

CARDIO SURGERY – ASSOCIATED
ACUTE KIDNEY INJURY
CSI - AKI

ΕΠΙΠΟΛΑΣΜΟΣ

- Η 2^η πιο συχνή αιτία ανάπτυξης AKI σε ICU μετά τη sepsis- AKI
- Η πιο συχνή περιεγχειρητική επιπλοκή σε cardiosurgery ICU
- 20-30% CSA-AKI
- 2-3% προσωρινή RRT

ΠΡΟΓΝΩΣΗ

- Αύξηση Χ3-Χ8 περιεγχειρητική θνητότητα
- 10,7% in- hospital mortality κ 30% long-term mortality (1-5yr) (Hu et al, J. Cardiothorac Vasc Anesth 2016)
- **SEVERITY:** RENAL STUDY: severe AKI (RRT) -> 52,6% 60-days mortality , 44,7% 90-days mortality
- **DURATION:** 7days -> 15,3% in hospital mortality / 3,40 5-year mortality
1-2 days -> 4,1% in hospital mortality / 1,66 5- year mortality
- Ο πιο σημαντικός παράγοντας πρόγνωσης 1- year survival -> ποσοστό μείωσης της sCr μέσα σε 24h από το peak

Persistent decrease of renal functional reserve in patients after cardiac surgery-associated acute kidney injury despite clinical recovery

Husain-Syed et al , 2019 J Am Soc Nephrol

- Conclusions. Among elective cardiac surgery patients, AKI or elevated post-operative CCA biomarkers were associated with decreased RFR at 3 months despite normalization of serum creatinine. Larger prospective studies to validate the use of RFR to assess renal recovery in combination with biochemical biomarkers are warranted.

25% with AKI -> CKD after 3- year period

ΠΡΟΓΝΩΣΗ

- Icu stay 5,4d vs 2,2d
- Hospital stay 15d vs 10,5 d
- Αυξημένο κόστος στη δημόσια υγεία- 26.000δολ για AKI και 69.000δολ AKI/RRT

RISK FACTORS

PATIENT-RELATED

Gender

Advanced age

Severe cardiac surgery

Previous cardiac surgery

Active congestive heart failure

Cardiogenic shock

NYHA class III/IV

LVEF<35%

LM disease

Anaemia

Coexisting disease (peripheral vascular disease, hypertension, atherosclerotic disease, COPD, previous cerebrovascular accidents, DM, CKD, CLD)

Nephrotoxins (ACEis/ARBs, antibiotics, diuretics, NSAID)

RISK FACTORS

PROCEDURE-RELATED

- Preoperative Preoperative contrast media exposure, insertion of IABP
Emergency status
- Intraoperative Type of surgery(valvular, valvular and coronary, emergency
and redo surgery)
CPB(non-pulsative,low-flow,low-pressure perfusion)
Hypotension, Hypothermia, Deep hypothermic CA,CPB
duration, Cross-clamp duration
Anaemia, Transfusion load, Embolism
- Postoperative Low cardiac output, Hypovolemia, Hypotension, Intensive
vasoconstriction, Atheroembolism,
Sepsis,Nephrotoxins,Cardiogenic shock

Cleveland Clinic Score

Derivation Cohort: 15,838 cardiac surgery patients,
Single U.S. Center, 1993–2002

Validation Cohort: 17,379 cardiac surgery patients
from the same center and time period

Variable	Points
Female sex	1
Congestive heart failure	1
Left ventricular ejection fraction < 35%	1
Preoperative intra-aortic balloon pump	2
Chronic obstructive pulmonary disease	1
Insulin-dependent diabetes	1
Previous cardiac surgery	1
Emergency surgery	2
Type of surgery	0–2
Preoperative serum creatinine	0–5
Score range	0–17

Mehta Score

Derivation Cohort: 449,524 cardiac surgery patients,
database of > 600 centers, 2002–2004

Validation Cohort: 86,009 cardiac surgery patients from the
same database, 2005

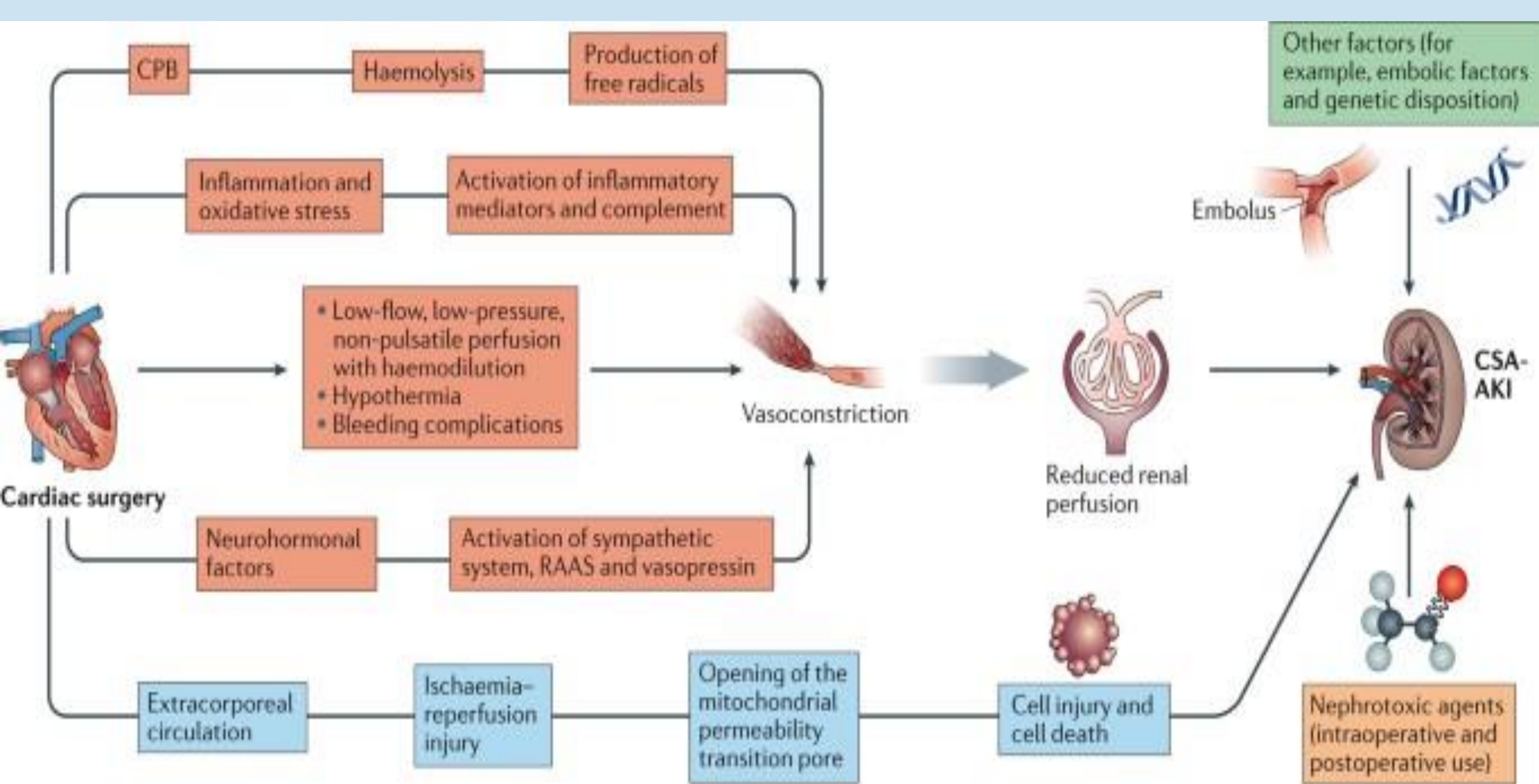
Variable	Points
Age ≥ 55	0–10
Non-White race	2
Preoperative serum creatinine	5–40
New York Heart Association Class IV heart failure	3
Diabetes treated with oral medications	2
Insulin-dependent diabetes	5
Chronic obstructive pulmonary disease	3
Recent myocardial infarction	3
Previous cardiac surgery	3
Cardiogenic shock	7
Type of surgery	0–7
Score range	0–85

Simplified Renal Index

Derivation Cohort: 10,751 cardiac surgery
patients, single Canadian center, 1999–2004

Validation Cohort: 9,380 cardiac surgery
patients, two Canadian centers, 1999–2003

Variable	Points
Preoperative glomerular filtration rate	1–2
Diabetes requiring medications	1
Left ventricular ejection fraction ≤40%	1
Previous cardiac surgery	1
Preoperative intra-aortic balloon pump	1
Nonelective surgery	1
Type of surgery	0–1
Score range	0–8



ΔΙΑΓΝΩΣΗ ΚΑΙ ΟΡΙΣΜΟΣ

A PROBLEMATIC ISSUE

Ποιο διαγνωστικό κριτήριο?

Stage	SCr criteria	Urine output criteria
RIFLE		
Risk	SCr increase to 1.5-fold or GFR decrease >25% from baseline	<0.5 mL/kg/h for 6 h
Injury	SCr increase to 2.0-fold or GFR decrease >50% from baseline	<0.5 mL/kg/h for 12 h
Failure	SCr increase to 3.0-fold or GFR decrease >75% from baseline or SCr \geq 4 mg/dL with an acute increase of at least 0.5 mg/dL	Anuria for 12 h
AKIN		
1	SCr increase \geq 0.3 mg/dL (\geq 26.5 μ mol/L) or increase to 1.5–2.0-fold from baseline	<0.5 mL/kg/h for 6 h
2	SCr increase >2.0–3.0-fold from baseline	<0.5 mL/kg/h for 12 h
3	SCr increase >3.0-fold from baseline or SCr \geq 4.0 mg/dL (\geq 354 μ mol/L) with an acute increase of at least 0.5 mg/dL (44 μ mol/L) or need for RRT	<0.3 mL/kg/h for 24 h or anuria for 12 h or need for RRT
KDIGO		
1	SCr 1.5–1.9 times baseline or \geq 0.3 mg/dL increase within 48 h	<0.5 mL/kg/h for 6–12 h
2	SCr 2.0–2.9 times baseline	<0.5 mL/kg/h for \geq 12 h
3	SCr 3.0 times baseline or increase in SCr to \geq 4.0 mg/dL or initiation of RRT	<0.3 mL/kg/h for \geq 24 h or anuria for \geq 12 h

GFR, glomerular filtration rate; RRT, renal replacement therapy; AKI, acute kidney injury.

