explain the variance in results[2]

Using hemodynamic parameters to reduce AKI

- Large meta-analysis including 65 RCTs and 9308 patients conducted to examine the effects of hemodynamic goal-directed therapy (GDT) on morbidity (including AKI)[21]

- All procedure types included
  - Major abdominal & orthopedic surgeries benefit most from GDT in reducing AKI
  - Intraoperative management through 8 hours after surgery

- 741 patients in the combined studies developed AKI
  - 421 were in the control group
  - 320 were in the goal-directed therapy group

- Fluids + inotropes significantly reduced AKI
- Using CO or DO_2 as hemodynamic target showed significant reduction in AKI
- Fluid administration alone did not reduce AKI

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Perioperative Fluid Management

- Balanced crystalloid solutions with electrolyte compositions are the preferred fluid for resuscitation[8]
  - Isotonic Solutions and Major Adverse Renal Events Trial (SMART)[23]
  - Saline against Lactated Ringer's or Plasma-Lyte in the Emergency Department (SALT-ED)[24]

- 0.9% Normal saline may cause adverse effects related to acid-base balance, renal vasoconstriction ↓glomerular filtration, ↑ risk of AKI[2]

Hydroxyethyl Starch (HES)

- Hydroxyethyl starch-containing solutions may increase AKI occurrence
  - Scandinavian Starch for Severe Sepsis/Septic Shock (6S) Trial[26]
  - Need for further research, should be used cautiously[2]

- In a study comparing the use of HES vs. crystalloids for GDFT in 202 high risk patients undergoing colorectal surgery:[27]
  - **No difference in postoperative complication rates**
  - HES group had lower 24h fluid balance (+3610 ml vs. +4226 ml in the crystalloid group)

- Crystalloid versus Hydroxyethyl Starch Trial (CHEST) published in 2012 initially found an increased need for renal replacement therapy in patients receiving HES vs. crystalloids;[28] Later analysis (2016) did not find this to be true- **no difference in patient outcomes[29]**

Vasopressor Use

- Majority of vasopressor studies focus on patients in the ICU (not intraoperatively)
- European Society of Intensive Care Medicine recommendations:[30]
  - Norepinephrine recommended as first-choice vasopressor to protect kidney function (Grade 1B evidence)
  - Suggest vasopressin in patients with vasoplegic shock after cardiac surgery (Grade 2C evidence)
- INPRESS Randomized Controlled Trial[19]
  - 298 patients randomized to receive norepinephrine to maintain SBP within +/-10% of baseline OR to standard management maintaining SBP>80 or within 40% of baseline
  - Norepinephrine infusion group resulted in less renal dysfunction (38.1% vs. 51.7%)
- Large RCT compared dopamine and norepinephrine as initial vasopressor in patients with shock: no difference in renal function or mortality but dopamine caused more arrhythmic events in patients with cardiogenic shock[31]
- Farag et al. (2019) study concluded that vasopressor infusions given during complex spine surgery were not associated with kidney injury[32]

AKI and Sepsis

- 1 in 3 patients with sepsis will develop AKI[34]
- Most common cause of AKI in critically ill[34]
- Fluid overload associated with worse outcomes[33]
- Vasopressors key to treating refractory hypotension[33]
  - Norepinephrine favorable choice
  - Vasopressin in septic shock not associated with improved kidney outcomes but may decrease need for RRT
- Nephrotoxins should be avoided but may be essential for management of underlying infection causing sepsis[33]

