# BODY CT PROTOCOLS

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General Comments

- All abdominal CT scans should be done on the multidetector scanner with 1-0.5 sec gantry rotation speed. Patients should not be NPO, but on clear liquids. Intravenous contrast should be given at 3-5 ml/sec for a total of 125 ml (Optiray 320) via 18-20 angiocath in antecubital vein. In HCC patients, use Optiray 350 and a total of 150 ml if patient weighs more than 150 lbs (most cases). Scan delay time for routine abdominal studies should be determined by using “SMART PREP” with region of interest (ROI) over the liver (threshold is at 50 HU above baseline).

Creatinine

Please refer to the most up to date MCP for Intravenous Contrast Media Guidelines for the most up to date guidelines for nephroprotection and treatment/prevention of allergic reactions.

Obtained in all patients ≥ 50 y.o. within 30 days of the exam
Obtain a creatinine in younger patients with history of
- renal disease
- malignancy
- chemotherapy within 30 days or other potentially nephrotoxic drugs
- paraproteinemia syndrome (multiple myeloma)
- collagen vascular diseases (lupus)
- diabetes

If the creatinine is ≤ 1.5 and the GFR is > 60mL/min/1.73m2 – go ahead and administer contrast if necessary
If the creatinine is >1.5 in a diabetic, >2.0 in a non-diabetic, or GFR is <30, then the radiologist must discuss the need for administering IV contrast with the ordering physician. If intravenous contrast is felt to be necessary, then the patient needs to be consented and nephroprotective measures (see below) need to be taken.

- To decrease risk of nephrotoxicity in patients with elevated creatinine in whom IV contrast is felt to be necessary, the clinician can hydrate (75-100cc/hour or 1cc/kg/hour preferably normal saline) for 24 hours (or as long as possible) and consider the nephroprotection measures listed below. In lieu of IV fluids, outpatients can be told to drink plenty of water the day before the study and continue for one day after. Consider reducing contrast dose.

- Consider using a lower osmolar agent (Visipaque) in patients with diabetes and renal insufficiency.

- Patients with increasing creatinine over a short period of time (days) should not receive I.V. contrast even if creatinine is < 1.5. These patients are likely going into renal failure.

- Patients with end-stage renal failure who are on regular dialysis may receive non-ionic I.V. contrast, preferably shortly before dialysis. Those requiring only intermittent dialysis (renal insufficiency) should not receive I.V. contrast.
Nephroprotection

N-ActylCysteine

Oral - 600mg twice a day, day before and the day of the exam

IV – 1200 mg bolus given prior to study followed by 1200 mg twice a day IV for 48hrs after the exam (Ref: Marenzi G, et al. N-Acetylcysteine and Contrast-Induced Nephropathy in Primary Angioplasty. NEJM 2006;354:2773-82.)

Hydration - Excellent PO or IV hydration (normal saline preferably) of patients both prior to and after the exam.

Bicarbonate - 3 amps of bicarb (150 mEq) in one liter of 5% dextrose solution at 3mL/kg/hr for 1 hr prior to study, then at 1mL/kg/hr for 6 hours following study

Diabetics taking Metformin (glucophage)

• If creatinine is normal (< 1.5), I.V. contrast may be given; Metformin should be stopped for 2 days after CT and creatinine checked prior to restarting Metformin. Contact referring clinician to obtain lab values.

• If creatinine > 1.5, do not administer I.V. contrast. Contact clinician and reschedule patient. Metformin needs to be stopped two days prior and post administration of I.V. contrast in these cases and lab values need to be checked prior to restarting Metformin.

Contrast Allergies

• Patients with severe contrast allergies such as anaphylaxis, cardiac or respiratory arrest should not receive I.V. contrast; discuss other possible imaging studies (US, MR, non-contrast CT, etc.) with clinicians.

• All other patients with a history of mild contrast allergies, moderate or severe reactions to foods or medications, or asthmatics on medication should be premedicated prior to procedure.

• Premedication:
  Oral: 50 mg p.o. of prednisone 13 h., 7 h. and 1 h. prior to procedure and 50 mg p.o. of Benadryl 1 h. prior to procedure. These patients should be accompanied to the hospital; they should not drive after taking Benadryl
  IV: 200mg hydrocortisone 6h and 2h prior to procedure and 50 mg po of Benadryl 1h prior to procedure

• Any adverse reaction – including hives – needs to be documented in the dictation of the study as well as in a progress note.

Central Venous Catheters

Before using a dialysis catheter – which should only be used as a last resort when the study requires IV contrast and no other access can be obtained – the radiologist must get the okay from the on-call nephrologists. Also, the radiologist should verify the specific instructions for withdrawing the heparin from the line. (Do not flush these catheters without withdrawing the heparin, since you will then bolus the patient with a large amount of heparin.) Nephrology must also arrange for proper re-packing of the catheter with heparin following the study.

Other central venous catheters cannot be used for power injections unless they are “power rated.” Determination of whether a catheter is “power rated” can be performed by:
Visual inspection
Radiographic inspection
Verification with the medical record of the type of catheter placed
Verification with documentation provided by the patient

If contrast is to be injected via a non “power rated” catheter, it must be via hand injection
with a syringe that is 10cc or larger through the largest lumen of the catheter.

Extravasation

Please see the official “Contrast Extravasation Guidelines” available in CT. These were
developed with input from the Plastic Surgery Department, and currently these guidelines apply to
all areas of radiology at UCSD Medical Center.