Acute kidney injury based on KDIGO (Kidney Disease Improving Global Outcomes) criteria in patients with elevated baseline serum creatinine undergoing cardiac surgery

Machado et al, Rev. Bras Cir Cardiovasc 2014

Conclusion:

- In this population, acute kidney injury based on the Kidney Disease Improving Global Outcomes criteria was a powerful predictor of 30-day mortality in patients with elevated preoperative serum creatinine who underwent cardiac surgery (coronary artery bypass grafting or cardiac valve surgery).

Acute kidney injury after cardiac surgery: A comparison of different definitions

Sutherland et al, Nephrology 2020

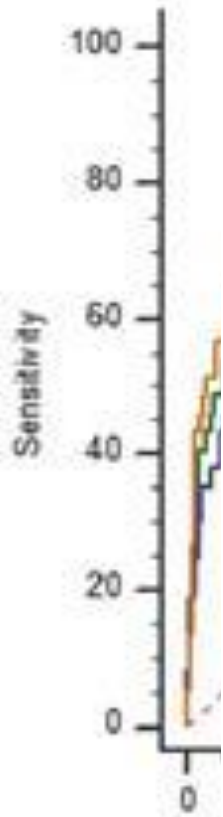
Conclusion:

- Risk, injury, failure, loss, end-stage kidney disease-risk was the best definition of AKI as determined by the ability to predict short-term mortality.
- AKIN criteria are not sensitive enough to capture all episodes of AKI in this population.
- KDIGO criteria most sensitive of the AKI definitions to identify the condition

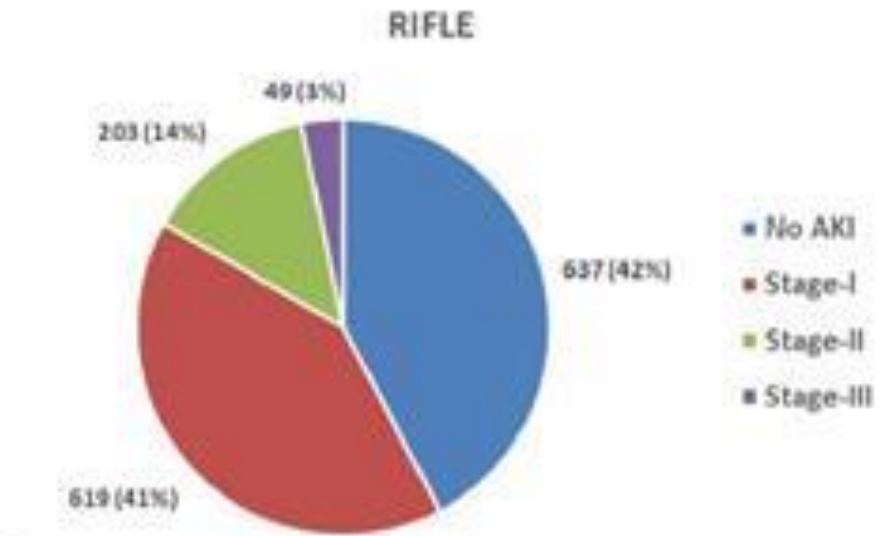
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Comparison of AKI Definitions: RIFLE, AKIN, and KDIGO

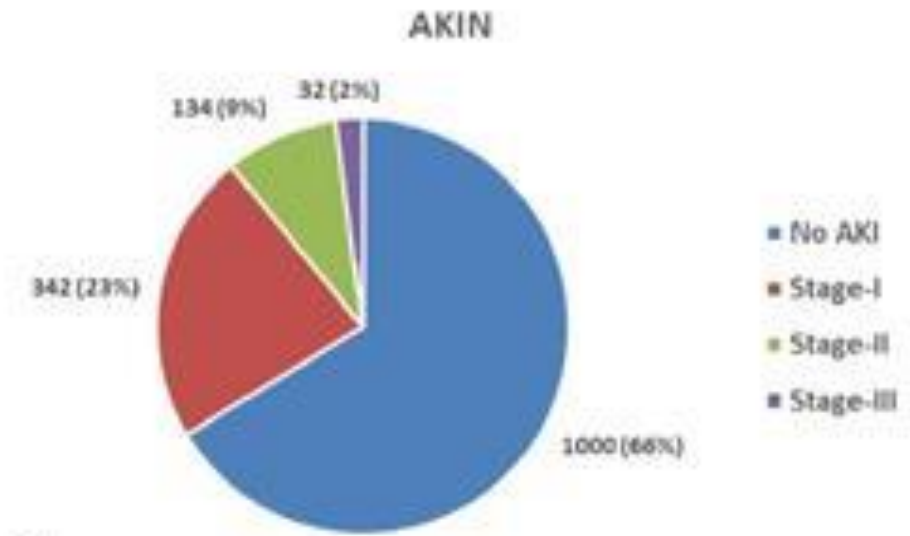
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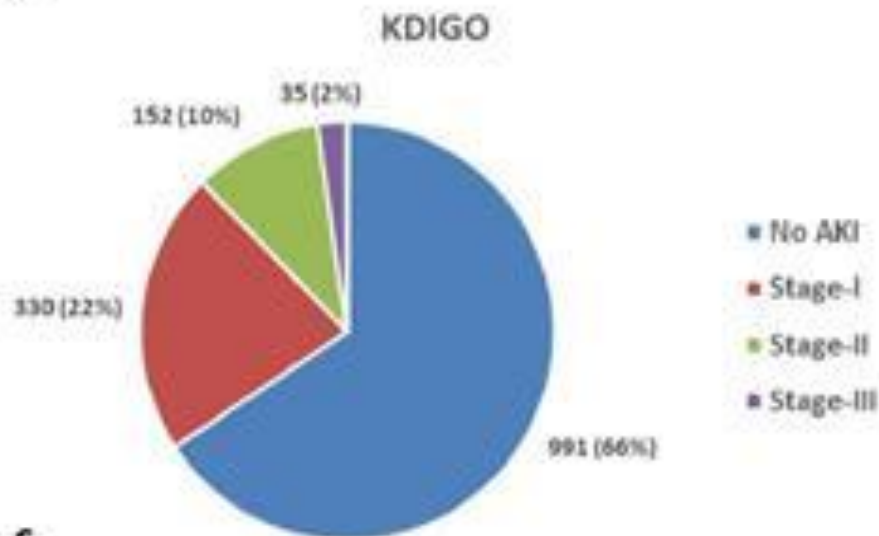
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a



b



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ΔΙΑΓΝΩΣΗ ΚΑΙ ΟΡΙΣΜΟΣ

A PROBLEMATIC ISSUE

Ποια η αξία της κρεατινίνης και της διούρησης για την έγκαιρη διάγνωση?

Urine Output

Αμφιλεγόμενη κλινική σημασία

McIroy et al, 2013 J.

Cardiothorac Vasc Anesth



Priyanka et al, 2020 J.

Thorac Cardiovasc. Surg)

Αύξηση διαγνωστικής αξίας με furosemide stress- test-> furosemide (1.0-1.5mg/kg)-> <200cc σε 2h -> βλάβη στα νεφρικά σωληνάκια σε πρώιμα στάδια

Creatinine

Evaluating Surrogate Measures of Renal Dysfunction After Cardiac Surgery

Duminda N. Wijeyesundera et al, Anesth. Analg 2003

Conclusions:

- The kinetics of serum creatinine were found to predict adverse

ΕΠΗΡΕΑΖΕΤΑΙ ΑΠΟ ΠΑΡΑΓΟΝΤΕΣ ΤΟΥ ΑΣΘΕΝΟΥΣ

increase of 0,12 mg/dl was associated with increased mortality

ΕΞΩΣΩΜΑΤΙΚΗ ΚΥΚΛΟΦΟΡΙΑ

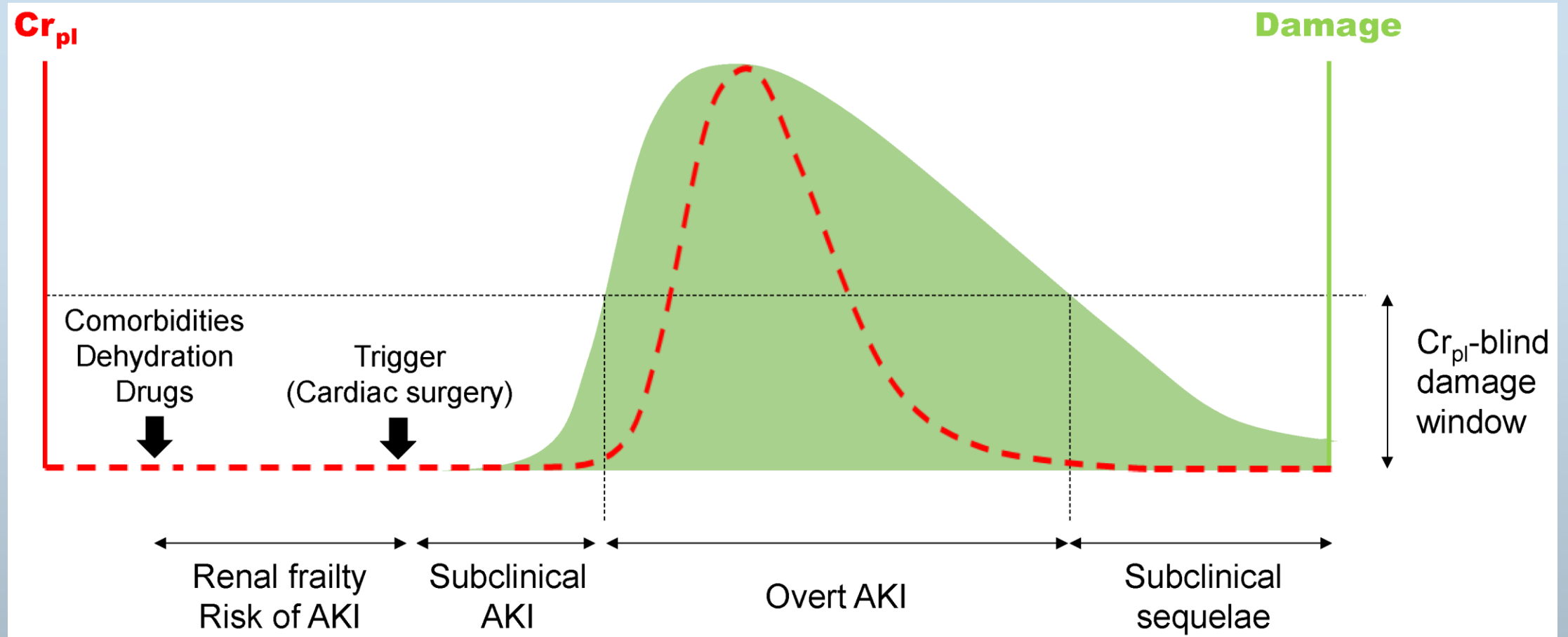
Cardiac and Vascular Surgery–Associated Acute Kidney Injury: The 20th International Consensus Conference of the ADQI (Acute Disease Quality Initiative) Group