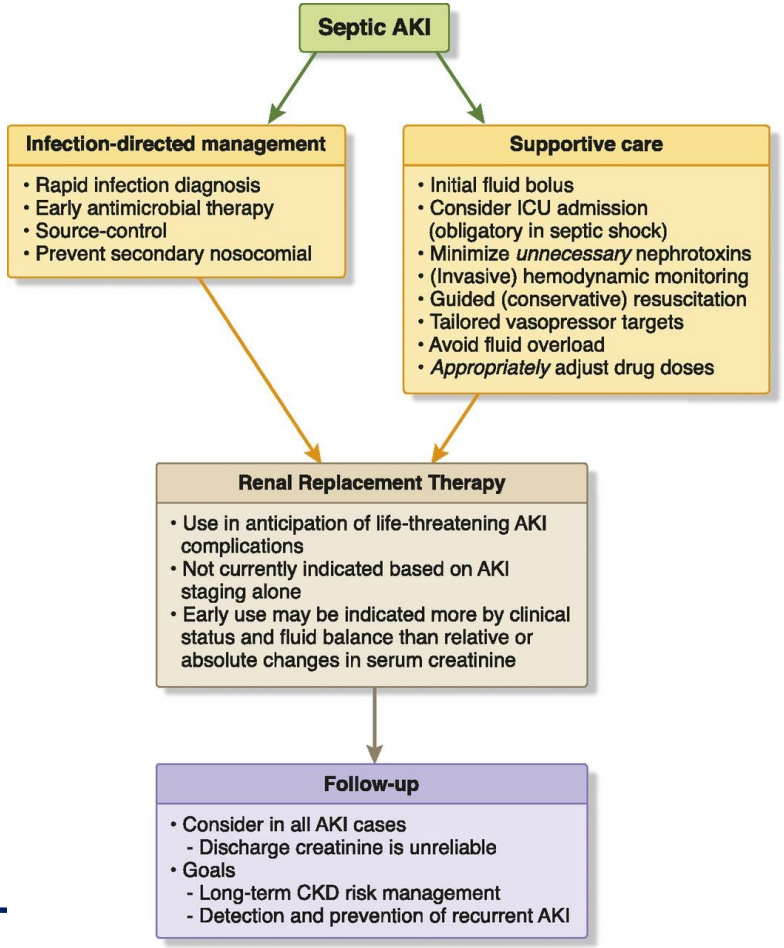

Image Source: Prowle JR *Clin J Am Soc Nephrol* 2018 [33]

Recommendation #3: Glycemic Control

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Pathophysiology: How Dysglycemia causes AKI

- Hyperglycemia occurs in 40% of non-cardiac surgeries and 80% of cardiac surgeries.[35]

- Hyperglycemia leads to tissue injury through:[35]
  - *Oxidative Stress*
  - *Inflammatory Marker Release*
  - *Vascular permeability*

- Kidney specific damage has been seen in animal studies exposing subjects to transient hyperglycemia:[36]
  - *Severe kidney damage*
  - *Decreased renal cortical perfusion and oxygen delivery*
  - *Elevated plasma creatinine*