Per the ACR Manual on Contrast Media and our official guidelines, here are some general
guidelines to follow, given that low osmolar contrast is now used in the CT department:

All patients who have had a contrast extravasation should be examined by a physician, either
the radiologist, or, if the radiologist is off-site, the emergency department (outpatients) or clinical
team (inpatients).

Physical Exam – Evaluate distal pulses, capillary refill, sensation, and motor skills. Examine
the site itself for edema, mass effect, tenderness
Elevate the extremity and apply cold compresses (20 min on, 20 min off)
Consider surgical consultation if:
  Physical examination findings are worrisome
  Over 100 mL of contrast was extravasated
  Over 60 mL of contrast was extravasated in the wrist, hand, or ankle
  Patient is at high risk of infection or tissue necrosis: diabetics, malignancy,
  immunosupression, limb ischemia, chronic steroid use, connective
  tissue disease (scleroderma, Raynaud’s), elderly, venous insufficiency in the
  limb, prior extensive surgery or radiation to limb (axillary lymph node
dissection)

Any patient that meets the above criteria:
  Document the amount of extravasation and treatment taken in the dictation
  and a progress note
  Discuss the event with the referring physician/inpatient clinical team
Outpatients:
  Instruct the patient to monitor the site for changes and what to do if
  the site worsens
  Contact the patient the following day by phone to check for signs of
  compartment syndrome, infection, or skin ulceration
CT - ABDOMEN AND PELVIS

**Fasting**

Patients should have nothing but clear liquids at least 4 hours before the exam. Most outpatients are told to have clear liquids only, after midnight (even if the scan is in the afternoon). The patients should not be NPO, they should be well hydrated for the exam in order to decrease renal complications from I.V. contrast.

**Oral Contrast**

A few general points on oral contrast:

Positive oral contrast is usually dilute hypaque or barium (1 - 3% concentration). More and more we are now using negative oral contrast such as water or Volumen. 250-300 cc of water should be given to all patients when the patient gets on the scanning table. This will ensure adequate distention of the stomach and duodenum.

Patients who may have a bowel perforation should be given dilute hypaque and not dilute barium. **This includes all patients being evaluated for abdominal pain from the Emergency Department.** Patients with suspected bowel obstruction do not require oral contrast because they usually have air and fluid within the bowel to provide negative contrast.

After the patient’s exam has been protocoted by the radiologist, the radiology technologist prepares the oral contrast under the direction of the radiologist, which will then be administered by a radiology technologist or licensed independent practitioner (LIP).

These are the current guidelines for administration of oral contrast, broken down by type:

**No Oral** - Acute Small Bowel Obstruction, Renal Stone

**Water**-

- Protocol: 20 min prior – 400 mL, Table – 400 mL
  
**Screen**

**Volumen** -

- Protocol: 60 min prior – 450 mL, 40 min prior – 450 mL, 20 min prior – 450 mL, Table – 400 mL water
- Indications: Inflammatory Bowel Disease, Small Bowel Mass, GI Bleed, Malabsorption/diarrhea, CTA - Mesenteric

**Barium** -

- Protocol: 60 min prior – 250 mL, 30 min prior – 250 mL, Table – 400 mL water
- Indications: Routine Cancer Follow-up, Lymphoma, Abscess, Gynecologic Mass/Malignancy, Acute Pancreatitis

**Hypaque** -

- Protocol: 60 min prior – 500 mL, 30 min prior – 500 mL, Table – 400 mL water
- Indications: Post-operative, Perforation, ED cases that need positive oral Contrast, Non-acute small bowel obstruction to assess transit (120 min & 60 min prior), Select cases of acute appendicitis(90 min & 40 min prior)
Rectal Contrast

Rectal contrast should not be given in patients with recent colonic or rectal surgery or in recent bone marrow transplant (consult with clinicians); it may be given in suspected diverticulitis (not usually needed), if there are no peritoneal signs (when in doubt, check with referring M.D.). Rectal contrast is administered via a catheter and enema bag (1 - 3% hypaque or water preferably) while the patient is on the scanning table. 200 cc usually adequately opacifies the rectosigmoid; the entire colon may require 900-1200 cc, especially in cases of suspected appendicitis. STOP if patient has significant discomfort. Positive rectal contrast should also be administered in cases of penetrating injury to the abdomen that may have resulted in colonic injury (ie stabbing to left lateral abdomen).

After the patient’s exam has been protocolled by the radiologist, the radiology technologist prepares the rectal contrast under the direction of the radiologist, which will then be administered by a radiology technologist or licensed independent practitioner (LIP).

Unopacified Bowel Loops

If masses are present which may represent unopacified loops of bowel you have several choices:
1. Give rectal contrast or air if unopacified loops are in the pelvis.
2. Give more oral contrast and repeat scan in a few minutes if unopacified loops are in the upper abdomen.
3. Repeat scan at same level. The bowel may have changed in shape due to peristalsis. Ideally, it will also be filled with contrast.
4. Give more oral contrast and repeat scan at same level several hours later. Bowel loops may become opacified and/or change in configuration.
5. Try decubitus or prone views. Loops of bowel will change position and may fill with contrast or air.
6. Inject contrast through colostomy, ileal loops, or other pouches in patients who have these. Many times the loops of bowel adjacent to the stoma may not opacify with oral contrast. By injecting the stomas directly (i.e. with a small catheter) good opacification of these bowel loops can be obtained.
7. Metoclopramide (Reglan) 10 mg po promotes gastric emptying and quickens bowel transit of contrast, although this is rarely given.
8. Suspected bowel wall thickening or intraluminal bowel mass: stool may mimic a mass or wall thickening. Wall thickening is a common over call on CT scans. If suspected, delayed scans, positional changes, and other maneuvers described above should be performed. The viscus should be well distended. For the stomach, fizzies and water should be given for distension if wall thickening is suspected.