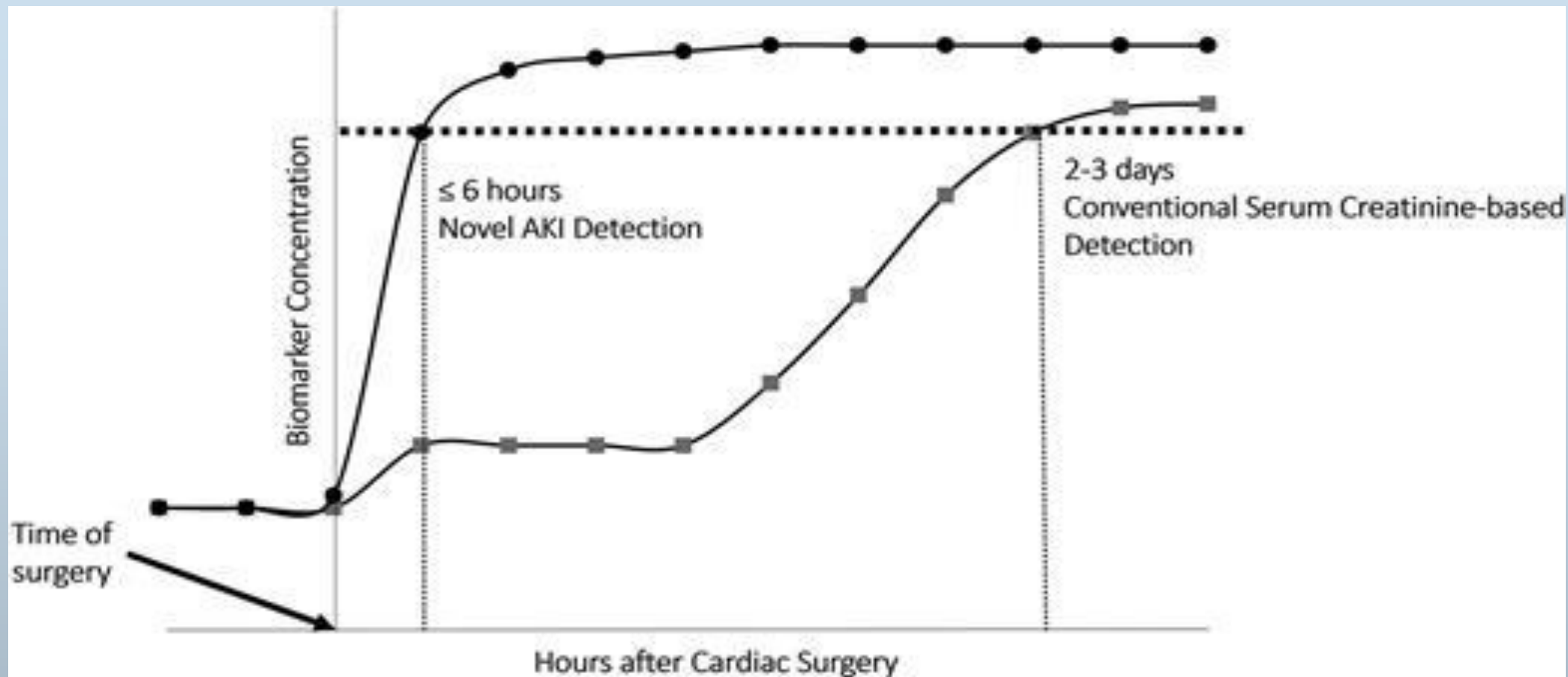
Nadim et al, J Am Heart Assoc 2018

Conclusion:

- We recommend that AKI should be defined by the KDIGO criteria, including both sCr and UO criteria

FUNCTIONAL BIOMARKERS VS DAMAGE BIOMARKERS

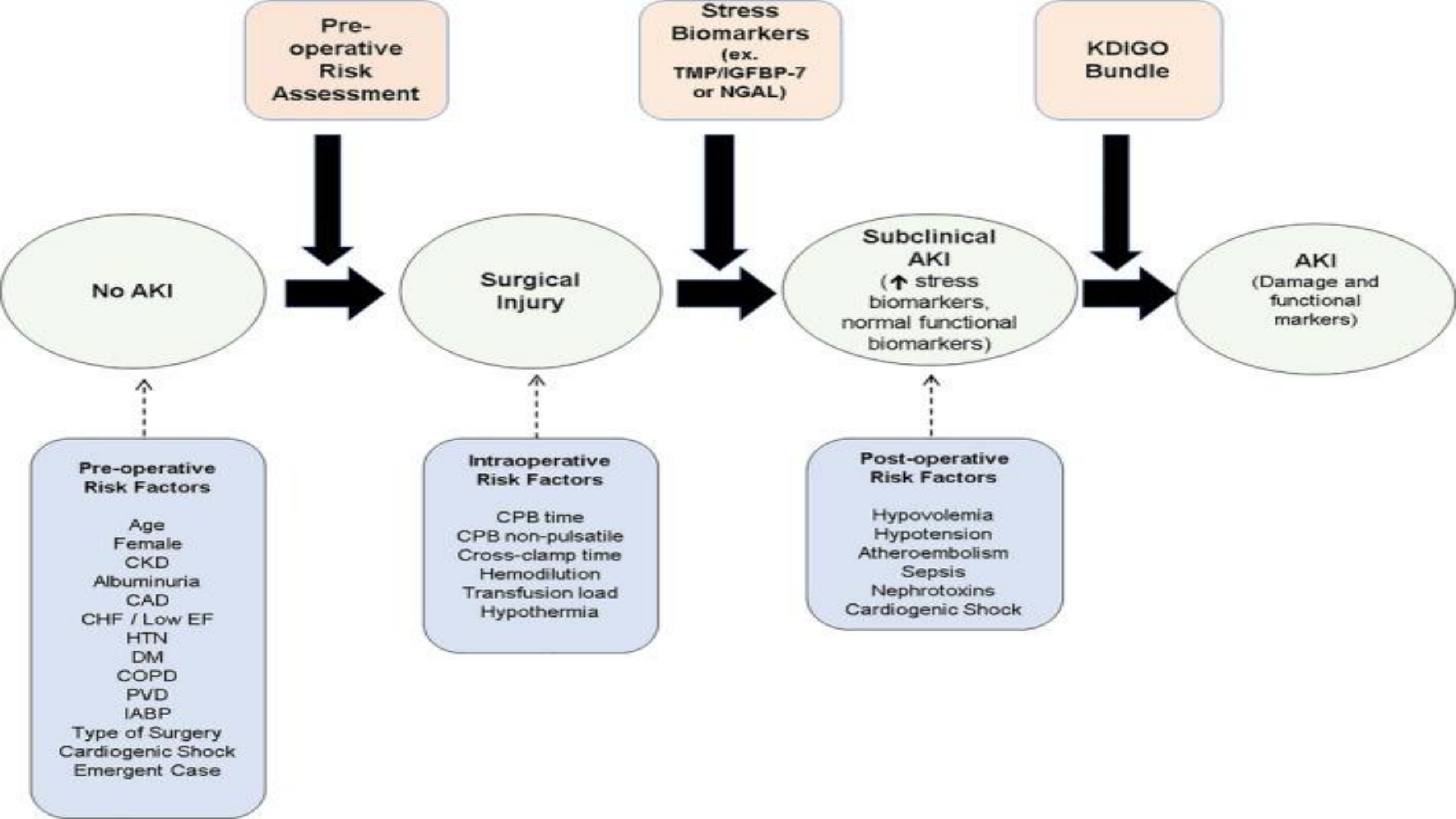




Biomarker	Source	Pathophysiology	Utility in Cardiac Surgery	Limitations
Neutrophil gelatinase-associated lipocalin	Blood, urine	Upregulated in the proximal tubules after ischemic or nephrotoxic injury to the kidneys	Early detection of AKI	More specific in children and adults without chronic kidney disease.
Cystatin C	Blood	Functional biomarker with decreased clearance in AKI	Early detection of AKI Unaffected by differences in muscle mass.	Some studies have indicated that Cystatin C has lower predictive value.
Interleukin-18	Urine	Mediates ischemic and inflammatory kidney injury in the proximal tubules	Early detection of AKI	Some studies have indicated that interleukin-18 has lower predictive value.
Kidney injury molecule-1	Urine	Rapidly expressed in proximal tubular cells after ischemic kidney injury	Early detection of AKI	Some studies have indicated that it peaks up to 2–3 days after kidney injury.
[Tissue inhibitor of metalloproteinase]x[insulin-like growth factor-binding protein 7]	Urine	Induces cell cycle arrest in renal tubular cells	Early detection of AKI Better sensitivity and specificity in predicting AKI.	Some studies have indicated that these biomarkers have lower specificity.
C-C motif chemokine ligand 14	Urine	Mediates inflammatory kidney injury in the proximal tubules	Predicts persistent AKI and the need for renal replacement therapy- and can be used as a marker for progression of AKI to chronic kidney disease	Does not provide early detection of AKI



Fig. 2. Nephrocheck (TIMP-2*IGFBP7) test, an FDA-approved laboratory test that measures urinary levels of cell cycle-arrest proteins to identify patients at risk of developing AKI following cardiac surgery.*



