Intravenous Contrast Media in CT

Lauren Hobson
CT Education & Applications Specialist

November 2016    Toshiba Medical Systems ANZ Pty Limited
Outline

1. IV Contrast Safety
2. Contrast Volume
3. Injection Rate
4. Injection Site
5. Contrast Timing
1. IV Contrast Anaphylaxis

Before you begin, you must determine if the patient is at an increased risk of an anaphylactic reaction:

RANZCR recommends screening patients with the following questions:

- Have you ever had a reaction after a contrast injection?
- Do you have or have you ever had asthma?
- Do you have or have you ever had eczema?
- Do you have an allergy to any of the following: Drugs/medications, food, pollens, dust, animals
1. A word on shellfish allergies...

“Numerous studies have shown that although iodine is common in contrast media, **iodine is not the cause of allergic reactions**. Certain proteins in seafood, rather, are the cause of allergy in patients with seafood allergies...Therefore, contrast media or the iodine is not likely to act as an allergen.”

(https://www.uspharmacist.com/article/intravenous-radiocontrast-media-a-review-of-allergic-reactions#sthash.HW2w7Ah.dpuf)
1. Anaphylaxis: Post Procedure Care Guidelines

- Cannula must remain in situ for 15 minutes for all other patients post IV contrast

- Patients who are at increased risk of an anaphylactic reaction to iodinated contrast media - cannula must remain in situ for 30 minutes
1. Renal Function

- eGFR >45 = no special precautions required

- eGFR 30-45 = risk of acute kidney injury likely to be low, patients with deteriorating renal function may benefit from hydration

- eGFR < 30 = careful weighing of the risk vs benefit of IV CM (consider hydration with 0.9% saline)

“Age should not be considered as an independent risk factor that should mandate testing as eGFR declines with age even in healthy individuals, due to the way it is calculated.”

The Royal Australian & New Zealand College of Radiologists, Iodinated Contrast Media Guideline, 2016, RANZCR
1. Renal Function

- IV CM should be given regardless of renal function if diagnostic benefit justifies the administration (decided by radiologist & referrer)

- Emergency imaging, eg. Acute stroke, trauma – don’t delay CT to wait for renal function test results
1. Diabetes

- Diabetic pts with high BSLs can be prone to break down of small vasculature within kidneys & reduced renal function

- Double the risk of developing contrast induced nephropathy

- Diabetic patient with an eGFR > 30 ok to scan (unless other risk factors present)

1. Diabetes: Metformin

- Metformin is NOT nephrotoxic

- Metformin is excreted through the kidneys, can cause an excess of metformin to build up if poor renal function

- Metformin buildup → lactic acidosis (lactic acid builds up in bloodstream faster than it can be removed, causing oxygen levels to drop)

1. Diabetes: Metformin

“Patients receiving intravenous iodinated contrast media with an eGFR > 30 should continue taking metformin.”

“Patients with an unknown recent eGFR or an eGFR < 30 or who are unwell or have deteriorating renal function should cease metformin for at least 48hrs from the time of the examination and an eGFR performed prior to restarting metformin.”
Dear _________________ (Referring Doctor)

Your patient __________________________ had a __________________________ (name of procedure) on __________ (date) and it was discovered that their eGFR was _____________ on ___________ (date of eGFR result). Due to the small risk of temporary decrease in renal function following iodinated contrast media administered for this procedure, we have advised your patient to do the following:

1. Cease taking their metformin containing medication from the time of this procedure for at least 48 hours
2. Have their renal function retested after this time before a decision is made to recommence this medication.
1. Diabetes: Metformin

- Be aware that Metformin can be in many diabetic medications

**Some Brand Names**

- **METFORMIN**: Diabex®, Diaformin®, Formet®, Metforbell®, Glucohexal®, Glucomet®, Glucophage®, Genrx metformin®, Genepharm metformin®
- **METFORMIN ER**: Diabex®, Diaformin XR®, Metex XR®
- **METFORMIN/GLIBENCLAMIDE**: Glucovance
- **METFORMIN/ROSIGLITAZONE**: Avandamet
- **METFORMIN/SITAGLIPTIN**: Janumet
- **METFORMIN/VILDAGLIPTIN**: Galvumet

1. Thyroid Disease

- Over or under active thyroid?
- Possible or confirmed thyroid cancer?
- Previously received or going to have radioactive iodine treatment?
- Currently taking thyroid medication?