CT DENSITIES

<table>
<thead>
<tr>
<th>Material</th>
<th>Hounsfield Units (HU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air, fat</td>
<td>Negative Hounsfield units (HU)</td>
</tr>
<tr>
<td>Fluid</td>
<td>0-20 HU</td>
</tr>
<tr>
<td>Abscess</td>
<td>0-40 HU</td>
</tr>
<tr>
<td>Parenchyma</td>
<td>40-70 HU (non contrast)</td>
</tr>
<tr>
<td>Bone</td>
<td>&gt; 500 HU</td>
</tr>
<tr>
<td>Calcified Lung Nodule</td>
<td>&gt;200 HU</td>
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</tbody>
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RETROSPECTIVE RECONSTRUCTION

Remember that one of the advantages of MDCT is the ability to retrospectively reconstruct the data. The minimum slice thickness depends on the detector configuration used for the particular scan. For instance, using the appendicitis protocol, 5 mm scans reconstructed into 2.5 mm slices may help visualize the appendix or increase your level of confidence. This is also helpful for small renal stones or lung nodules. It is best to do reconstructions soon after the scan (< 24-48 hours) because the raw data is only saved temporarily. Thin recons also provide much better MPR images and we are using these more and more.

BREATH HOLD

If possible, all abdominal CT scanning should be done during a single breath hold. It is often helpful to coach the patient regarding breathing, and hyperventilating the patient prior to scanning. Emphasize to the patient that it is important that he or she does not breathe or move during the study. If it is absolutely necessary to let the breath out early, tell them to let it out slowly and evenly because this causes less motion artifact. Instruct the patient to take a deep breath in and out several times. Prior to scanning, ask the patient to take a medium-sized breath in and hold it. When performing a multiphase study such as a triple-phase liver or pancreas protocol, instruct the patient to try to take the same sized breath with each scanning phase. With 16 slice scanners and above, quite shallow breathing may be best approach.
PROTOCOLS

General Considerations

These protocols are intended as guidelines only. All CT scans must be closely monitored by a radiologist, who may modify these procedures as needed. According to hospital and Medical Group compliance guidelines, a CT of the abdomen does not include the pelvis unless the requesting clinician has ordered both “abdomen and pelvis.” If the radiologist believes that a pelvis is indicated and it has not been requested, he or she should contact the referring physician and discuss this with them. If the physician cannot be contacted, the radiologist can go ahead and scan the abdomen and pelvis if he or she believes it is indicated. The report should reflect the reason for the pelvic CT and the attempt made to contact the primary doctor.

The radiologist should review most scans prior to taking the patient off the table, and all examinations from the Emergency Department and Trauma should be reviewed prior to the patient leaving the CT department.

ROUTINE ABDOMEN/PELVIS

Please note that the “routine abdomen/pelvis” protocol serves as a starting point for many examinations. Please see the comments below for tailoring the examination for specific indications.

Contrast:
- Oral
- Intravenous 3-5 ml/sec for 125 ml (Optiray 320)

Scan delay time:
- Portal Venous phase - “SMART PREP”, ROI over liver (50 HU above baseline)
- Delayed scans thru kidneys at 3 minutes

Scan method:
5 mm, pitch of 1.5:1, Rotation speed(RS)=0.8 sec, 2.5 mm reconstructions
Coverage: dome of liver to S.P. (symphysis pubis).

Comments:
ED studies -
  Appendicitis – Default examination should be no oral and with IV. In pediatric patients, consider also administering oral contrast. In patients with symptoms for more than 48-72 hours (higher rate of complications) and those with other underlying disease (Inflammatory bowel, HIV, post partum, etc) IV contrast should be given from the start.
  Diverticulitis – Default examination should be no oral and with IV. Per current ED
guidelines, if a noncontrast exam was performed and, after reviewing the noncontrast images, if there are findings that warrant further investigation, give IV contrast.

Other bowel pathology –
If there is concern for acute gastrointestinal bleeding, bowel ischemia, bowel obstruction, or perforation, perform with IV contrast only. Oral contrast in the bowel lumen can obscure intraluminal bleeding and subtle abnormalities in bowel wall enhancement. In a patient with known obstruction, typically inpatients, oral contrast is sometimes administered to assess transit through the site of obstruction. These patients should receive a long oral prep.

Cervical or endometrial cancer –
Patient with a known diagnosis undergoing staging or follow-up. Patient places 60-120mL of surgilube via catheter in her vagina prior to scanning.

ROUTINE CHEST, ABDOMEN AND PELVIS

Contrast:
- Oral
- Intravenous 3-5 ml/sec for 125 ml (Optiray 320)

Scan Method:
- Portal venous phase - “SMART PREP”, ROI over liver (50 HU), 5 mm,
- Delayed scans thru kidneys at 3 minutes

Scan method:
5 mm, RS=0.8, single breath if possible.
Coverage: thoracic inlet to S.P. (symphysis pubis).