ПРОЛНΨΗ

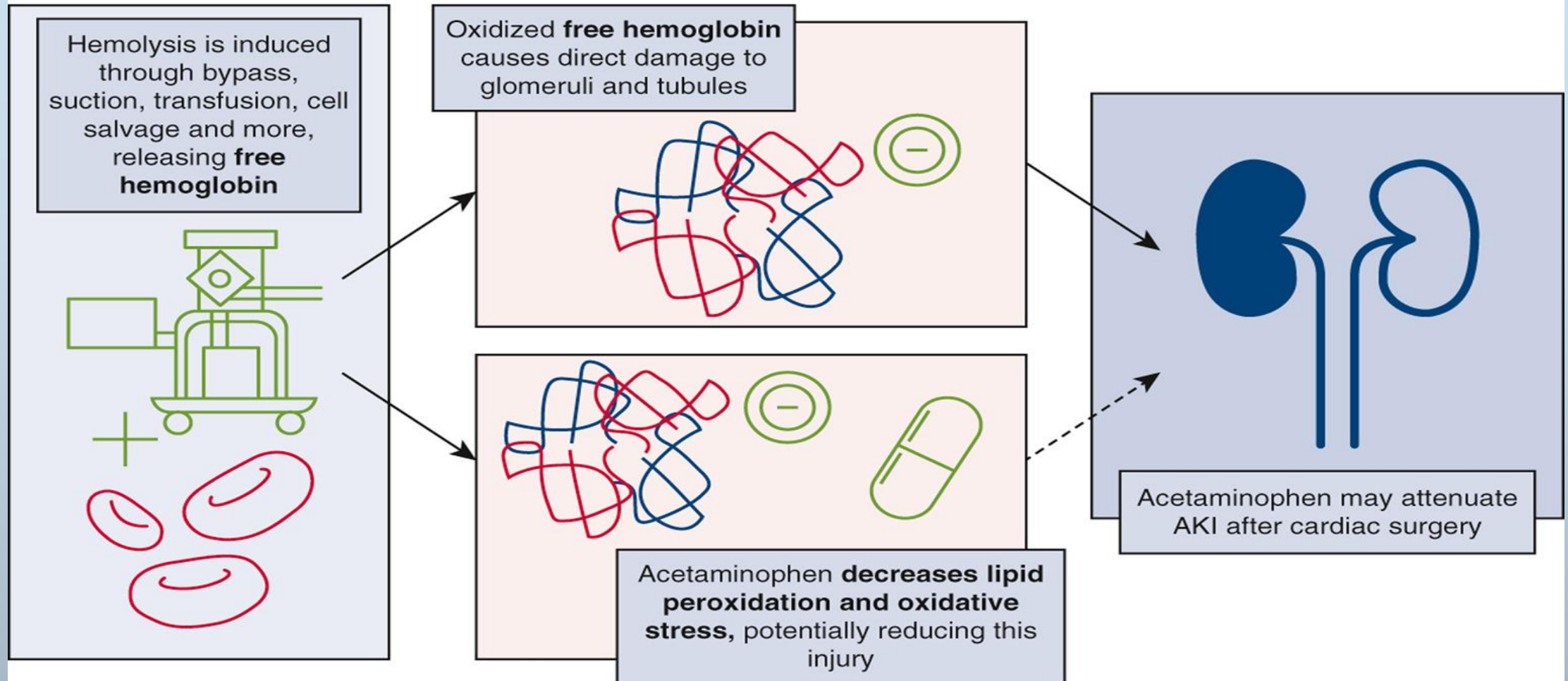
Pharmacologic	Fenoldopam	Maybe less AKI but no change in overall outcomes	Meta-analysis * [50], N = 1107 pts in 7 RCTs	AKI (8.5% vs. 20.3%, RR 0.42 CI 0.26–0.69, $p = 0.0006$) but more hypotension (25.8% vs. 14.7%, RR 1.76 CI 1.29–2.39, $p = 0.0003$); no changes in mortality or RRT.
	Levosimendan	No impact	RCT, N = 849 [51]; RCT, N = 508 [52]	No difference in mortality or renal outcomes in either prophylactic administration or to treat low LVEF postop
	Dopamine	No impact	ICU Meta-analysis, N = 1019 in 24 studies (17 RCTs) [53]; RCT, N = 126 [54]	No impact on improvement of AKI in ICU patients; no change in incidence of AKI in cardiac surgical patients
	Spironolactone	No impact	RCT, N = 233 [55]	No difference in KDIGO AKI, trend toward harm (43% AKI in spironolactone group vs. 29% in placebo, $p = 0.02$)
	Bone morphogenetic protein-7 agonist (THR-184)	No difference	RCT, N = 452 [56]	KDIGO CTS-AKI rates similar in pts with recognized risk factors for AKI (range 74%–79% for various doses of THR-184 vs. 78% in placebo, $p = 0.43$)
	Mesenchymal stem cells	No difference	RCT, N = 156 [57]	Pts with CSA-AKI got MSC v

N-acetylcysteine (NAC)	No benefit	Meta-analysis, N = 1391 in 10 studies [61]	Perioperative administration of NAC resulted in similar CSA-AKI rates (RR 0.841, 95% CI 0.691–1.023, $p = 0.083$)	
Statins	No benefit	RCT, N = 615 [62]	No change in CSA-AKI patients either naïve to or on preoperative statins; trial stopped early for futility; 20.8% AKI in statin group, 19.5% in placebo group (RR 1.06, CI 0.78–1.46, $p = 0.75$)	
Erythropoietin	May benefit low-risk populations but overall no benefit	Meta-analysis, N = 473 in 6 RCTs [63]	Suggestion in sub-group analysis of reduced AKI when given prior to induction of anesthesia (OR 0.27, CI 0.13–0.54, $p = 0.0002$) and in low risk populations (OR 0.25, CI 0.11–0.56, $p = 0.0008$) but overall no difference (OR 0.69, CI 0.35–1.36, $p = 0.28$).	

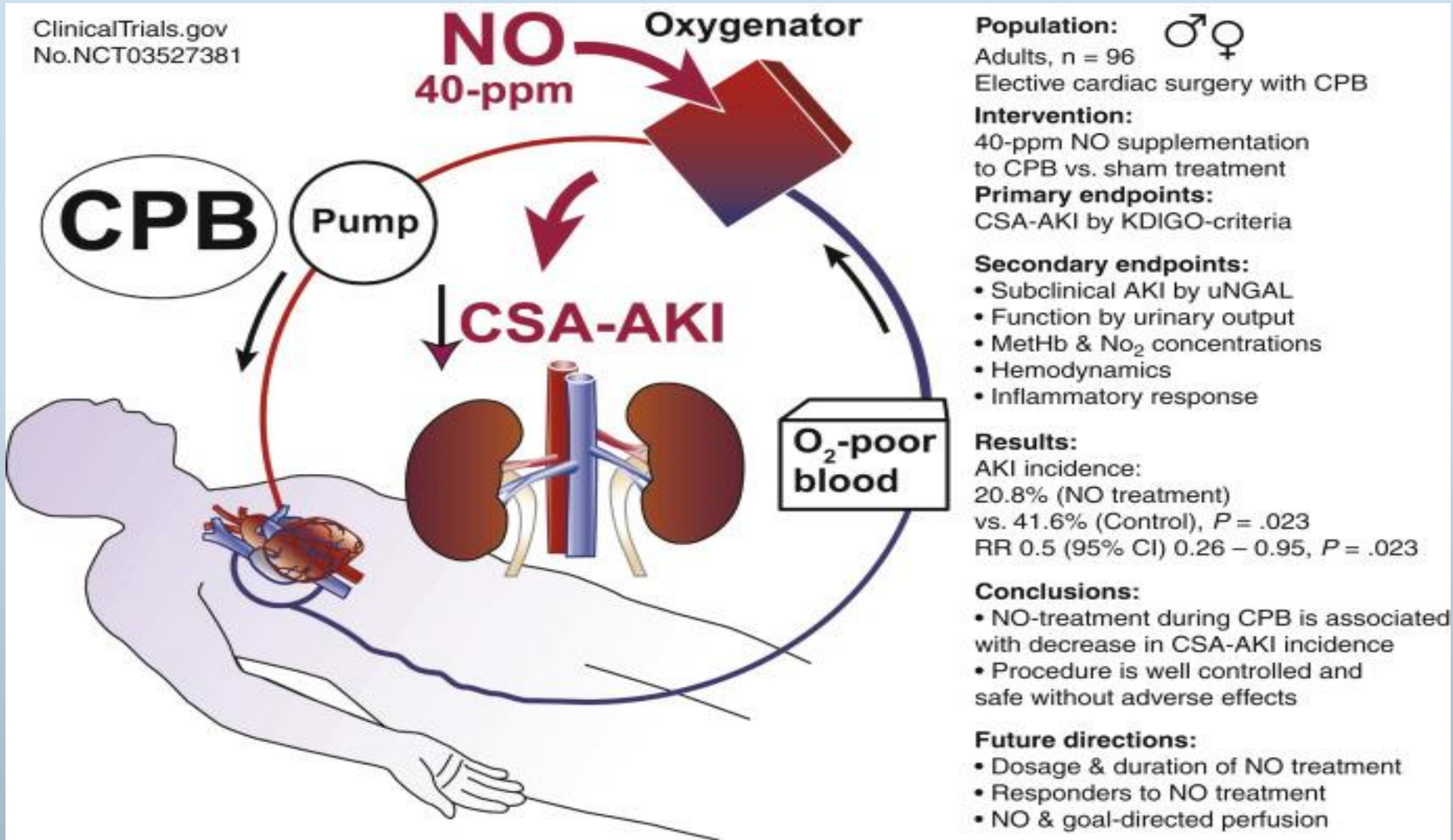
Furosemide	No benefit	RCT, N = 126 [54]; RCT, N = 42 [64]	In Lassnigg, furosemide led to increase in Cr of 0.3 vs. 0.1 in the placebo group ($p < 0.001$). In Mahesh in high-risk patients it increased UOP (3.4 mL/kg/h vs. 1.2 mL/kg/h, $p < 0.001$) without changing AKI rates (43% vs. 43%, RR 1.1, 95% CI 0.6–2.2)
Steroids	No benefit	RCT, N = 7286 [65]	High-risk patients undergoing CPB at given methylprednisolone (250 mg IV $\times 2$) vs. placebo had CSA-AKI rates of 40.6% in steroids vs. 39.2% in placebo (ARR 1.04, 95% CI 0.96–1.11)
Dexmedetomidine	May have AKI benefit, no mortality change	Meta-analysis, N = 1575 in 10 RCTs [60]	Perioperative administration of dexmedetomidine resulted in lower CSA-AKI rates (8.7% vs. 12.3%, OR 0.65, CI 0.45–0.92, $p = 0.02$) but similar mortality (0.8% vs. 2.3%, OR 0.43, 95%

