PCI σε ασθενείς με χρόνια νεφρική νόσο

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Γ.Ν.Α. «Ευαγγελισμός»
Πιθανή σύγκρουση συμφερόντων

Ομιλητής: Κωνσταντίνος Τριανταφύλλου

☑ Δεν έχω πιθανή σύγκρουση συμφερόντων σχετική με την παρουσίαση αυτή.
## Epidemiology - Classification

<table>
<thead>
<tr>
<th>CKD Stages</th>
<th>Description</th>
<th>GFR mL/min /1.73 m²</th>
<th>Prevalence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Kidney damage with normal or increased GFR</td>
<td>≥90</td>
<td>2.3</td>
</tr>
<tr>
<td>2</td>
<td>Kidney damage with mild decrease in GFR</td>
<td>60-89</td>
<td>2.5</td>
</tr>
<tr>
<td>3A</td>
<td>Kidney damage with mild to moderate decrease in GFR</td>
<td>45-59</td>
<td>4.6</td>
</tr>
<tr>
<td>3B</td>
<td>Kidney damage with moderate to severe decrease in GFR</td>
<td>30-44</td>
<td>1.6</td>
</tr>
<tr>
<td>4</td>
<td>Kidney damage with severe decrease in GFR</td>
<td>15-29</td>
<td>0.4</td>
</tr>
<tr>
<td>5</td>
<td>Kidney failure</td>
<td>&lt;15</td>
<td>0.1</td>
</tr>
</tbody>
</table>

- **Chronic kidney disease**
  - CV complications: x 10-200 fold
  - Defined by GFR rather than Scr.
  - eGFR: MDRD or Cockroft-Gault

- **CKD : GFR <60/min**
  - In diabetic patients proteinuria supports a diagnosis of CKD.

### Prevalence of CKD (U.S.)

- **NCDR Cath-PCI registry**
  - General adult population: 14%
  - Patients ≥60 years old: 35%
  - PCI patients : 29% (at least mild)

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*Tsai TT et al.*  
“Early invasive therapy is associated with greater 1-year survival in patients with non–ST-elevation myocardial infarction and mild-to-moderate renal insufficiency, but the benefit declines with lower renal function, and is less certain in those with renal failure or on dialysis.”

# Risk Factors for Contrast-Induced Nephropathy (CIN)

## Presenting Factors
- Acute coronary syndrome
  - Hypotension
  - Heart failure
  - Volume depletion
- Nephrotoxic medications
  - Anemia
- Procedural factors
  - IABP placement
  - Multi-vessel disease
- Contrast amount
- Contrast type

## Clinical Factors
- Chronic kidney disease
  - Diabetes mellitus
  - Advanced age
  - Female gender
- Peripheral vascular disease
  - Hypertension
  - Ejection fraction < 40%

## Mechanism Not Elucidated
- Direct toxic injury to renal tubules
- Ischemic injury to renal medulla (vasomotor changes, hypoperfusion)

## Drugs

### 1. Influence Renal Hemodynamics
- NSAIDs
- COX-2 inhibitors
- Nesiritide
- ACE-I s
- ARBs
- Dipyridamole

### 2. Tubular Toxicity
- Diuretics
- Antibiotics (aminoglycosides, vancomycin, amphotericin B)
- Immunosuppressants
  - (tacrolimus, cyclosporine A)

### 3. Enhanced Toxicity After CIN
- Metformin
- Statins
## Classic CIN definition:

\[ \uparrow sCr \geq 25\% \text{ or } \geq 0.5 \text{ mg/dL within 48-72 hours of contrast administration} \]

### ACUTE KIDNEY INJURY (AKI)

*Diagnosis and Classification Criteria*

<table>
<thead>
<tr>
<th>AKIN</th>
<th>RIFLE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Serum creatinine (Cr)</strong></td>
<td><strong>Urine output (common to both)</strong></td>
</tr>
<tr>
<td><strong>Stage 1:</strong>&lt;br&gt;[ \uparrow \geq 0.3 \text{ mg/dL} \text{ or} \text{ or } \uparrow 1.5 \times \text{ to } 2 \times ]</td>
<td>[ &lt;0.5 \text{ mL/kg/hr for at least 6 hours} ]</td>
</tr>
<tr>
<td><strong>Stage 2:</strong>&lt;br&gt;[ \uparrow 2 \times \text{ to } 3 \times ]</td>
<td>[ &lt;0.5 \text{ mL/kg/hr for } &gt;12 \text{ hours} ]</td>
</tr>
<tr>
<td><strong>Stage 3:</strong>&lt;br&gt;[ \uparrow &gt;3 \times \text{ or} \geq 4.0 \text{ mg/dL acute } \uparrow \geq 0.5 \text{ mg/dL} \text{ or} \text{ RRT} ]</td>
<td>[ &lt;0.3 \text{ mL/kg/hr for 24 hours} \text{ or} \text{ anuria for 12 hours} ]</td>
</tr>
<tr>
<td><strong>Loss</strong></td>
<td>Persistent acute renal failure &lt;br&gt;or complete loss of kidney function for &gt;4 weeks</td>
</tr>
</tbody>
</table>

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Most powerful predictor:
Pre-existing CKD

Other important patient-related factors:
Older age, female gender, DM, anemia & HF.
Incidence and Prognosis of Acute Kidney Injury (AKI)

Depends on both the population studied and the definition used.