RETROPERITONEAL HEMORRHAGE
(AKA - Non-contrast Abdomen/Pelvis)

Contrast:
- No oral contrast; if IV, 4-5 cc/sec of 125 cc, “SMART PREP” liver (40 HU)

Scan Method:
- 5 mm, RS=0.8, dome of liver to symphysis pubis

Comments:
If spontaneous hemorrhage due to anticoagulation is suspected, no IV contrast is necessary. IV contrast should be used to detect vascular extravasation due to a recent intervention (cardiac catheterization, biopsy, etc.) or trauma. If extravasation is present on the initial scan, consider obtaining delayed phase images through the area of concern.

TRAUMA

Contrast:
- Water as oral contrast
- Intravenous 3-5 ml/sec for 125 ml (Optiray 320)

Scan Method:
• “SMART PREP”, ROI over liver (50 HU)
• 5 mm, RS=0.8, 2.5 mm reconstructions
• Delayed scans thru kidneys at 3 minutes

Comments:
• Clamp Foley prior to scan
• If renal or bladder injury present, make sure collecting system and bladder are opacified and determine if extravasation is present. If necessary, repeat examination of the kidneys at a 10 minute delay.
• If penetrating injury to a site that places the patient at risk for colonic injury, rectal contrast should be administered as described above.
• If pelvic fractures are present, scan the entire abdomen and pelvis during the delays to assess for extravasation.

CT CYSTOGRAPHY

If bladder injury is suspected because of multiple pelvic fractures, you should do CT cystogram following the routine abdominal CT. **You need to actively distend the bladder in order to exclude bladder injury. Passive filling of the bladder via the I.V. injection is not sufficient to exclude rupture.**

- Inject 200-300 cc of dilute contrast in bladder via Foley catheter by gravity. Dilute contrast is a 2-3% solution of iodine. (100 cc of 320 Optiray contrast in a 1 liter saline bag.)
- The Foley catheter must be placed by the trauma or emergency service, who should have already cleared the patient from possible urethral injury.
- Rescan lower abdomen and pelvis. Check for intraperitoneal extravasation along gutters and between bowel loops. Check for extraperitoneal extravasation anterior to the bladder and along the anterior abdominal wall and scrotum. **Post-void images are not necessary.**

TRIPLE PHASE LIVER - HCC
(Non contrast, arterial, portal venous, equilibrium)

This scan is performed in cases of surveillance or follow-up for hepatocellular carcinoma in patients with chronic liver disease/cirrhosis and follow-up after chemoembolization of liver malignancy (primary or metastatic) and in patients who have had a liver transplant.

Contrast:
- Oral water
- Optiray 350 IV contrast, hyperventilate patients prior to breath hold. Scans should be done in single breath for each phase. For patients who weigh more than 80 kg (175 lbs), use 150 mL of contrast instead of 125 mL. Injection should be performed to administer entire contrast load in approximately 30 sec. Therefore, rate for 125 mL will be at 4mL/sec, and rate for 150 mL will be 5mL/sec. A higher ma (approx 350 depending on size of patient) should be used to better resolution.

Scan Method:
- 5 mm, RS=0.8 (same for remainder)– pre contrast – top to bottom of liver
• 5 mm – post contrast – top to bottom of liver for arterial phase, 2.5 mm recon
• Arterial phase – “SMART PREP” Aorta (170HU baseline) (usual delay 30 sec) Ideally obtain excellent hepatic arterial opacification with minimal contrast in portal vein;
• Portal venous phase – 5mm at 70 sec delay with 2.5 mm recon. Scan the entire abdomen in this acquisition (top of the liver to sp)
• Equilibrium Phase – 5 mm at 180 sec delay with 2.5 mm recon (top of liver to bottom of kidneys)

**DUAL PHASE LIVER**
(arterial, portal venous, delay)

This scan is performed for further characterization of a known or suspected liver lesion in a non-cirrhotic patient and to “rule out liver metastases,” particularly in patients with malignancies known to produce hypervascular metastases (breast, renal, melanoma, neuroendocrine, GI stromal tumor, sarcomas, thyroid, and testicular.) Recently most cancer patients are being scanned with triple phase even with non hypervascular primaries such as colon cancer. For young lymphoma or testicular ca patients (<40 yo), do routine abdomen protocol with delays.

**Contrast:**
- Oral water
- Optiray 320 IV contrast, hyperventilate patients prior to breath hold. Scans should be done in single breath for each phase.

**Scan Method:**
- 5 mm RS=0.8 (same for remainder) with 2.5 mm recon– post contrast – top to bottom of liver for arterial phase
- Arterial phase – “SMART PREP” Aorta (170HU baseline) (usual delay 30 sec) Ideally obtain excellent hepatic arterial opacification with minimal contrast in portal vein;
- Portal venous phase – 5mm with 2.5 mm recon at 80 sec delay. Scan the entire abdomen in this acquisition (top of the liver to sp)
- Delay Phase – 5 mm with 2.5 mm recon 3 minutes from injection (top of liver to bottom of kidneys)

**General Notes:**
Consider a 10 -15 minute delay of the liver in patients who have had equivocal studies in the past for hemangiomas or if there is a history of cholangiocarcinoma.

**ADRENAL MASS**

Use this protocol for evaluation of patient with a known adrenal lesion that has been previously incompletely characterized or in patients with biochemical evidence suggestive of adrenal pathology.