- If the patient answered YES to any of these, the Radiologist should be consulted regarding the need for thyroid function test results prior to the procedure

- Emergency procedures should not be delayed while waiting for thyroid function test results
1. Extravasation

- Contrast delivered into the subcutaneous tissues instead of into the venous system, usually causing pain and swelling

- Can have severe side effects associated with skin changes, tissue necrosis and compartment syndrome
1. Extravasation

- Uncommon, < 1% of patients

- More common with power injectors vs hand injection

- Risk factors include use of small veins, fragile or previously damaged veins, obesity and large volume injections

- Risk can be reduced by use of an appropriately sized vein with relation to injection rate, saline test flush, direct visual monitoring of the injection site during the injection, warming contrast to 37°C
1. Extravasation: Management

- Use conservative treatment with limb elevation, cold or warm compresses

- Keep the patient under observation for at least two hours

- In some depts, policy may be to get a plastic surgery consult if >100mL

- Follow up phone call to patient a few days later to ensure swelling has reduced and there are no skin changes or other symptoms

1. Full Safety Guidelines

- See the full guideline for more information on IV Contrast Media safety

Outline

1. IV Contrast Safety

2. Contrast Volume

3. Injection Rate

4. Injection Site

5. Contrast Timing
2. Contrast Volume Calculation

- To calculate the contrast bolus required for an exam:

  \[(Scan \ Time + 5sec) \times Injection \ Rate\]

  \[(Scan \ Time + 10sec) \times Injection \ Rate \ (CTA/Cardiac)\]

  eg. Cardiac CTA \((0.275 + 10) \times 5 = 51.4mL\)

- Remember a 50mL saline flush for CTA studies
2. Saline Flush

- A saline flush makes use of CM that would have stayed in injection tubing & peripheral veins = \(\uparrow\)CE for longer

- Reduces streak artefact in SVC and brachiocephalic vein

- Increases post procedure hydration

- Unclogs line if it isn’t being removed

- No dual barrel injector, consider layering contrast & saline

- With correct technique, a saline flush allows contrast volume to be reduced
2. Reduced Contrast Volume

- Case study, 30mL contrast with 50mL saline flush CTPA
- Need to utilise Voice Timing in SURE Start

**PE Study using 30ML of IV contrast**

**Background**
A 72 year old patient with emphysema and low renal function presents with acute profound hypoxia. The patient is extremely short of breath. No pneumothorax was seen on the CXR. Patient was referred for urgent PE study using a low volume of contrast media. Patient was scanned on the Aquilion PRIME.

**Findings**
Excellent quality PE study performed using only 30mL of contrast. No evidence of pulmonary embolus. No pulmonary trunk or right heart enlargement. Widespread emphysema is present throughout all lobes, particularly the upper lobes and left lower lobe. There is a focus of consolidation within the costophrenic angle of the right lower lobe.
2. What is Voice Timing?

- Recommended for CTPA and Cardiac CTA
- Reduces risk of valsalva, hence failed study
- Saves approx. 3 sec by telling patient to hold breath before contrast peaks and scan starts
- Be careful of slow CO
2. Voice Timing
2. Contrast Volume: Patient Size

- Larger patients have a larger blood volume
- Contrast dilutes = ↓ Iodine concentration in blood = ↓ CE
- Magnitude of contrast enhancement decreases proportionally with an increase in patient weight
- Amount of iodine should be adjusted for body weight
2. Contrast Volume: Gender