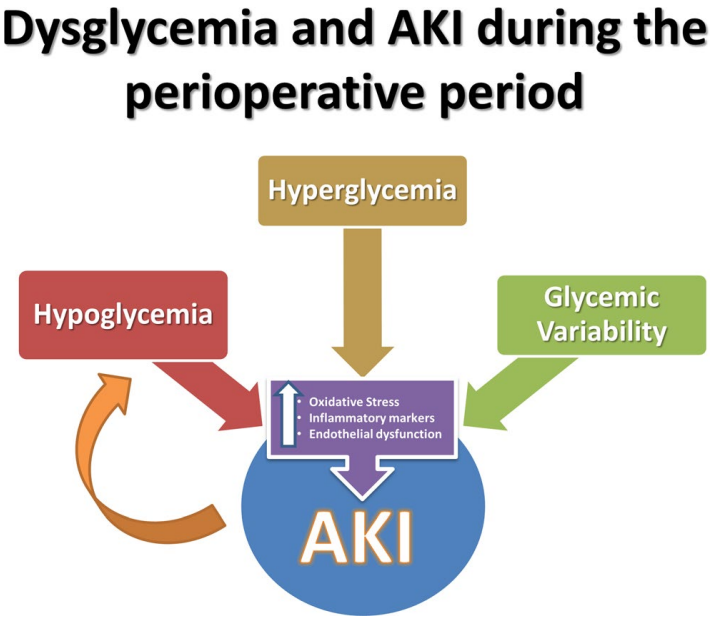


Image Source: Mendez et al. *Current Diabetes Reports* 2016

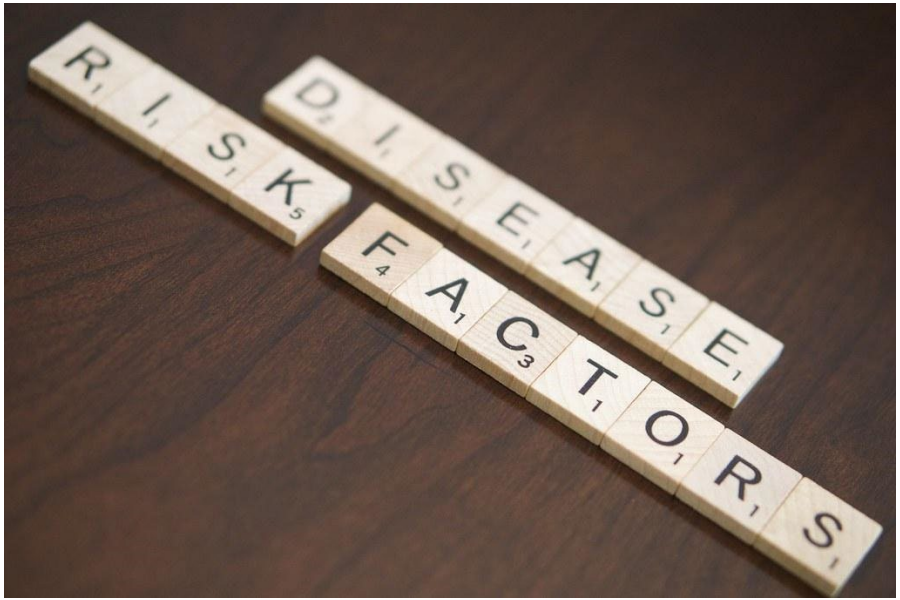
Risk Factors predicting Hyperglycemia

Patients without diabetes:[37]

- Black ethnicity
- Female
- Immunosuppression
- High BMI
- Renal failure
- Hypertension
- Hypercholesterolemia

Patients with diabetes:[38]

- Older Age
- Minority Ethnic Group
- Male
- High BMI
- High Risk Surgical Procedure



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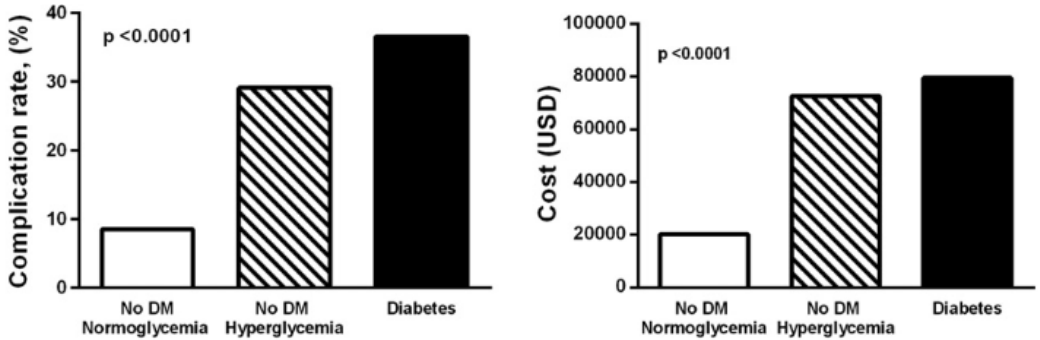
Impact of Hyperglycemia

- Increased BMI may predispose patients to AKI due to difficult volume assessment and resuscitation risking pre-renal AKI.[39]

- In a 2 center study of gastrointestinal surgery, average cost of hospitalization and complications, including AKI *(p= <0.0001)* for non diabetic patients with normoglycemia was $20,273 compared to $72,675 for non-diabetic patients with hyperglycemia[39]



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Role of Anesthetics and Hyperglycemia in Renal Injury[40]

- Surgery induced stress may disguise the role of anesthesia in postoperative renal complications.
- Acute hyperglycemia, intra-renal inflammation and Renin Angiotensin System activation were independently triggered in rats receiving 1 hour of anesthesia.
- Blood glucose significantly increased within 10 minutes of receiving anesthesia
- Acute hyperglycemia affects inflammation more potently than chronic hyperglycemia
- RAS activation causes significant renal injury in patients with acute and chronic hyperglycemia.