Acetaminophen

Perioperative Acetaminophen is Associated with Reduced Acute Kidney Injury after Cardiac Surgery



Nitric Oxide



Preoperative strategies

1. Νεφροτοξικά φάρμακα

- Αμινογλυκοσίδη -> use for as short a time as possible

The European Renal Best Practice Working Group
(ERBP)

- ΑΜΕΑ/ΑΤ -> διακοπή τουλάχιστον 24^h πριν το χειρουργείο

2021 Joint Consensus ADQI and Perioperative Quality Initiative
(POQI)

2. Prehabilitation -> αμφιλεγόμενος ρόλος

3. Αποφυγή μεγάλης ένδειας ενδοαγγειακού όγκου

4. Θεραπεία αναιμίας με χορήγηση iv iron σε Hb<12,5 και φερριτίνη<100mg/dl

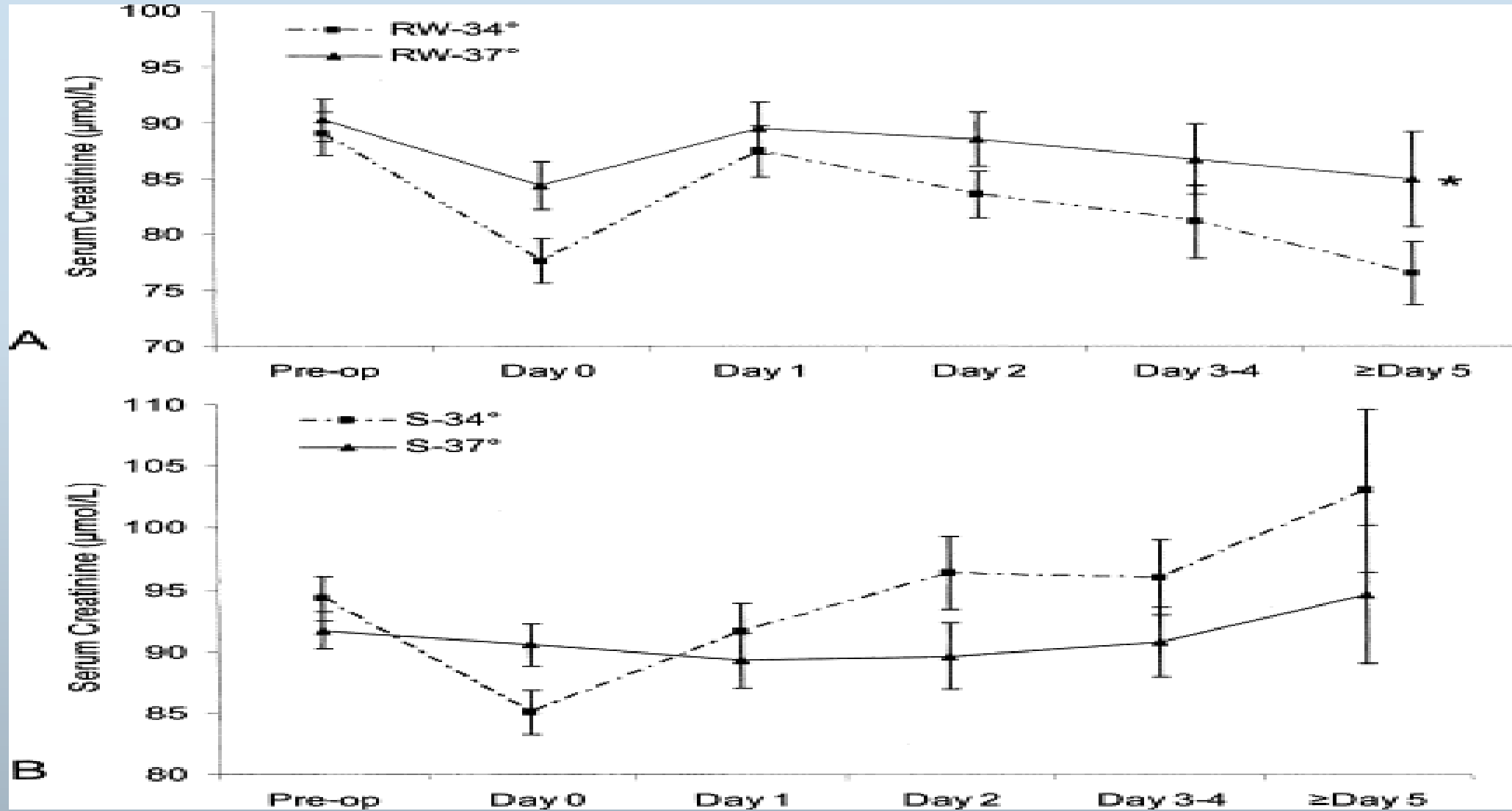
5. Χορήγηση αλβουμίνης σε υπαλβουναϊμία (2C)

6. Αποφυγή 24-72^h σκιαγραφικών παραγοντων πριν το χ/ο (2C)

7. Glu<180 mg/dl- αποφυγή μεγάλων διακυμάνσεων τιμών γλυκόζης

Intraoperative	Volatile anesthetic agents (vs propofol)	Cardiac	2C	...
	Cold renal perfusion for AAA	Vascular	2C	...
	Avoidance of hyperthermia	Cardiac	2C	...
	Pulsatile CPB	Cardiac	2D ^a	...
	Avoidance of hemodilution	Cardiac	2C	...
	Techniques to prevent procedure-related atheroembolism	Vascular	2C	...
	OPCAB technique	Cardiac	...	1A
	Remote ischemic preconditioning	Cardiac	2B ^a	More research needed for vascular and low risk cardiac surgery
	Minimization of aortic manipulation	Cardiac	...	More research needed
	MAP >75	Cardiac	...	More research needed
Postoperative	Intraoperative ultrafiltration	Cardiac	...	More research needed
	KDIGO bundle	Cardiac	1B ^a	...
	Low tidal volume ventilation strategy	Cardiac	1C	...
	Loop diuretics (for			

1. Rewarming temperature on CPB



1. Duration of rewarming temp >37 -> independently risk factor for AKI ->
2. Avoid Hyperthermic Reperfusion >37
(STS/SCA/AmSECT 2022)

- 2016 Multicenter study -> 8407 pts ->

51% increase in the incidence of AKI for every 10 minutes of hyperthermic perfusion

2. Oxygen delivery on CPB -> GOAL-DIRECTED OXYGEN DELIVERY STRATEGY

Ranucci et al 2018 ²²	Nine centers in 7 countries	CABG and/or valve, aorta with CPB	326	A goal-directed perfusion strategy of maintaining oxygen delivery ≥ 280 mL/min/m ² versus control (a conventional perfusion strategy of	AKIN	<i>J Thorac Cardiovasc Surg</i> (5.21)
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2019 N. ZEALAND- AUSTRALIA-> 19.000 pts
-> DO₂<270ml/min/m² -> increased odds of AKI

Mukaida et al 2021 ²³	Japan	CABG and/or valve, or other, with CPB	275	Maintaining an oxygen delivery index value > 300 mL/min/m ² versus control (a conventional strategy of target pump flow 2.6 L/min/m ²) during CPB reduced the incidence of AKI.	KDIGO	<i>J Thorac Cardiovasc Surg</i> (5.21)
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3. Διεγχειρητική ΜΑΠ

- Αμφιλεγόμενη η σχέση διεγχειρητικής ΜΑΠ και CS AKI
- It is recommended to adjust the MAP during CPB with the use of arterial vasodilators (if MAP >80 mmHg) or vasoconstrictors (if MAP >50mmHg) after adjusting the depth of anaesthesia and assuming sufficiently targeted pump flow. (IA) (EACTS/EACTA/EBCP 2019)

Azau et al 2014 ¹¹	France	CABG, valve, or aorta, with CPB	292	A high level of MAP (75–85 mm Hg) versus control (MAP, 50–60 mm Hg) during normothermic CPB did not reduce the risk of AKI.	30% rise in sCr	<i>Perfusion</i> (1.97)
Kandler et al 2019 ¹²	Denmark	CABG + valve, with CPB	90	Arterial pressure >60 mmHg versus control (MAP, 47 mm Hg) during CPB did not reduce the incidence of AKI or chronic kidney injury at postoperative 4 mo.	RIFLE	<i>J Cardiothorac Sur</i> (1.64)
Vedel et al 2018 ¹³	Denmark	CABG and/or valve, with CPB	197	A higher MAP (70–80 mm Hg) versus control (MAP, 40–50 mm Hg) increased the number of patients with postoperative <u>doubling of sCr.</u>	sCr ≥2 times of baseline	<i>Circulation</i> (29.7)

Increasing mean arterial pressure during cardiac surgery does not reduce the rate of postoperative acute kidney injury

Azau et al, Perfusion 2014

- **Conclusion:** Maintaining a high level of MAP (on average) during normothermic CPB does not reduce the risk of postoperative AKI.
- It does not alter the length of hospital stay or the mortality rate.

Defining an Intraoperative Hypotension Threshold in Association with De Novo Renal Replacement Therapy after Cardiac Surgery

Ngu J et al, Anesthesiology 2020

- **Conclusions:** MAP less than 65 mmHg for 10 min or more post-CPB is associated with an increased risk of de novo postoperative renal replacement therapy.
- There was no association between hypotension before and during CPB with RRT.
- The association between intraoperative hypotension and AKI was weaker in comparison to factors such as renal insufficiency, heart failure, obesity, anemia, complex or emergent surgery, and new-onset postoperative atrial fibrillation.
- Nonetheless, post-CPB hypotension is a potentially easier modifiable risk factor that warrants further investigation.

Intraoperative Hypotension and Acute Kidney Injury, Stroke, and Mortality during and outside Cardiopulmonary Bypass: A Retrospective Observational Cohort Study

Anesthesiology 2022

- **Conclusions:** This study confirms previous single-center findings that intraoperative hypotension throughout cardiac surgery is associated with an increased risk of acute kidney injury, mortality, or stroke.