- Magnitude of contrast enhancement is different between men & women
- Primarily due to differences in blood volume
- Higher contrast enhancement observed in females after administration of fixed iodine load per body weight
- Contrast arrives slightly earlier in females
## 2. If in doubt... Contrast Volumes Common Exams

<table>
<thead>
<tr>
<th>Exam</th>
<th>Volume &amp; Concentration (mgI/mL)</th>
<th>Saline flush</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brain</td>
<td>50mL, 300</td>
<td>No</td>
</tr>
<tr>
<td>CTA Brain</td>
<td>50mL, 350</td>
<td>Optional</td>
</tr>
<tr>
<td>Brain Perfusion</td>
<td>50mL*, 350</td>
<td>Yes</td>
</tr>
<tr>
<td>Soft Tissue Neck</td>
<td>70mL, 300</td>
<td>No</td>
</tr>
<tr>
<td>CTA Neck</td>
<td>50-75mL, 350</td>
<td>Yes</td>
</tr>
<tr>
<td>Chest</td>
<td>50mL, 300</td>
<td>No</td>
</tr>
<tr>
<td>CTPA</td>
<td>30-50mL, 350</td>
<td>Yes</td>
</tr>
<tr>
<td>PV Abdomen</td>
<td>75-100mL, 300</td>
<td>No</td>
</tr>
<tr>
<td>CTA Abdomen</td>
<td>75-100mL, 350</td>
<td>Yes</td>
</tr>
<tr>
<td>CTA Femoral Runoff</td>
<td>100mL, 350</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Outline

1. IV Contrast Safety
2. Contrast Volume
3. Injection Rate
4. Injection Site
5. Contrast Timing
3. Injection Rate Principles

- Increased injection rate = higher arterial enhancement, but reduces temporal window due to short duration.

- Hepatic enhancement is more gradual and apparent at low injection rates, eg. 3mL/sec.

- Slower, longer injections to create a prolonged enhancement for exams with long scan duration.
3. Injection Rate: Routine Studies

- Post Contrast Brain: Hand injection
- Post Contrast Neck: 1-2mL/sec
- Chest, Abdomen, CAP: 3mL/sec (2.5mL/sec if using a 22g cannula)

- Increase rate for larger patients if cannula size allows (don’t forget to increase volume also, remember contrast volume formula)
### 3. Injection Rate: CTA

<table>
<thead>
<tr>
<th>Weight (kilograms)</th>
<th>Weight (pounds)</th>
<th>Injection Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;59 kg</td>
<td>&lt;130 lb</td>
<td>3.5 mL/s</td>
</tr>
<tr>
<td>60–99 kg</td>
<td>131–220 lb</td>
<td>4 mL/s</td>
</tr>
<tr>
<td>&gt;100 kg</td>
<td>&gt;220 lb</td>
<td>5 mL/s</td>
</tr>
</tbody>
</table>

- CT Brain Perfusion: 5mL/sec
- CTA Cardiac: 5mL/sec = average pts, 6mL/sec = large pts
  (Only use 4mL/sec if unable to secure an 18 gauge cannula and patient is small)

- If a patient is big enough to increase from 100 to 120kV for a CTA study, increase injection rate also
3. Injection Rate: Cannula Sizes

Maximum injection rates for each cannula size depend on the manufacturer, but as a general guide:

- **22g**: 4mL/sec
- **20g**: 6mL/sec
- **18g**: 8mL/sec

(Braun Introcan Safety Cannula, max flow rate at 300psi)
Maximum injection rates for each cannula size depend on the manufacturer, but as a general guide:

- **22g**: 4mL/sec  *(or 3mL/sec)*
- **20g**: 6mL/sec
- **18g**: 8mL/sec

*(Braun Introcan Safety Cannula, max flow rate at 300psi)*
3. Injection Rate: Cannula Sizes

Maximum injection rates for each cannula size depend on the manufacturer, but as a general guide:

**22g**: 4mL/sec  *(or 3mL/sec)*

**20g**: 6mL/sec  *(or 4-4.5mL/sec)*

**18g**: 8mL/sec  
(Braun Introcan Safety Cannula, max flow rate at 300psi)
3. Injection Rate: Cannula Sizes

Maximum injection rates for each cannula size depend on the manufacturer, but as a general guide:

**22g**: 4mL/sec  *(or 3mL/sec)*

**20g**: 6mL/sec  *(or 4-4.5mL/sec)*

**18g**: 8mL/sec  *(or 6-7mL/sec)*

(Braun Introcan Safety Cannula, max flow rate at 300psi)
3. Injection Rate: Cannula Sizes

Maximum injection rates for each cannula size depend on the manufacturer, but as a general guide:

- **22g**: 4mL/sec *(or 3mL/sec)*
- **20g**: 6mL/sec *(or 4-4.5mL/sec)*
- **18g**: 8mL/sec *(or 6-7mL/sec)*

"Although 22g catheters may be able to tolerate flow rates up to 4 ml/sec, a 20-gauge or larger catheter is preferable for flow rates of 3 ml/sec or higher. An antecubital or large forearm vein is the preferred venous access site for power injection. If a more peripheral (e.g., hand or wrist) venipuncture site is used, a flow rate of no greater than 1.5 ml/sec may be more appropriate."

3. Injection Rate: Alternate Cannulas

- eg. BD Nexiva Diffusics
- Allow use of a smaller gauge (22g = up to 6.5mL/sec)
- Reduces destabilising risks that lead to extravasation

<table>
<thead>
<tr>
<th>Color</th>
<th>Gauge</th>
<th>Catheter Length (in)</th>
<th>Catheter ID (mm)</th>
<th>Catheter OD (mm)</th>
<th>Extension Tube ID (mm)</th>
<th>Gravity Flow Rate (mL/min)</th>
<th>Max CT Flow Rate (mL/sec)</th>
<th>High Pressure Rating (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diffusics™ Closed IV Catheter System</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yellow</td>
<td>24</td>
<td>0.75</td>
<td>0.53</td>
<td>0.71</td>
<td>1.22</td>
<td>21</td>
<td>3.0</td>
<td>325</td>
</tr>
<tr>
<td>Blue</td>
<td>22</td>
<td>1.00</td>
<td>0.67</td>
<td>0.90</td>
<td>1.65</td>
<td>45</td>
<td>6.5</td>
<td>325</td>
</tr>
<tr>
<td>Pink</td>
<td>20</td>
<td>1.00</td>
<td>0.83</td>
<td>1.10</td>
<td>1.65</td>
<td>68</td>
<td>10.0</td>
<td>325</td>
</tr>
</tbody>
</table>
3. Contrast Tab

- Contrast tab (v7 onwards) could also be used to calculate contrast volumes and injection rates:
Outline

1. IV Contrast Safety
2. Contrast Volume
3. Injection Rate

4. Injection Site

5. Contrast Timing
4. Injection Site

- Right Cubital fossa is always preferred, especially for imaging that involves the neck, ascending aorta and heart.

- Left cubital fossa can be used, but contrast follows path of least resistance and may flow up the neck, resulting in streak artefact from neat contrast.

- In addition, the injection through the left arm may be subject to a higher dispersion and more delayed flow due to narrowing of the brachiocephalic vein in some patients than the right arm.
4. Left Arm Injection

- Left subclavian vein passes between sternum and (superior to) arch, which can be a narrow space in some patients, which can cause retrograde filling of jugular vein.
4. Left Arm Injection

Image Courtesy Andrew Dawe, QE Medical Imaging, SA
4. Alternate Injection Site

If cubital fossa can’t be used:

1. Forearm or hand
   - Smaller veins = not suitable for 18-20g, use 22g
   - Slower inj rate needed = slower & lower enhancement (unless using Diffusics cannula)
   - Enhancement delayed compared to antecubital vein (consider contrast timing – use SUREStart or increase manual delay)