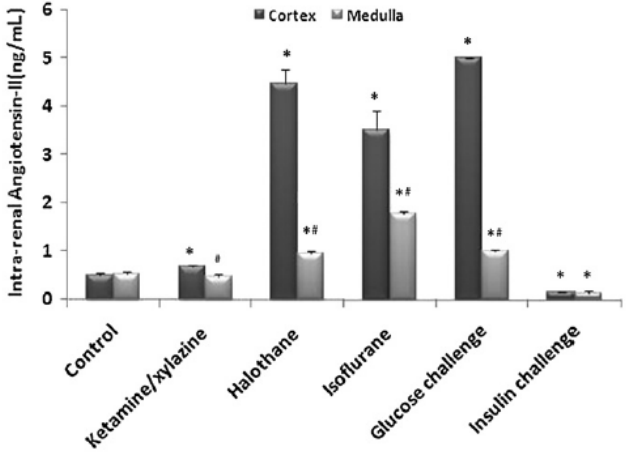

Fig. 7 Intra-renal Angiotensin-II. Control, conscious rats, not subjected to any anaesthetic procedure; Stress control, conscious rats receiving sham i.v. 'anaesthesia' by 0.9% saline; Ketamine/xylazine, rats anaesthetized with a mixture of ketamine/xylazine, 15% : 85% (v : v); Halothane, rats anaesthetized by gas insufflation, with 2% halothane; Isoflurane, animals anaesthetized by gas insufflation, with 2% isoflurane. *Statistically significant difference, compared to the respective value of control or stress control group; #Statistically significant difference between the results obtained in cortex and medulla (relevant for renal extracts only).

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‘Perfect’ Glycemic Range[41]

- Glycemic control is an independent, and modifiable, predictor of poor outcomes in surgical patients
- AKI may further complicate glycemic control as it associated with insulin resistance and reduced renal clearance of insulin.
    - Maintaining a blood glucose of 80-110 mg/dL has not proven to have protective effects on the kidneys in patients who already have AKI.
- Multiple Recommendations for ‘Perfect’ Glycemic Range

Table 2
Guidelines recommendations on glycemic control in critically ill patients in the ICU and in patients with AKI [52–57].

Guidelines	Patients	Glycemic control range
Sepsis Survival Campaign Intensive Care Med 2013; 39:165–228	Critically ill patients with sepsis	<180 mg/dl
American Diabetes Association Diabetes Care. 2010; 33 (suppl 1):S11–S61	Critically ill patients	144–180 mg/dl
ASPEN JPEN 2013; 37: 23–36	Critically ill patients	140–180 mg/dl
KDIGO Kidney Int 2012; 29 (suppl): 1–138	AKI in the ICU	110–149 mg/dl
European Best Practice Guidelines NDT 2012; 27: 4263–4272	AKI in the ICU	110–180 mg/dl
KDOQI on KDIGO 2012 AJKD 2013; 61: 649–672.	AKI in the ICU	110–149 mg/dl

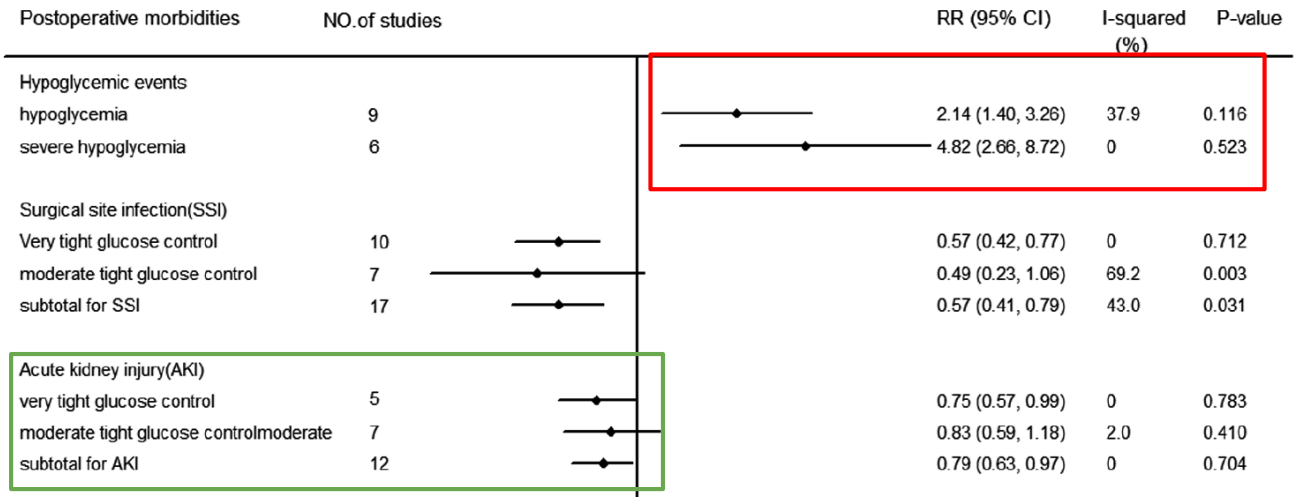
AKI: Acute Kidney Injury; ASPEN: American Society of Parenteral and Enteral Nutrition; ICU: Intensive Care Unit; KDIGO: Kidney Disease Improving Global Outcomes.