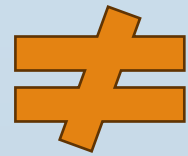
Intraoperative target blood pressure

Targeting a higher blood pressure during
CPB did not reduce AKI
(a low level of GRADE evidence)

SCA 2022

4. Αγγειοσυσπαστικά

Νορεπινεφρίνη



Βαζοπρεσσίνη

Vasopressin *versus* Norepinephrine in Patients with Vasoplegic Shock after Cardiac Surgery: The VANCS Randomized Controlled Trial

Hajjar et al, *Anesthesiology* 2017

- **Conclusions** : The authors' results suggest that vasopressin can be used as a first-line vasopressor agent in postcardiac surgery vasoplegic shock and improves clinical outcomes.
- The primary endpoint was a composite of mortality or severe complications (stroke, requirement for mechanical ventilation for longer than 48 h, deep sternal wound infection, reoperation, or acute renal failure) within 30 days.
- The primary outcome occurred in 32% of the vasopressin patients and in 49% of the norepinephrine patients (unadjusted hazard ratio, 0.55; 95% CI, 0.38 to 0.80; $P = 0.0014$)

Reccomendation

ADQI group 2018

- Reccomended norepinephrine as the first choice for the treatment of vasoplegia during cardiac and vascular surgery
- More research is needed before supporting vasopressin as an equal choice to norepinephrine

Society of Cardiovascular Anesthesiologists 2022

- Use of vasopressin in vasoplegic shock patients reduced AKI (Low level of GRADE evidence)

Choice of specific vasopressor agent						
Lasnigg et al 2000 ¹⁴	Austria	CABG and/or valve, with CPB	123	Renal-dose dopamine (2 µg/kg/min) versus control (normal saline placebo) is ineffective for preventing AKI.	$\Delta\text{Crea}_{\text{max}} > 0 >$ 0.5 mg/dL	<i>J Am Soc Nephrol (10.12)</i>

Dopamine infusion alone during CPB and the perioperative period is not recommended to reduce the risk of CSA AKI (III) (STS/SCA 2022)

5. Ιν υγρά και διουρητικά

- Συστήνεται η ανάνηψη με ισορροπημένα κρυσταλλοειδή υγρά όπως R/L από 0.9% saline (ADQI)
- Η αλκαλοποίηση των ούρων με bicarbonate δε συστήνεται ως ρουτίνα
- 4% albumin δεν είχε καμμία διαφορά σε σχέση με R/L στη μείωση της AKI, αλλά αύξησε την πιθανότητα αιμορραγίας και λοίμωξης (The Albumin in Cardiac Surgery trial, ALBICS, 2020)
- Hydroxyethyl starch (HES) δε συστήνεται σε ασθενείς υψηλού κινδύνου για CSA-AKI
- Τα διουρητικά δε συστήνονται για την πρόληψη της AKI, αλλά για τη ρύθμιση του ισοζυγίου υγρών

Association between postoperative fluid balance and acute kidney injury in patients after cardiac surgery: A retrospective cohort study

Shen et al, J.Crit Care 2018

- **Conclusions**

Compared to zero FB, postoperative positive FB was associated with higher AKI incidence.

Yet, the association between negative FB and AKI was insignificant.

A “U”-shape association between postoperative fluid intake and AKI was detected.

Intraoperative fluid balance and cardiac surgery-associated acute kidney injury: a multicenter prospective study

Palomba et al, Braz J Anesthesiol 2022

- **Conclusion**

Patients undergoing on-pump CABG with LFB when compared with patients with RFB present similar CSA-AKI rates and ICU-LOS,

but higher in-hospital mortality, cardiovascular complications, and H-LOS.

6. Μετάγγιση RBC

The least of 3 evils: exposure to red blood cell transfusion, anemia, or both?

Loor et al, J Thor Cardiovasc Surg 2013

- **Results:** After risk adjustment, comparison of all 4 groups showed that double exposure to anemia (HCT <25%) and RBC transfusion was associated with the highest risk: lowest eGFR (P = .008), highest troponin values (P = .01), longest ventilator requirement (P < .001), longest length of stay (P < .001), and highest mortality (P = .007).
- **Conclusions:** Although single exposure to anemia or RBC transfusion alone was associated with risk, it was generally lower than that of anemia and RBC exposure in combination.

Effects of restrictive red blood cell transfusion on the prognoses of adult patients undergoing cardiac surgery: a meta-analysis of randomized controlled trials

Chen et al, Crit Care 2018

• Conclusions

Our meta-analysis demonstrates that **the restrictive** red blood cell transfusion strategy was **not inferior** to the liberal strategy with respect to 30-day mortality, pulmonary morbidity, postoperative infection, cerebrovascular accidents, acute kidney injury, or acute myocardial infarction, and fewer red blood cells were transfused.

TRICS III (The Transfusion Requirements in Cardiac Surgery) study, 2019

- No difference in the incidence of new-onset AKI requiring renal replacement therapy in patients who were transfused to a restrictive (7,5 g/dl) versus a liberal transfusion (9,5g/dl) threshold.
- No difference in the incidence of milder forms of AKI between two groups

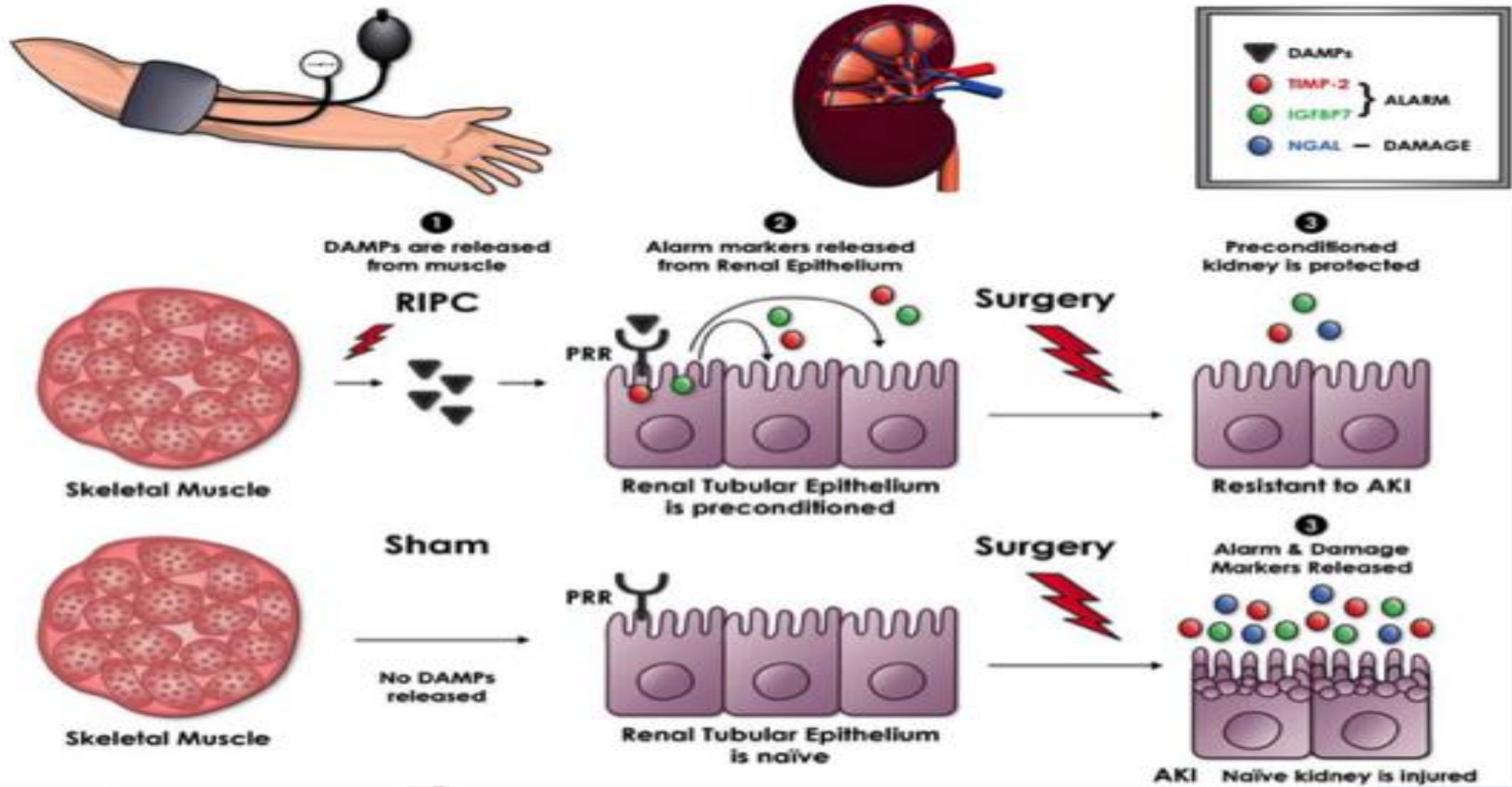
EACTS/EACTA GUIDELINES 2017

- It is recommended that one transfuse PRBCs on the basis of the clinical condition of the patient rather than on a fixed haemoglobin threshold. I B
- A haematocrit of 21–24% may be considered during CPB when an adequate DO₂ (4273 ml O₂/min/m²) level is maintained. IIB

SOCIETY OF CARDIOVASCULAR ANESTHESIOLOGISTS PRACTICE UPDATE 2022

- Modifying/selecting transfusion threshold did not prevent AKI (a moderate level of GRADE evidence)