**Contrast:**
- No oral
- 125 mL Optiray 320 at 3-4 mL/sec
Scan method:
- Noncontrast - 5 mm, RS=0.8 (same for remainder), single breath from liver dome to bottom of kidneys, reconstruct at 2.5 mm intervals – needs to be checked
- Portal venous phase – 5 mm at 80 sec delay. Scan from the liver dome to the SP in this acquisition if evaluation of the pelvis is desired, otherwise only the abdomen (top of liver to bottom of kidneys) needs to be scanned – reconstruct at 2.5 mm intervals
- Delay Phase – 5 mm 15 minutes from injection (top of liver to bottom of kidneys) – reconstruct at 2.5 mm intervals

General Notes:
If the noncontrast images demonstrate a homogeneous lesion that is less than 10 HU, the lesion is highly likely to be an adrenal adenoma and no further imaging is necessary. Therefore, the radiologist should check the noncontrast images prior to proceeding with the remainder of the study unless evaluation of the entire abdomen and pelvis was requested for other reasons.

RENAL MASS

Use this protocol for suspected renal mass:
Contrast:
- Oral contrast.
- 125 mL Optiray 320 4-5mL/second

Scan Method:
- Noncontrast – 5mm RS=0.8 (same for remainder) top to bottom of kidneys using same MA as post IV scans
- Corticomedullary Phase – 5mm 30 sec delay with 2.5 mm recons- Top of liver to bottom of kidneys
- Nephrographic Phase – 5mm 80 sec delay with 2.5 mm recons- Top of liver to SP
- Delayed Phase – 5mm 3 minute delay with 2.5 mm recons– Top of liver to bottom of kidneys

General Notes:
Low attenuation masses in the medulla may be missed if only corticomedullary phase scanning is performed.

RENAL INFECTION
(Not a protocol, see below)

Acute Pyelonephritis: for suspected pyelonephritis use routine abdomen protocol with delayed images of kidneys at 4 -- 5 minutes.

Renal Abscess: Same as renal mass. Noncontrast scans for baseline attenuation values are important in differentiating abscess (should not enhance more than 10 HU) from focal pyelonephritis (enhance significantly after iv contrast, but less than more normal parenchyma)

RENAL STONE

The bladder should not be empty; preferably it should be full in order to better assess the
ureterovesical junction.

**Contrast:**
- No oral, no I.V. initially

**Scan method:**
- 5 mm, RS=0.8, single breath top of kidney to bottom of bladder, reconstruct at 2.5 mm intervals
- When stone is detected in ureterovesical junction vs. bladder, acquire axial images through the bladder in prone position

**If IV contrast is needed, timing is based on why IV contrast is being given:**
- 3-4 ml/sec for 125 ml (Optiray 320)
- 80 sec delay, scan 5 mm top of liver to SP for incidental abdominal pathology
- 6 min scan delay or longer, 5 mm top of kidneys through SP for delineation of ureters.

**General Notes:**
- Most ureteral stones are at UVJ. Look for ureteral stone and secondary signs (i.e. hydronephrosis, periureteral or perinephric stranding, enlarged kidney, delayed nephrogram or pyelogram).
- Look for other pathology: Pancreas, appendix, diverticulitis, TOA, etc.
- AIDS patients on protease inhibitors (i.e. Indinovir) may have non-opaque stones.
- If questions of small stones vs. phlebolith, you must do retrospective reconstructions at 2.5 mm through area of concern.
- To determine if UVJ stone is in bladder or ureteral orifice a limited prone scan through this area can be obtained.

**RENAral ARterY STENOSIS**

**Contrast:**
- No oral
- 125 mL Optiray 320 at 3-4 mL/sec

**Scan method:**
- Noncontrast: 5 mm, 30 HS from top of kidneys to iliac bifurcation
- Arterial: smart prep over aorta with threshold 100 HU, 2.5mm, 3.75 HQ with 1.25mm reconstruction from top of kidneys to SP

**RENAral UPJ/DONOR**

**Contrast:**
- No oral
- 125 mL Optiray 320 at 3-4 mL/sec

**Scan method:**
- Noncontrast: 5 mm, RS=0.8 from top to bottom of kidneys – study must be checked at this
point as hydronephrosis in donor may require imaging the remainder of the abdomen and pelvis to r/o stone

- Arterial: smart prep over aorta with threshold 100 HU, scan 2.5mm, RS=0.7 with 1.25mm reconstruction from top of kidneys to iliac bifurcation
- Nephrographic phase: 80 sec delay from top of liver to SP, RS=0.8, 5mm with 2.5 mm recons
- Delay: 7-10min delay
  - For Donor: perform topogram to assess for collecting system anatomy, if any questions, do as UPJ
  - For UPJ: do as CT urogram delays – top of kidneys to SP 2.5 mm, RS=0.8, recon 2.5mm

**CT UROGRAPHY**

Performed for hematuria work-up or known/suspected urothelial malignancy. Patient should have moderate distension of the bladder (don’t let go to the bathroom before scanning) or the Foley catheter must be clamped at the beginning of the exam

**Contrast:**
- No oral, patient should drink 32 oz of water upon arrival to department; patient should be well hydrated and encouraged to drink.
- 125 mL Optiray 320 at 3-4 mL/sec with 250 cc of normal saline via IV immediately following

**Scan method:**
- Noncontrast - 5 mm, RS=0.8 (same for remainder) recon 2.5mm from top of kidneys to iliac crest
- Nephrographic - delay 80 sec, 5mm with 2.5mm recon from dome of liver to SP
- Delay – Wait 8 minutes, perform a AP KUB (Scanogram) to evaluate ureter opacification
  - If most of the ureters tract are visualized, scan entire abdomen (2.5 mm with 1.25mm recon) usually a 15 minute scan is best to opacify distal ureters.
  - If KUB does not show opacification of ureters, contact the radiologist and obtain another KUB using 1 minute intervals until adequate opacification is achieved.
  - If a portion of ureter is not opacified on delayed scan, rescan the unopacified segment after standing the patient and placing in the prone position. Do not scan more than 2 more times.

