**Contrast Medium Induced Nephrotoxicity (CIN): Precautions and policies in patients with decreased renal function**

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**Physicochemical Properties Contrast Media Used for CTA**

(Non-ionic, low- and iso-osmolar)

**Adverse Effects and Precautions**

(Overall: 1.31%; Severe: 0.04%)

- **Idiosyncratic**
  - Allergy-like reactions
  - Delayed cutaneous reaction

- **Dose dependent**
  - Local pain, nausea, vomiting
  - Nephrotoxicity
  - Cardiovascular effects

- **Extravasation Injury**

- **Thyroid function**

- **Drug interactions**
  - Metformin, beta-blockers, IL-2, hydralazin

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**References / Guidelines**

- Need institutional guidelines/policy (and good judgement)
  - [http://radportal.stanfordmed.org](http://radportal.stanfordmed.org)

- **ACR guidelines**
  - American College of Radiology (ACR). Manual on Iodinated Contrast Media

- **ESUR guidelines**

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**i.v. Contrast Agents for CT**

- Non-ionic iodinated contrast media (CM)
  - Low-osmolar or iso-osmolar

- All CM are extracellular fluid markers after i.v. injection, complex early arterial dynamics (pharmacokinetics)

- Slightly variable physicochemical properties come at different concentrations, similar safety profiles
Normal Kidney Function

- 20% of cardiac output in kidneys (~1000 mL/min)
- Filters off 20% of renal plasma flow (~125 mL/min)
- Reabsorption up to 99% (active/pass.)
  - Proximal tubule
  - Loop of Henle
  - Distal loop/collecting ducts
- Urine 1.25 mL/min (1.5L/day)

GFR: glomerular filtration rate

Chronic Kidney Disease (CKD): Stages

Normal kidney function: GFR > 90 mL/min/1.73m² and no evidence of kidney damage (e.g. proteinuria)

Serum creatinine (Cr) is filtered in the kidneys, and neither re-absorbed nor excreted. Can be used to calculate renal function (GFR) [Creatinine clearance]

Serum creatinine (Cr) concentration rises with decreasing renal function, however

Serum creatinine (Cr) is NOT a good marker for renal function (depends on e.g. muscle mass, etc)

Chronic Kidney Disease (CKD): Stages

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<table>
<thead>
<tr>
<th>STAGE</th>
<th>GFR (mL/min/1.73m²)</th>
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<tbody>
<tr>
<td>II mild CKD</td>
<td>60-90</td>
</tr>
<tr>
<td>III moderate CKD</td>
<td>30–59</td>
</tr>
<tr>
<td>IV severe CKD</td>
<td>15–29</td>
</tr>
<tr>
<td>V kidney failure</td>
<td>&lt;15</td>
</tr>
</tbody>
</table>

Serum creatinine levels (in mg/dL) indicating an estimated GFR of less than 60 mL/min/1.73 m²

Calculations based on 4-parameter MDRD formula:
GFR (mL/min/1.73m²) = \( \frac{186 \times (\text{Scr} \times 0.011)^{1.154} \times \left(\frac{\text{age}}{1.21}\right) - 1.154}{(0.742 \text{ if female}) \times (0.742 \text{ if female})} \)

Contrast Medium Induced Nephrotoxicity (CIN)

- Acute impairment of renal function
- Incr. serum Creatinine 0.5 mg/dL (44.2 µmol/L) or >25%
- Typically peaks 2 to 3 days after CM admin., then returns to baseline within 2 weeks: if not, contributes to increased risk of death
- <1-2% in general population
- 12-50% in pts. w. renal impairment ± diabetes

Contrast Medium induced Nephrotoxicity Pathophysiology

Mechanism not fully understood
- Vascular effect (?)
- Chemotoxicity on tubular epithelium (?)
- Well known Risk factors


GFR = glomerular filtration rate,

Scr = serum creatinine in µmol/L, age is given in years
Contrast Medium Induced Nephrotoxicity (CIN) Patients at Risk

- decreased renal function (Cr > 1.5 mg/dL) (<60mL/min/1.73 m²)
  particularly in pts with diabetes, on nephrotoxic drugs, volume depletion
- hypertension
- gout, proteinuria, myeloma, ...

Contrast Medium Induced Nephrotoxicity (CIN) Practical Consequences for CT

- (1) screen for patients at risk to develop CIN
  - all inpatients need Cr
  - all outpatients > 70 y, pts w diabetes, history of kidney disease (single kidney, renal mass), myeloma
- (2) for patients at risk, take measures to reduce risk
  - hydration !!!
  - less contrast (300 mg I/mL instead of 370 mg I/mL

Contrast Medium induced Nephrotoxicity (Prevention)

- hydration
- low–osmolar CM
- amount of CM
- iso–osmolar CM ?

Max. Dose (Cigarroa quotient): 5ml per (kg BW) per (mg/dl serum creatinin)

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Contrast Medium Induced Nephrotoxicity (CIN) Prevention in Patients at Risk

- Hydration (volume expansion)
  - 3 mL/kg BW / hour, for one hour (+/– bicarbonate)
  - 1 mL/kg BW / hour, for three hours
  (oral hydration probably ok in outpatients if necessary)
- Acetylcystein (Mucomyst)
  - may be helpful, cheap
  - 2x 600–1200 /d, 24h before until 48 after CM
- Radiologist may chose to use less CM
  - clinical decision (cannot risk diagnostic quality)
  - use less concentration (volume remains the same), or use less volume (e.g. protocol for ‘smaller’ patient)
Integrated Scanning-Injection Protocol

**64-channel CTA of the abdominal Aorta**

- **Scantime:** 10s for ALL patients (pitch variable) (automated tube current modulation)
- **Inj. duration:** 18s for ALL patients
- **Delay:** ‘care-bolus’ w/ 8s delay (\(t_{\text{CM}} + 8\))

<table>
<thead>
<tr>
<th>Weight</th>
<th>Flow</th>
<th>Volume</th>
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<tbody>
<tr>
<td>&lt;121 lb</td>
<td>4.0 mL/s</td>
<td>72 mL</td>
</tr>
<tr>
<td>121–145</td>
<td>4.5 mL/s</td>
<td>81 mL</td>
</tr>
<tr>
<td>(average)</td>
<td>5.0 mL/s</td>
<td>90 mL</td>
</tr>
<tr>
<td>186–209</td>
<td>5.5 mL/s</td>
<td>99 mL</td>
</tr>
<tr>
<td>&gt;210 lb</td>
<td>6.0 mL/s</td>
<td>108 mL</td>
</tr>
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+ saline flush

Contrast Medium Induced Nephrotoxicity (CIN)

**Patients with eGFR <60mL/min/1.73m^2**

- there is no absolute contraindication of CM injection based on renal function
- risk of not obtaining CT may exceed risk of nephrotoxicity. This remains clinical decision, usually together w/ referring service
- IF INDICATED, this needs to be documented in protocol
- nurses/technologists can inject

Contrast Medium and Hemodialysis

- synchronization of contrast administration and hemodialysis is not necessary.
- nephrologists often prefer dialysis before contrast medium administration
- when protocoling, state that patient is on dialysis and CM injection ok (as with all CM injections in pts w/ renal insufficiency)

Thank You!!

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