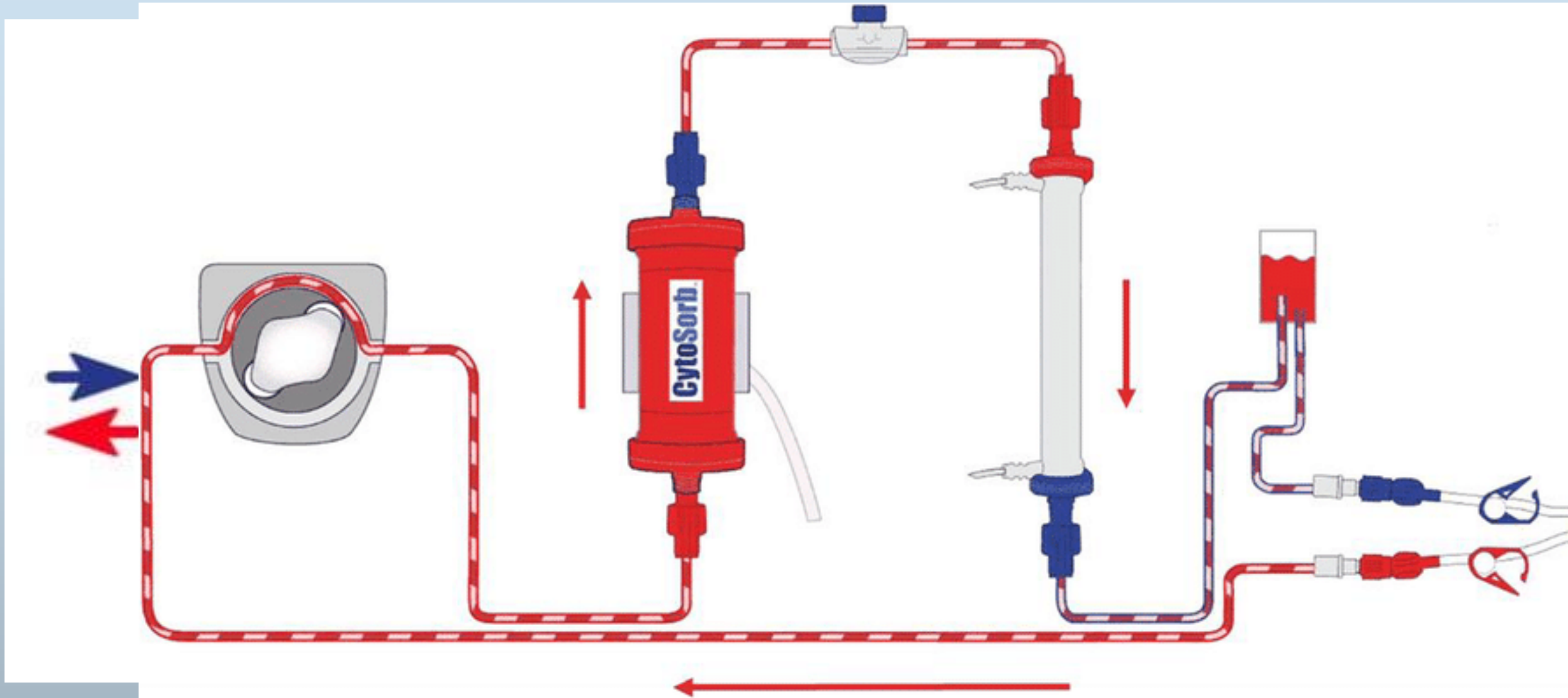
7. Renal



Re preconditioning stimulus

Systemic (anti-inflammatory and genes)

8. Removal of Hemolysis Products



Postoperative strategies

KDIGO GUIDELINES 2012

1. Διακοπή ΑΜΕΑ/ΑΤ για τουλάχιστον 48h MTX
2. Αποφυγή νεφροτοξικών φαρμάκων
3. Συχνός έλεγχος κρεατινής ορού και αποβολής ούρων
4. Αποφυγή υπεργλυκαιμίας
5. Αποφυγή σκιαγραφικών παραγόντων
6. Ρύθμιση ισοζυγίου υγρών και αιμοδυναμικού status βάσει λειτουργικού αιμοδυναμικού monitoring

	Design	Outcome	Patients	Intervention	Results
PrevAKI 1	Single center prospective RCT	Primary: all KDIGO stage AKI within 72 h postop	276 patients (138 control and 138 intervention) undergoing on-pump cardiac surgery at high risk of AKI by Nephrocheck [®] 4 h post-CPB	Bundled care including discontinuing ACEi/ARBs, avoiding nephrotoxins, and an algorithmic approach to hemodynamic management (see text) resulting in more dobutamine, less hyperglycemia, and fewer ACEi/ARBs in intervention group	<u>Lower rate of all-stage AKI</u> (71.7% in control vs. 55.1% in intervention, $p = 0.004$, OR 0.483, 95% CI 0.293–0.796)

PrevAKI 2 [29]

Multicenter
prospective RCT

Primary:
adherence to
bundled care

278 patients (142
control and 136
intervention)
undergoing on-
pump cardiac
surgery at high
risk of AKI by
Nephrocheck[®] 4
h post-CPB

Bundled care
including
discontinuing
ACEi/ARBs,
avoiding
nephrotoxins,
and an
algorithmic
approach to
hemodynamic
management
resulting in more
dobutamine and
more crystalloid
in intervention
group

Increased
adherence to
bundle (4.2% in
control vs. 65.4%
in
intervention, $p < 0.001$, OR 42.92,
95% CI 17.61–
104.60);
secondary
outcomes
without
difference in all-
stage AKI (41.5%
in control vs.
46.3%) but less
stage 2 and 3 AKI
(23.9% in control
vs. 14.0%, OR
0.52, 95% CI
0.28–0.96)

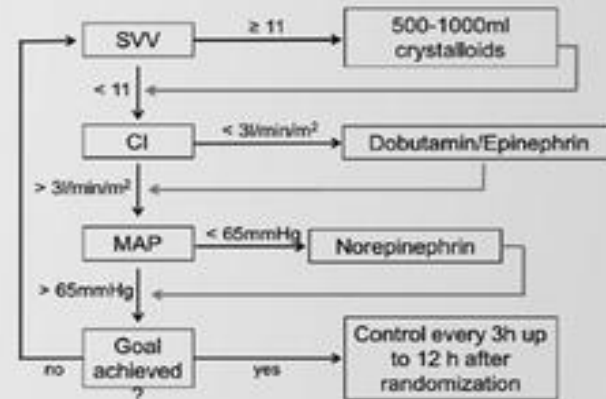
High-risk

- Elevation of renal stress markers (biomarkers)
[TIMP-2]*[IGFBP7] \geq 0.3

Intervention

(according to the KDIGO recommendation)

- Discontinuation of nephrotoxic agents (ACEi/ARBs for 48 hours)
- Optimization of volume status and perfusion pressure (according to the following algorithm for 12 hours)



- Consideration of functional hemodynamic monitoring (e.g. PICCO monitoring)
- Close monitoring of sCr and UO
- Avoidance of hyperglycemia (for 72 hours)
- Consideration of alternatives to contrast agents

Engelman [28]

QI initiative with pre- and post-implementation comparison

Primary: incidence of KDIGO stage 2 and 3 AKI

435 patients undergoing cardiac surgery before Nephrocheck[®] use vs. 412 patients after

Activation of kidney response team in at-risk patients (based on Nephrocheck[®]) which advised targeted hemodynamic management, liberalized transfusion, and avoidance of nephrotoxins; no specific algorithms or in-group treatment differences reported

Lower stage 2 and 3 AKI after implementation (2.3% pre vs. 0.24% post, $p = 0.01$)

THE NEPHROCHECK TEST

Intended to aid in assessing the risk of moderate to severe AKI.

WHO TO TEST

All cardiac surgery patients on post-op day 1 at 05:30.

WHO NOT TO TEST

Pre-op creatinine >2, on dialysis or received methylene blue

STAGES OF ACUTE KIDNEY INJURY (AKI)

	Serum Creatinine	Urine Output
2	Increase of 2.0 – 2.9 x baseline	<0.5 ml/kg/h for 12 hours
3	Increase of >3x baseline or increase of sCr to >4mg/dL or initiation of RRT	<0.3 ml/kg/h for 24 h or anuria for 12 h

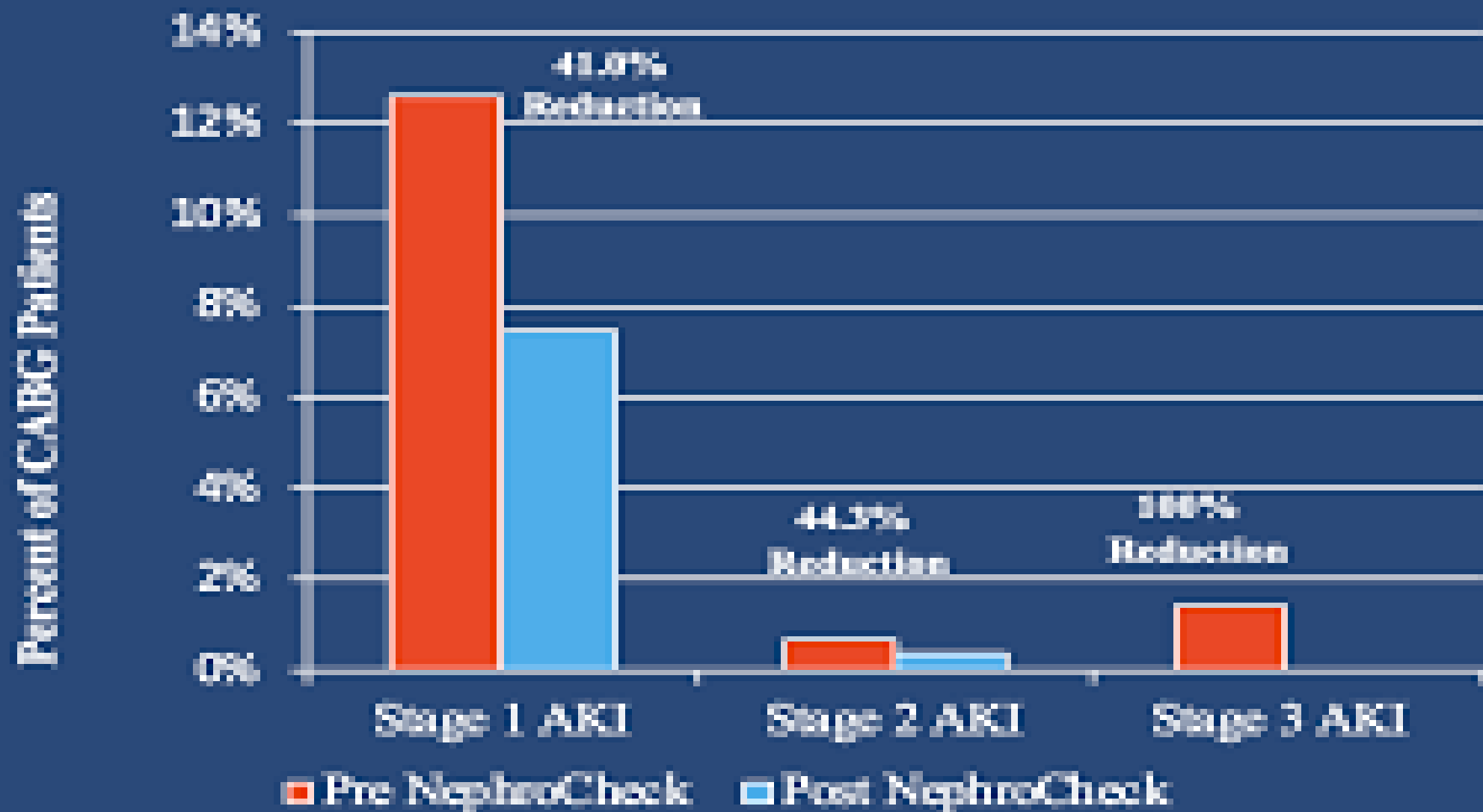
WHEN & HOW TO TEST

1. Pt meets test inclusion: at 05:30am POD1 collect **fresh urine** specimen from foley bag (at least 10 ml).
2. **Results** will show up in EMR chemistry section under urine miscellaneous – click for value range. Lab will report results in time for HVCC 07:00 team rounds