**Comments**
- Check noncontrast scan for stones and obstruction. If stones are present in a patient less than 50 years old, contact the radiologist as the patient may not require IV contrast.
  - If obstruction, consider increasing scan delay.
  - For ureters with significant hydro and delayed excretion, get follow up KUB at 2 hours and see if ureter is opacified. KUB can be repeated as needed
  - Data sent to 3D workstation at thin reconstructions.

**PANCREATIC MASS**

**Acute Pancreatitis:** Pancreatitis work-up should be done as routine abdomen. Non-contrast CT
should be performed only in patients with suspected pancreatic hemorrhage.

Contrast:
- Patient should drink water as the oral contrast, in addition to 32 oz of water upon arrival to department. **OPACIFICATION AND DISTENTION OF DUODENUM IS VERY HELPFUL**
- 125 mL Optiray 320 at 4-5 mL/sec

Scan Method:
- Try to scan entire pancreas in single breath hold for all phases. **Have patient try to reach same depth of inspiration as for localizing scan and contrast scan to avoid cutting off pancreas.**
- Noncontrast – 5mm RS=0.8 (same for remainder), with 2.5 mm recons from liver dome to iliac crests
- Arterial phase – 2.5mm scan with 1.25mm reconstructions from top to bottom of liver at 35 sec delay, ideally obtain excellent hepatic arterial opacification with minimal contrast in portal vein;
- Portal venous phase – 5mm at 80 sec delay with 2.5 mm reconstructions. Scan the entire abdomen in this acquisition (top of the liver to sp).
- Delayed 3 minute scan through liver and kidneys.

**CT ENTEROGRAPHY**

This protocol is for evaluation of the small bowel utilizing low attenuation oral contrast (VOLUMEN). **This protocol requires active monitoring by resident/fellow.** Indications include Crohn disease, intermittent small bowel obstruction (such as adhesions, etc in an outpatient setting), evaluation for small bowel tumors, and obscure gastrointestinal bleeding (continued GI bleeding despite negative upper and lower endoscopy). You must specify in the protocol whether you want an arterial and portal venous phase study (CT Enterography for GI Bleed) or portal venous phase only (CT Enterography for Bowel Disease).

Contrast:
- Volumen oral contrast per protocol
- 125 mL Optiray 320 at 3-4 mL/sec

Scan method:
**For Crohn disease or other diffuse bowel pathology; Portal venous phase study only is sufficient**

**For occult GI bleeding and search for GI malignancy: arterial, portal venous and delayed scans are usually needed.**

Before giving IV contrast perform a low mA single slice through mid abdomen or topogram and check if there is adequate bowel distention. (Make sure most of Volumen is not in stomach)
- Arterial phase study – 5mm RS=0.7 with 2.5 mm reconstructions with a smart prep (HU=100), top of liver to SP
- Portal venous phase study – 5mm RS=0.8 at 80 sec delay. Scan from the liver dome to the SP – reconstruct at 2.5 mm intervals
- Delayed Phase – 5 mm RS=0.8 at 3 minutes from injection, top of liver to bottom of kidneys
CT COLONOGRAPHY

Prep: Dry prep preferable but contraindicated in some patients (fleet soda / clean prep)
Stool and fluid tagging is performed: Tagitol taken with breakfast, lunch and dinner day before; 60 cc of gastrografin night before
   . Night before and morning of the procedure bowel prep
   . Instruct patient to empty the bowel before the scan and to communicate when maximal distension is achieved
No oral, No IV contrast (unless indicated by radiologist), 1 mg of glucagons sc 10 minutes prior to scanning.
CO2 insufflation / Physician controlled / Use small rectal tube (test tube before using)
In a lateral decubitus position, place Rectal Tube, inflate balloon cuff.
Contact resident if there is any problem with catheter insertion.
Start insufflation with patient in prone position, when patient feels discomfort have patient turn onto their right side and then slowly supine and finally on left side (to fill right colon with air insufflate CO2 using the autoinsufflator at 25 mmHG as pressure limit. Usual volume of air to be administered fluctuates between 4-6.
Obtain scout view to ensure adequate insufflation of all segments of colon before scanning
Scan Method

2.5, 7.5 mm/sec table speed HS
Scan supine and prone
Low mAs = 100 ma

Comments

Keep insufflating air between supine and prone positioning.
At end of study, cut tubing before removing rectal catheter for immediate relief of distention
Send Data to 3D workstation.

AORTIC DISSECTION

Contrast:
• No oral contrast
• 125 mL Optiray 320 at 4-5 mL/sec
Scan method:
• Noncontrast: 5 mm, RS=0.8 from top of arch to iliac crests
• Arterial: Smartprep over aortic arch with threshold 100 HU, 2.5mm, RS=0.7 with 1.25mm reconstruction from apices to SP
• Portal Venous phase at 5 mm increments from dome of liver to SP to assess organ perfusion.

General Comments:
- No oral contrast is given because it interferes with 3D reconstruction.
- Non-contrast scan may show intramural hematoma not well seen with contrast.
- If an aortic dissection is found in abdominal scan, consult the radiologist about obtaining a
chest CT immediately after the scan
- Do 3D processing on Vitrea and send to PACS

**AORTIC ANEURYSM – PRE EVT**

Use this protocol for initial evaluation of a known or suspected abdominal aortic aneurysm.