Source	Recommended Glucose Range
KDIGO (2012) controversial recommendation as these thresholds have not been examined in a randomized controlled trial and the risks of hypoglycaemia are significant[42]	110 - 149 mg/dL
NICE-SUGAR (2009): Normoglycemia in Intensive Care Evaluation: Survival Using Glucose Algorithm Regulation - randomized control trial suggests adopting higher glycemic values in critically ill patients to avoid the risks of tight glycemic benchmarks. A blood glucose target of 81 - 108 mg/dL resulted in higher mortality than a target of < 180 mg/dL without preventing AKI[43]	< 180 mg/dL
ERPB (2009): European Renal Best Practice statement on KDIGO Guidelines (Systematic Review) There is benefit in avoiding hyperglycemia > 210 mg/dL however, the relative risk of death is much higher in patients with hypoglycemia and thus offsets the small benefit of targeting a lower blood glucose[44]	110 - 180 mg/dL

Perioperative Glucose Control: Tight vs. Moderate[45]

Meta Analysis of 12 RCT showed a decreased relative risk of AKI with glucose controlled <150 mg/dL with an increased risk of hypoglycemic events

- Very Tight Glucose Control (< 110 mg/dL)
- Moderate Tight Glucose Control (111 - 150 mg/dL)



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Intensive Insulin Therapy

- Systematic review of 5 RCTs demonstrated intensive insulin therapy reduced the incidence of AKI in adult surgical patients by 38%.[46]
- When compared to a liberal glycemic control strategy (>200), moderate glucose control (150-200) for **diabetics** undergoing surgery was associated with a significantly lower risk of mortality.
  - No difference was found between strict (<150) vs moderate (150-200)[47]
- Intensive insulin therapy and a carbohydrate-restrictive strategy were comparable in their effects on the incidence of acute kidney injury evaluated using the RIFLE criteria[48]
- Oral antidiabetic medication are not recommended based on limited efficacy and adverse effects including hypoglycemia and lactic acidosis with metformin.[35]

Summary: Hyperglycemia and AKI

- Increased risk of AKI at both high and low blood glucose range. Treat hyperglycemia while avoiding glycemic variability and hypoglycemia. KDIGO recommends moderate targets for glycemic control.[42]
- Utilize insulin therapy to manage hyperglycemia during the perioperative period in diabetic and non-diabetic surgical patients.[42]
- Treat hyperglycemia with moderate glycemic targets.[41]

Recommendation #4: Avoid Nephrotoxins

Avoiding Nephrotoxic Drugs

- Nephrotoxic drugs are associated with increased risk of AKI[2,8,42,49]
- Cincinnati Children's avoidance of AKI quality improvement program[50]
  - Proactively screened for nephrotoxic drug exposure in EHR
  - Monitored daily SCr for patients exposed
  - Reduced exposure rate to nephrotoxic drugs by 38%
  - Reduced AKI rate by 64%

clinical investigation www.kidney-international.org

A sustained quality improvement program reduces nephrotoxic medication-associated acute kidney injury

Stuart L. Goldstein[1], Theresa Mottes[1], Kendria Simpson[1], Cynthia Barclay[2], Stephen Muething[3], David B. Haslam[4] and Eric S. Kirkendall[5]

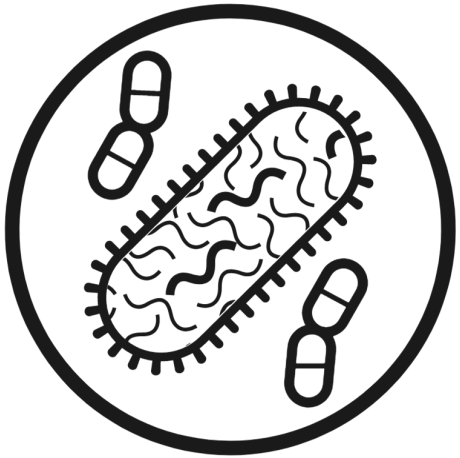
[1]Center for Acute Care Nephrology, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio, USA; [2]Pharmacy Services, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio, USA; [3]Anderson Center for Healthcare Excellence, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio, USA; [4]Infectious Diseases, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio, USA; and [5]Hospital Medicine, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio, USA