AKI ACTION PLAN (on back of card)

NC/ACUTE KIDNEY RESPONSE TEAM (AKRT) 2.0		
NEG <0.3	(+) 0.3 -2.0	HIGH (+) >2.0
FAST TRACK	TELE UNIT @ 4PM	ACTIVATE AKRT
Remove Foley, arterial line, central line. Transfer to telemetry if meeting all other criteria (CI/HR/Resp. fxn) liberal diuretics.	Keep Foley and monitor hourly UO until afternoon rounds. Transfer to telemetry (after 4PM) if all other transfer criteria are met (CI/HR/Resp. fxn) and no oliguria treatment was required.	Keep Foley and monitor hourly UO. Maintain hemodynamic monitoring.
<u>May use:</u> ARBs/ACE-I Toradol prn (if pre-op GFR>60) Consider holding diuretics if Toradol given.	<u>AVOID</u> <u>NEPHROTOXINS</u> NSAIDS, ARBs/ACE-I, Vanco/Gentamycin Transfusion threshold Hgb <7.0 unless oliguric.	<u>AVOID</u> <u>NEPHROTOXINS</u> NSAIDS, ARBs/ACE-I Vanco/Gent Renal dosing of medications
Transfusion threshold Hgb <7.0 Check SCr daily	<u>IF PT BECOMES OLIGURIC:</u> (UO <.5 cc/kg/hr X 3 hours) activate AKRT/Nephrology consult. Use lactated ringers boluses if CVP<8; PAD<14; Hold Lasix unless pulmonary edema. Repeat NC in 24hr	Goal directed therapy (keep PAD>14 with LR, No diuretics unless PAD>20 or CHF), reassess transfusion threshold. CI >2.5, SBP>130. Monitor SVO2, Echo if <55% Nephrology Consult Repeat NC in 24hr

AKI Results by KDIGO Stage



Management

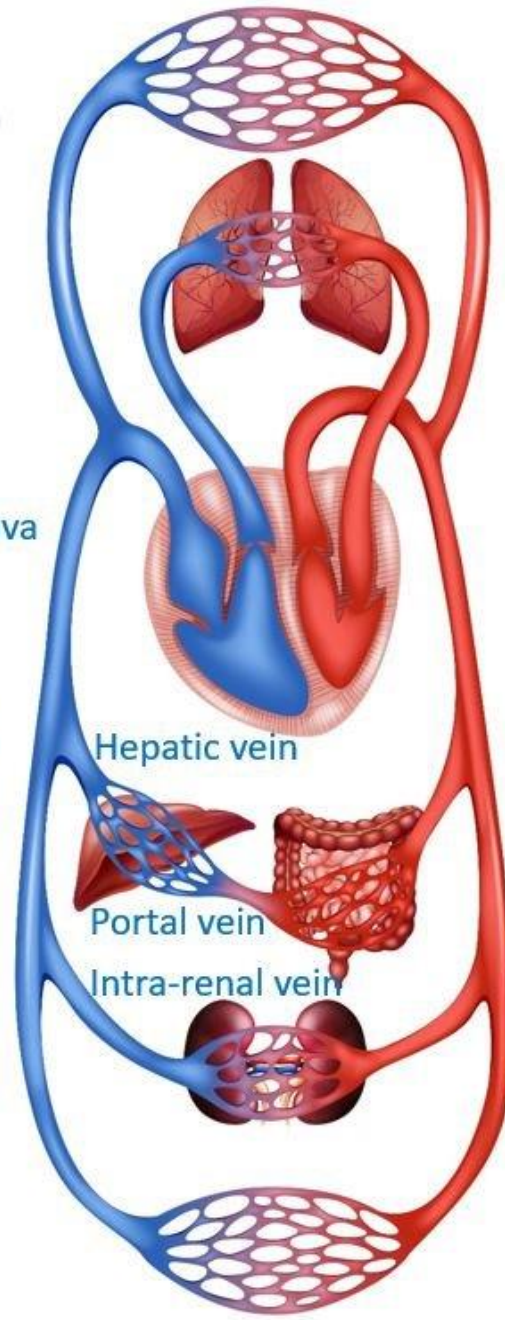
- Αποτροπή εξέλιξης AKI
- Ανάρρωση
- Αντιμετώπιση επιπλοκών
- Δε συστήνεται η χορήγηση νατριουρητικών πεπτιδίων, φενολδοπαμίνης, ντοπαμίνης, μαννιτόλης για τη θεραπεία
- RRT->εξατομίκευση
- **Συνεχή παρακολούθηση αιμοδυναμικού status ασθενούς**
- **Συνεχή αξιολόγηση του ισοζυγίου υγρών**

- ΣΥΝΕΧΗ ΠΑΡΑΚΟΛΟΥΘΗΣΗ ΑΙΜΟΔΥΝΑΜΙΚΟΥ STATUS ΑΣΘΕΝΟΥΣ
- ΥΠΟΣΤΗΡΙΞΗ LV Κ RV
- ΒΕΛΤΙΣΤΟΠΟΙΗΣΗ ΠΡΟΦΟΡΤΙΟΥ ΚΑΙ ΜΕΤΑΦΟΡΤΙΟΥ RV
- ΔΙΑΤΗΡΗΣΗ SR
- ΒΕΛΤΙΣΤΟΠΟΙΗΣΗ ΜΑΠ
- ΣΥΝΕΧΗ ΑΞΙΟΛΟΓΗΣΗ ΕΝΔΟΑΓΓΕΙΑΚΟΥ ΟΓΚΟΥ



Inferior vena cava

Pipes



Lung ultrasound
&
Intra-abdominal free fluid

Leaks

Focused cardiac ultrasound

Pump

Do the flow alterations in portal and intra-renal veins predict acute kidney injury in cardiac surgery patients?



Reference: Beaubien-Souligny W, et al. J Am Heart Assoc. 2018;7(19):e009961. PMID: 30371304



N = 145 undergoing cardiac surgery with cardiopulmonary bypass



Mean age 66y,
74% male



LV EF 55%



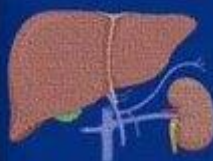
eGFR 76 ml/min
Pre-surgery NT pro-BNP 475



Single-center prospective cohort study

Methods:

Philips ® Sparq machine with concurrent EKG tracing



IVC ultrasound + Hepatic + Portal + intra-renal venous Doppler

Portal pulsatility fraction (PF) = $V_{max} - V_{min} / V_{max} \times 100$



Scans performed before surgery, at ICU admission, daily x 3 days post-surgery

Results:

Incidence of AKI = 33.8% (n = 49)
Diagnosed on day 1 = 35 of 49
None required dialysis



Portal vein pulsatility ($\geq 50\%$) associated with AKI (HR 2.09; CI 1.11-3.94, p=0.02)



Monophasic (diastole-only flow) intra-renal venous pattern associated with AKI (HR 2.81; CI 1.42-5.56; p=0.003)

Other associations with AKI:

Right ventricular dysfunction at cardiopulmonary bypass (HR 2.61, p=0.007)

Higher CVP at the end of surgery (HR 1.04 per 1 mmHg ↑ p=0.02)

IVC > 2 cm (HR 2.35, p=0.02)

High NT-pro-BNP (HR 2.06 per 1 log ↑, p=0.03)



Conclusions: Portal flow pulsatility and intrarenal flow alterations are markers of venous congestion and are independently associated with AKI after cardiac surgery.

VExUS grading

Grade 0

No congestion; IVC < 2 cm

Grade 1

Mild congestion

IVC \geq 2 cm + any combination of normal or mildly abnormal waveforms

Grade 2

Moderate congestion

IVC \geq 2 cm + at least 1 severely abnormal pattern

Grade 3

Severe congestion

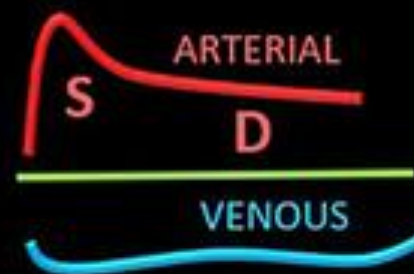
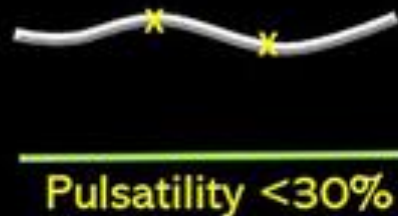
IVC \geq 2 cm + 2 or more severely abnormal waveforms

Hepatic vein

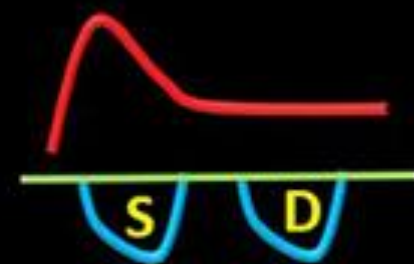
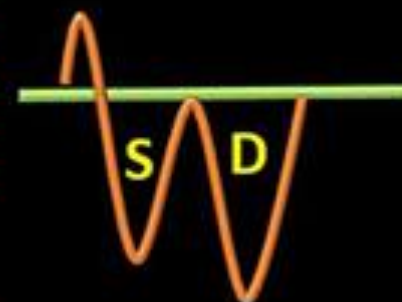
Portal vein

Intrarenal

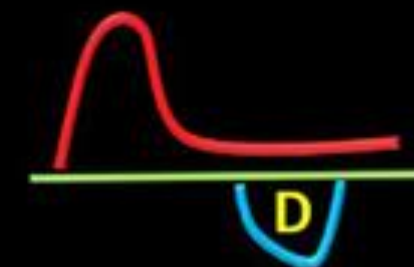
Normal



Mildly abnormal



Severely abnormal



Ευχαριστώ πολύ