**KDIGO definition & NCDR data:**

7% in the general population / 16% in those presenting with MI.

**AKI following PCI increases with increasing severity of CKD:**

- Stage 3A: 8%
- Stage 3B: 12.9%
- Stage 4: 26.6%

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**Fox CS, et al.**
*Circulation* 2012;125:497-504.

**Tsai TT, et al.**
### AKI risk calculation (I)

**With procedural variables**

#### Risk Factors

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Integer Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypotension</td>
<td>5</td>
</tr>
<tr>
<td>IABP</td>
<td>5</td>
</tr>
<tr>
<td>CHF</td>
<td>5</td>
</tr>
<tr>
<td>Age &gt; 75 years</td>
<td>4</td>
</tr>
<tr>
<td>Anemia</td>
<td>3</td>
</tr>
<tr>
<td>Diabetes</td>
<td>3</td>
</tr>
<tr>
<td>Contrast media volume</td>
<td>1 for each 100 cc³</td>
</tr>
<tr>
<td>Serum creatinine &gt; 1.5 mg/dl</td>
<td>4</td>
</tr>
</tbody>
</table>

**OR**

- eGFR < 60 ml/min/1.73 m²
- eGFR (ml/min/1.73 m²) = 186 x (SCR)⁻¹.¹⁵⁴ x (Age)⁻⁰.²⁰³ x (0.742 if female) x (1.210 if African American)
  - 2 for 40 - 60
  - 4 for 20 - 40
  - 6 for < 20

#### Risk Score

<table>
<thead>
<tr>
<th>Risk Score</th>
<th>Risk of CIN</th>
<th>Risk of Dialysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 5</td>
<td>7.5%</td>
<td>0.04%</td>
</tr>
<tr>
<td>6 to 10</td>
<td>14.0%</td>
<td>0.12%</td>
</tr>
<tr>
<td>11 to 16</td>
<td>26.1%</td>
<td>1.09%</td>
</tr>
<tr>
<td>≥ 16</td>
<td>57.3%</td>
<td>12.6%</td>
</tr>
</tbody>
</table>

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**PATIENT PRESENTATION**

- PCI indication
- PCI status
- Coronary artery disease presentation
- Cardiogenic shock
- Heart failure within 2 weeks
- Pre-PCI LVEF

**CLINICAL HISTORY**

- Diabetes mellitus and type of therapy

**PATIENT CHARACTERISTICS**

- Age
- Weight
- Height

**PRE-PROCEDURAL LABORATORY ASSESSMENT**

- Serum creatinine
- Hemoglobin
- Troponin I
- Troponin T
- Creatine kinase MB

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**AKI risk calculation (II)**

**Without procedural variables**

**SCAI risk calculator**


https://bmc2.org/calculators/cin

**Calculated risks:**

Mortality, transfusion, CIN
Strategies to reduce the risk of CI - AKI

**MACD: Maximum allowable contrast dose = 3.7 x GFR (by the Cockroft-Gault equation).
Contrast medium selection
IOCM vs LOCM


NAC prevents AKI?

Statins prevent AKI?

TRACK-D trial


Prevention of Contrast Nephropathy by Furosemide With Matched Hydration

The MYTHOS (Induced Diuresis With Matched Hydration Compared to Standard Hydration for Contrast Induced Nephropathy Prevention) Trial

Continuous infusion of isotonic saline solution matched with urine output

Control group
FMH group

\[ P = 0.003 \]
\[ RR = 0.16 \]
\[ (95\% CI 0.04-0.58) \]

\[ P = 0.005 \]
\[ RR = 0.29 \]
\[ (95\% CI 0.10-0.85) \]

\[ P = 0.44 \]
\[ RR = 0.42 \]
\[ (95\% CI 0.10-1.82) \]

\[ P = 0.44 \]
\[ RR = 0.42 \]
\[ (95\% CI 0.10-1.82) \]

CIN incidence (%)
Hemodialysis or hemofiltration after or during contrast agent exposure

“prophylactic hemodialysis in patients with advanced chronic renal failure undergoing coronary angiography reduces the intensity of acute renal deterioration due to contrast medium exposure, shortens hospital stay, and improves renal outcome.”