**Contrast:**
- No oral contrast
- 125 mL Optiray 320 at 4-5 mL/sec

**Scan method:**
- Noncontrast: 5 mm, RS=0.8 from top of arch to iliac crests
- Arterial: Smartprep over abdominal aorta with threshold 100 HU, RS=0.7, 2.5mm with 1.25mm reconstruction from liver dome to SP

**Comments**
Study should only be performed in hemodynamically stable patients. Hemodynamically unstable patients with high degree of suspicion of aortic pathology should go directly to OR. If patient becomes unstable in CT, a quick noncon scan may be diagnostic.

**AORTIC ANEURYSM – POST ENDOVASCULAR STENT**

Use this protocol for follow-up of an abdominal aortic aneurysm that has had an endovascular stent repair.

**Contrast:**
- No oral contrast
- 125 mL Optiray 320 at 4-5 mL/sec

**Scan method:**
- Noncontrast: 5 mm, RS=0.8 from top of arch to iliac crests
- Arterial: Smartprep over abdominal aorta with threshold 100 HU, RS=0.7, 2.5mm with 1.25mm and 2.5mm reconstruction from liver dome to SP
- Delayed: 3 minute delay, 2.5mm, RS=0.8 with 1.25mm and 2.5mm reconstruction from liver dome to SP – same parameters as used during arterial exam

**Comments**
The noncontrast portion of the exam is to evaluate for pre-existing high density in the aneurysm, such as calcifications or prior embolization. The delayed phase is for evaluation for delayed leaks.

**CT PELVIS WITHOUT ABDOMEN**

**Contrast:**
- Oral and
• 125 mL Optiray 320 at 3-5 mL/sec I.V., non-contrast if indicated, full bladder.

Scan Method:
• 80 sec. delay
• 5 mm, 15 HQ
LIVING RELATED LIVER DONOR

Contrast:
- No oral contrast
- 125 mL Optiray 320 IV contrast at 4-5 mL/sec, hyperventilate patients prior to breath hold. Scans should be done in single breath for each phase.

Scan Method:
- Noncontrast: 5mm, 30 HS, top to bottom of liver
- Arterial: 2.5 mm 15 HS (smartprep aorta with threshold = 100 HU), top to bottom of liver. Reconstruct at 1.25 mm intervals
- Portal venous phase – abdomen and pelvis – 70 sec post injection, 2.5 mm 15 HS through liver, 5 mm 30 HS through pelvis

Comments
- Check noncontrast study for fatty liver – excludes donation
- Check arterial anatomy: accessory or anomalous branches

Determine liver volumes:
- If adult donor to child: lateral segment of left lobe is donated: determine volume of lateral segment of left lobe
- If adult donor to adult: right lobe of liver is donated: determine volume of right lobe, volume of entire liver; % of right lobe to entire liver

- How to determine liver volume on workstation
  - Select Portal venous series usually
  - Go to volume analysis, choose abdomen, then aorta from 3D guide
  - Then 3D tools – select paintbrush
  - Delineate lateral segment of left lobe manually by pressing down on “shiftkey” while moving your cursor along the edges of the left lobe – go ~1 cm to the right of the left hepatic and left portal vein for medial margins of the lateral segment of the liver
  - Delineate the area on each image for all slices
  - Hit apply
  - Go to 3D (top left corner of image), select histogram, this will give you the volume of the lateral segment
  - If right lobe is being measured, use middle hepatic vein and gallbladder fossa as landmarks

CT PORTOGRAPHY/HEPATIC ANGIOGRAPHY

CT portography/CT hepatic angiography provides the sensitivity of CT portography in detecting focal hepatic lesions and the specificity of CT hepatic angiography in distinguishing perfusion defects from true lesions.

The study is performed via a single arterial puncture using a sheath, injectable guidewire in the
hepatic artery and small caliber catheter in the superior mesenteric artery.

The initial injection is into the SMA. The liver is scanned caudad to cephalad 20 sec scan delay, 5 mm HS. The second injection is into the hepatic artery. The liver is scanned cephalad to caudad, 10 sec delay, 5 mm HS. In essence, the study is a “first pass” and “second pass” examination.

**Injection rate:** 3 cc/sec for 40 seconds per injection

---

**CT PELVIMETRY**

Discuss with ordering physician and attending radiologist prior to protocoling/performing, as MRI pelvimetry is more commonly used now and has no associated radiation.

**Indications**
- Trial of labor in breech presentation.

  Requirements for trial of labor in breech presentation:
  - Frank breech, 2500-3800 gms, non-hyperextended neck (check scout view for neck position) adequate pelvimetry measurements.

**Goal:**
- Provide accurate measurements of maternal pelvis and fetal positioning.

**Technique:**
- Patients should be supine with knees flexed for comfort. Pelvis should not be tilted otherwise several scans may be needed to see ischial spines and measurements may not be accurate.
  - AP scout view: 40 mA, 120 kVp
  - 70 mA, 120 kVp large patient
  - Lateral scout view: 75 mA, 120 kVp
  - 120 mA, 140 kVp large patient
  - Axial image: 40 mA, 80 kVp, 10 mm collimation
    - At level of ischial spines from AP or LAT scout view. Use inferior margin of foveae if cannot see ischial spines on scouts.