2. Foot
   - Contrast will mix with non-iodinated blood, leading to poor opacification
4. Alternate Injection Site

3. PICC Lines & Portacaths (only as a last resort, need a very slow injection rate)

4. PowerPICC or PowerPort preferred (compatible with pressure injection for CT, need someone trained to access and compatible extension tubing, proof required from pt)
4. Alternate Injection Site

5. Power rated CVC lines are also being introduced that are compatible with CT

- Many radiology departments have the protocol NOT to use a non-pressure rated CVC line in case damage is caused to the line and there is no back up plan for the patient’s vascular access
Outline

1. IV Contrast Safety
2. Contrast Volume
3. Injection Rate
4. Injection Site
5. Contrast Timing
5. Factors involved in IV CM enhancement

Patient Factors
- **Application**: target organs
- **Magnitude**: weight, height, cardiac output, age, gender
- **Timing**: cardiovascular (cardiac output), venous access
- **Others**: breath-holding, disease state, renal function

CT Scanning Factors
- **Magnitude**: scan duration, scan delay
- **Timing**: scan delay (fixed, test-bolus, bolus-tracking), scan duration
- **Others**: multi-phase scan, scan direction, ECG-gating, radiation

Contrast Medium Factors
- **Magnitude**: iodine mass (concentration, volume), rate, saline flush
- **Timing**: injection duration (volume, rate), saline flush, viscosity
- **Others**: injection pattern (uniphase, biphasic, exponentially-decay)

(Bae, 2010)
5. Injection Site and Contrast Timing

- Contrast travelling from inj site to aorta varies, 14-32sec
- Contrast travelling from inj site to pedal arteries, 6-39sec (fast acquisition may cause table to outrun contrast)

- Central venous injection = shorter travel distance = shorter time to peak enhancement = improved enhancement compared to peripheral injections
- Central venous injection can result in enhancement 4-6 seconds earlier

- Forearm or wrist injection can cause a delay of 2-4 seconds
5. Pathology and Contrast Timing

- Stenosis or aneurysm may cause delayed enhancement

- Liver cirrhosis = decreased hepatic enhancement and portal venous perfusion = delayed PV phase and higher than average hepatic enhancement during arterial phase
5. Cardiac Output

- Reduced cardiac output = delayed contrast bolus arrival

- Magnitude of peak aortic enhancement increases substantially in aorta vs hepatic enhancement (only slight)

Source: Bae, 2010
5. Cardiac Output

- Consider using SUREStart for PV abdomen (Trigger in aorta @180HU, 40 sec delay)

- Be careful with use of Voice Timing (could result in long breath hold, consider turning off or increasing significantly to still get benefit of table moving while giving breathing instruction)

- Check total scan time for SUREStart (timeout risk, consider increasing delay before SUREStart begins)
Summary

- Always screen patient carefully before IV contrast according to RANZCR guidelines

- Always cannulate an appropriate vein with an appropriate sized cannula to avoid extravasation or a suboptimal study

- To calculate contrast volume, use: \((\text{Scan Time} + 10) \times \text{inj rate}\)

- Always use right cubital fossa if possible

- 20g cannula for routine studies that don’t require an injection rate \(>5\text{mL/sec}\), 18g for CTA or studies \(\geq5\text{mL/sec}\)
Summary

- 22g cannula for routine studies where cannulation is difficult – don’t attempt CTA, or study quality will drop

- Consider use of alternate cannulas (eg. diffusics) or Power PICC, Port or CVC if available for patients with difficult venous access

- Poor CO will delay peak opacification times, consider using SUREStart to ensure correct timing or increase pre-scan delay

- Consider using contrast tab to calculate contrast volume & inj rate (if available in your current software version)
Summary

- This presentation contained current recommendations of RANZCR and other current literature.

- Always discuss issues such as contrast allergies, diabetes and renal function with your radiologist to make individual patient decisions.

- Remember each patient is different and tailor your cannulation, contrast rate, volume and examination to suit them.
Resources


Bae, KT (2010), *Intravenous Contrast Medium Administration and Scan Timing at CT: Considerations and Approaches*. Radiology, 256(1).

Made For life