But……“may result in hemodynamic or inflammatory changes that are in turn nephrotoxic and thus offset the removal of contrast agents”.

### Recommendations for prevention of contrast-induced nephropathy

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Dose</th>
<th>Class (^a)</th>
<th>Level (^b)</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Patients undergoing coronary angiography or MDCT</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patients should be assessed for risk of contrast-induced AKI.</td>
<td></td>
<td>IIa</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td><strong>Patients with moderate-to-severe CKD</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydration with isotonic saline is recommended.</td>
<td></td>
<td>I</td>
<td>A</td>
<td>384,385,397</td>
</tr>
<tr>
<td>Use of low-osmolar or iso-osmolar contrast media is recommended.</td>
<td>&lt;350 mL or &lt;4 mL/kg or total contrast volume/GFR &lt;3.4.</td>
<td>I</td>
<td>A</td>
<td>398–400</td>
</tr>
<tr>
<td>Short-term, high-dose statin therapy should be considered.</td>
<td>Rosuvastatin 40/20 mg or atorvastatin 80 mg or simvastatin 80 mg.</td>
<td>IIa</td>
<td>A</td>
<td>386,401</td>
</tr>
<tr>
<td>Iso-osmolar contrast media should be considered over low-osmolar contrast media</td>
<td></td>
<td>IIa</td>
<td>A</td>
<td>398,399,402</td>
</tr>
<tr>
<td>Volume of contrast media should be minimized.</td>
<td></td>
<td>IIa</td>
<td>B</td>
<td>388,389</td>
</tr>
<tr>
<td>Furosemide with matched hydration may be considered over standard hydration in patients at very high risk for CIN or in cases where prophylactic hydration before the procedure cannot be accomplished.</td>
<td>Initial 250 mL intravenous bolus of normal saline over 30 min (reduced to ≤150 mL in case of LV dysfunction) followed by an i.v. bolus (0.25–0.5 mg/kg) of furosemide. Hydration infusion rate has to be adjusted to replace the patient’s urine output. When the rate of urine output is &gt;300 mL/h, patients undergo the coronary procedure. Matched fluid replacement maintained during the procedure and for 4 hours post-treatment.</td>
<td>IIb</td>
<td>A</td>
<td>403,404</td>
</tr>
<tr>
<td>N-Acetylcysteine administration instead of standard hydration is not indicated.</td>
<td></td>
<td>III</td>
<td>A</td>
<td>405</td>
</tr>
<tr>
<td>Infusion of sodium bicarbonate 0.84% instead of standard hydration is not indicated.</td>
<td></td>
<td>III</td>
<td>A</td>
<td>384,406</td>
</tr>
<tr>
<td><strong>Severe CKD</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prophylactic haemofiltration 6 hours before complex PCI may be considered.</td>
<td>Fluid replacement rate 1000 mL/h without negative loss and saline hydration continued for 24 hours after the procedure.</td>
<td>IIb</td>
<td>B</td>
<td>407–409</td>
</tr>
<tr>
<td>Prophylactic renal replacement therapy is not recommended as a preventive measure.</td>
<td></td>
<td>III</td>
<td>B</td>
<td>409,410</td>
</tr>
</tbody>
</table>

2014 ESC/EACTS Guidelines on myocardial revascularization.  
After PCI:

Higher rates of MACE (including restenosis, stent thrombosis, repeat TVR)
Higher risk of hemorrhagic complications
Compliance with treatment issues.

1. Ultra-low contrast coronary angiography [CV/eGFR<1, diluted contrast media with saline to a higher volume, iodixanol (Visipaque) in all cases]

2. Staged PCI at least 7 days later with zero contrast:
   a. Cine images of initial angiography displayed on adjoining screen: to guide catheter engagement, coronary guide wire placement creating a metallic silhouette of the coronary artery & major branches
   c. Baseline FFR, CFR
   d. IVUS imaging (PRD, MLD, DRD) pre
   e. Lesion preparation accordingly and stenting
   f. IVUS imaging post stenting to guide post-dilatation*
   g. Control FFR, CFR

*Target: obtain MSA ≥ 90% of the mean of proximal and distal reference areas
1. Location and laterality of the vascular anastomosis of the transplanted kidney (EIA & V, IIA & V, or Ao & IVC).

2. Instrumentation of the vessels that supply the transplanted kidney should be avoided or done cautiously under fluoroscopy.