Avoidance of Nephrotoxic Drugs

Antimicrobials	Contrast	NSAIDs
- Avoid use of aminoglycosides unless no other suitable options, use topical/local administrations if possible, and avoid dosing with multiple administrations per day.[42] - Avoid amphotericin B, use antifungals as appropriate. Use lipid formulation of amphotericin B if applicable.[42]	- Assess risk for contrast induced AKI prior to study. Explore alternatives if patient is at risk.[42] - For patients at risk, use lowest possible dose of iso-osmolar or low-osmolar iodinated contrast and utilize isotonic sodium chloride or sodium bicarbonate IV fluid solutions.[42] - Concurrent use of other nephrotoxic drugs with contrast increases risk for CI-AKI.[42]	- NSAID use can increase AKI risk close to twofold[51] - GFR is reduced with NSAID use d/t loss of vasodilatory prostaglandin[2]

Nephrotoxic Drugs- Indirect

- Antibiotics ⟶ breakdown of bacteria ⟶ bacteria cell products in circulation ⟶ systemic inflammation and damage to kidneys and/or kidney injury[52]
- Allergic interstitial nephritis may cause damage to kidneys without other signs of allergy[52]



Recommendation #5: Early Recognition of AKI

Early Recognition of AKI

- Early recognition of AKI patients through EHR alerts is associated with lower in-hospital mortality, lower risk of death, and lower risk of progression to later AKI stages[4]
- Proactive screening for nephrotoxic drugs and regular SCr monitoring in patients receiving nephrotoxic drugs reduced exposure by 38% and AKI by 64%[50]
- American Society of Nephrology launched AKI!NOW initiative to promote early recognition and management of AKI which help optimize treatment and prevent progression.[53]

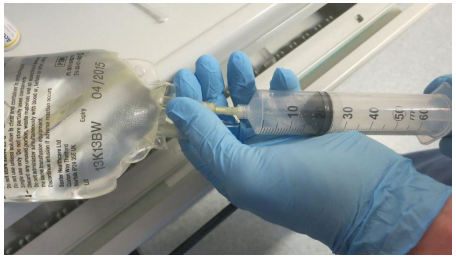
AKI!NOW Recommendations:

  - Provider education at all levels in healthcare regarding AKI, particularly around identifying patients at risk
  - Generate specific guidance on AKI evaluation and management
  - Develop global toolkit
  - Engage hospital administration and make AKI a part of quality initiative
  - Raise awareness of AKI as complication of other disease processes

Interventions under Research

MPOG
MULTICENTER PERIOPERATIVE OUTCOMES GROUP

Other Proposed Pharmacologic Interventions



- Low dose “renal dopamine” prophylaxis
  - Theorized to prevent renal vasoconstriction
  - More harm than good[30]
- High dose furosemide
  - Literature does not support loop diuretics for kidney protection only[30]
- N-acetylcysteine/supplements such as selenium, zinc, vitamin C, E, and B1
  - Antioxidants
  - Not currently supported in literature[2]
- Statin therapy
  - Potential anti inflammatory, antioxidative, and endothelial protective properties
  - Not currently supported in literature, may actually worsen AKI[2]
- Dexmedetomidine
  - Theory: ↑renal blood flow, ↓ oxidative insult to kidney
  - Preliminary research shows dexmedetomidine may be helpful, need for further research[2]

Remote Ischemic Preconditioning[2]

- Application of controlled ischemia to remote tissues or organs to create a protective adaptive response in distant organs
- Typical protocol for AKI prevention includes inflating a blood pressure cuff around the upper arm to 200-300 mmHg for five minutes and released. Cycle is repeated several times
- Mixed results in studies -> differing protocols, patient populations, and study design
- Protective effect may be lessened in cases with propofol

Conclusion: Further investigation needed before adopting into practice

Summary

1. Anesthesia providers should focus on reducing the anesthesia-related intraoperative risk factors associated with AKI such as:
   - Hypotension
   - Hyperglycemia
   - Use of nephrotoxic agents

2. Assessing risk factors preoperatively can assist anesthesia providers in identifying patients who may require additional interventions to prevent AKI.

3. Early Recognition of AKI optimizes treatment and reduces risk of progression to later stages of kidney disease.

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