3. Implement the more aggressive preventative strategies for CI-AKI (any eGFR).


5. Avoid vascular closing devices & indwelling arterial / venous catheters.
Table 15: Antithrombotic drugs dose adjustment in patients with CKD

<table>
<thead>
<tr>
<th>Drug</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASA</td>
<td>No dose adjustment.</td>
</tr>
<tr>
<td>Clopidogrel</td>
<td>No dose adjustment.</td>
</tr>
<tr>
<td>Prasugrel</td>
<td>No dose adjustment. No experience with end-stage renal disease/dialysis.</td>
</tr>
<tr>
<td>Ticagrelor</td>
<td>No dose adjustment. No experience with end-stage renal disease/dialysis.</td>
</tr>
<tr>
<td>Enoxaparin</td>
<td>No adjustment needed for i.v. use in particular for PCI. Dose adjustment for subcutaneous injection in patients with creatinine clearance &lt;30 mL/min: half dose.</td>
</tr>
<tr>
<td>Unfractionated heparin</td>
<td>No adjustment of bolus dose.</td>
</tr>
<tr>
<td>Fondaparinux</td>
<td>Contra-indicated in patients with severe renal impairment (GFR &lt;20 mL/min).</td>
</tr>
</tbody>
</table>
| Bivalirudin   | • In patients with moderate renal insufficiency (GFR 30–59 mL/min) a lower initial infusion rate of 1.4 mg/kg/h should be given.  
|               | • In patients with severe renal insufficiency (GFR <30 mL/min) bivalirudin should not be used.  
|               | • No reduction in the bolus dose is needed.                                     |
| Abciximab     | No specific recommendation. Careful consideration of bleeding risk.             |
| Eptifibatide  | • In patients with moderate renal insufficiency (GFR ≥30 to <50 mL/min), an i.v. bolus of 180 µg/kg should be administered, followed by a continuous infusion dose of 1.0 µg/kg/min for the duration of therapy.  
|               | • In patients with severe renal insufficiency (GFR <30 mL/min) eptifibatide is contra-indicated. |
| Tirofiban     | In patients with severe renal insufficiency (GFR <30 mL/min) the infusion dose should be reduced to 50% (0.05 mcg/kg/min). |

2014 ESC/EACTS Guidelines on myocardial revascularization.  
### Specific recommendations for patients with moderate or severe CKD

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Class</th>
<th>Level</th>
<th>Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>CABG should be considered over PCI in patients with multivessel CAD and symptoms/ischaemia whose surgical risk profile is acceptable and life expectancy is beyond 1 year.</td>
<td>IIA</td>
<td>B</td>
<td>25,382,390–392</td>
</tr>
<tr>
<td>PCI should be considered over CABG in patients with multivessel CAD and symptoms/ischaemia whose surgical risk profile is high or life expectancy is less than 1 year.</td>
<td>IIA</td>
<td>B</td>
<td>390,391</td>
</tr>
<tr>
<td>It should be considered to delay CABG after coronary angiography until the effect of contrast media on renal function has subsided.</td>
<td>IIA</td>
<td>B</td>
<td>393–395</td>
</tr>
<tr>
<td>Off-pump CABG may be considered rather than on-pump CABG.</td>
<td>IIb</td>
<td>B</td>
<td>396</td>
</tr>
<tr>
<td>New-generation DES are recommended over BMS.</td>
<td>I</td>
<td>B</td>
<td>375,376</td>
</tr>
</tbody>
</table>

PATIENTS WITH MILD TO MODERATE CKD

5,920 patients with eGFR <60 and multivessel disease

- Repeat Revascularization (LT)
- MI* (LT)
- Stroke (ST)
- Death (LT)
- Death (ST)

PCI vs CABG:
- Higher risk of death (HR: 2.02) and repeat revascularization (HR: 2.44)

* In those with incomplete revascularization

ST = Short-term (30 days)
LT = Longer-term

PATIENTS WITH ESRD

Revascularization in Patients With Multi-vessel CAD and CKD:
Everolimus-Eluting Stents Versus CABG.
Συμπεράσματα

Οι ασθενείς με Χ.Ν.Α. δεν είναι όλοι ίδιοι.

Ανάλογα με το στάδιο της Χ.Ν.Α. και τις εκάστοτε συνυπάρχουσες νόσους τελικά χρειάζεται εξατομίκευση ως προς τις επιμέρους επιλογές της PCI.

Η σωστή ενυδάτωση και η ελαχιστοποίηση χρήσης σκιαγραφικού μέσου είναι βασικά για την αποτροπή περαιτέρω επιδείνωσης της νεφρικής λειτουργίας.

Επί πολυαγγειακής νόσου η επιλογή PCI έναντι CABG πρέπει να γίνεται κατόπιν συζήτησης σε Heart Team

Εμπειρία και κατάλληλα υλικά απαιτούνται για τις συχνά πολύ απαιτητικές τεχνικά PCI σε ασθενείς με Χ.Ν.Α.

Σωστή χρήση φαρμάκων με προσαρμογές δόσεων όπου χρειάζεται βελτιστοποιούν την κλινική έκβαση.