**References:**
- Aronson D, Kier R. CT Pelvimetry: The foveae are not accurate landmark for the level of the ischial spines. AJR 156:527-530, March 1991

---

**CT PELVIMETRY DOSE ESTIMATION**

**AP SCOUT:**
<table>
<thead>
<tr>
<th></th>
<th>KVp/mA</th>
<th>Surface Dose</th>
<th>Uterus/Fetus Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average patient</td>
<td>120/40</td>
<td>56 mR*</td>
<td>4/8 mR*</td>
</tr>
<tr>
<td>Large patient</td>
<td>120/70</td>
<td>98 mR</td>
<td>8.4 mR</td>
</tr>
</tbody>
</table>

**LATERAL SCOUT:**

<table>
<thead>
<tr>
<th></th>
<th>KVp/mA</th>
<th>Surface Dose</th>
<th>Uterus/Fetus Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average patient</td>
<td>140/75</td>
<td>136.5 mR</td>
<td>12.9 mR</td>
</tr>
<tr>
<td>Large patient</td>
<td>140/120</td>
<td>218.4 mR</td>
<td>20.6 mR</td>
</tr>
</tbody>
</table>

**AXIAL SLICE:**

<table>
<thead>
<tr>
<th></th>
<th>KVp/mA</th>
<th>Surface Dose</th>
<th>Uterus/Fetus Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average patient</td>
<td>120 kVp</td>
<td>8.4 mR/mAs</td>
<td>672 mR</td>
</tr>
<tr>
<td>Large patient</td>
<td>140 kVp</td>
<td>11.9 mR/mAs</td>
<td>952 mR</td>
</tr>
<tr>
<td>Decreased Resolution</td>
<td>80 kVp</td>
<td>3.2 mR/mAs</td>
<td>256 mR</td>
</tr>
</tbody>
</table>

The total dose ranges from a uterus/fetus dose of 109.8 mR (1.098 mGy) for an average patient using decreased resolution to uterus/fetal dose of 375 mR (3.75 mGy) for a large patient with full resolution.

*mR = millirads
1 Gray (gy) = 1 joule/kilogram = 100 rads → 10 milliGy = 1 rad

**CT PELVIMETRY**

<table>
<thead>
<tr>
<th>MINIMUM</th>
<th>DISTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>AP scout view: (Mid pelvis) cm</td>
<td>Maximum distance between ileopectineal lines (A-A) (Transverse Inlet).</td>
</tr>
<tr>
<td>Lateral scout View:</td>
<td>Minimum distance between midportion of sacra promontory to superior, posterior aspect of the Symphysis pubis (B-B) (AP Inlet). Mover cursors along inner sacrum and inner symphysis pubis to find shortest distance.</td>
</tr>
<tr>
<td>Axial image:</td>
<td>Minimum interspinous distance (C-C). Proscribe from: a) LATERAL SCOUT is ischial spines visible b) AP SCOUT is ischial spines visible. c) INFERIOR MARGIN OF FOVEAE if ischial spines</td>
</tr>
</tbody>
</table>
Not visible on scouts. (Take second axial slice 5 mm-1 cm inferior to first if ischial spines not seen on first axial image).

________ 9.5 –10 cm

Type of breech presentation (Circle)

Footling Feet first
Frank Hips flexed, knees extended
Compete Hips and knees flexed

Hyperextension of the fetal neck YES NO

If the head is hyperextended, Breech vaginal delivery is not recommended.
APPENDIX A

Management of Contrast Reactions

Look for any signs of contrast reaction, no matter how mild they may seem.

Patients experiencing reactions will be monitored according to the severity of the reaction.

If there are a few hives only, the patient may be discharged from the department as soon as the hives begin to fade and the patient is medically stable.

If the reaction is more severe, follow the treatment guidelines below.

<table>
<thead>
<tr>
<th>Severity of Reaction</th>
<th>Symptoms</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mild</strong></td>
<td><em>Nausea, warmth (heat), pallor, flushing (these are normal physiological responses to contrast injection and do not require intervention or documentation)</em>&lt;br&gt;Cough, headache, dizziness, vomiting, anxiety, altered taste, itching, shaking, sweats, rash (hives) chills</td>
<td>Signs and symptoms appear self-limited without evidence of progression (e.g. limited urticaria with mild pruritis, transient nausea, one episode of emesis). Requires observation (15 –20 minutes) to confirm resolution and/or lack of progression but usually no treatment. Patient reassurance is usually helpful.</td>
</tr>
<tr>
<td><strong>Moderate</strong></td>
<td>nasal stuffiness, swelling-eyes or face, tachycardia/bradycardia, hypertension, bronchospasm (wheezing), dyspnea, laryngeal edema, pronounced cutaneous reaction</td>
<td>The symptoms listed are considered as indication(s) for immediate monitoring and treatment. These situations require close, careful observation for possible progression to a life-threatening event.</td>
</tr>
<tr>
<td><strong>Severe</strong></td>
<td>Laryngeal edema, profound hypotension, unresponsiveness, convulsions, clinically manifested arrhythmias, cardiopulmonary arrest</td>
<td>Requires immediate recognition, monitoring and treatment, almost always requires hospitalization</td>
</tr>
</tbody>
</table>

*Call x6111 for Code Blue*
| Urticaria                                                                 | If severe/widely disseminated: Alpha-agonist (arteriolar and venous constriction):  
|                                                                         | *Epinephrine SC (1:1,000) 0.1-0.3ml (if no cardiac contraindication) |
| Discontinue injection, if not completed                                 |
| No treatment needed in most cases                                       |
| Hi-receptor blocker:                                                     |
| Diphenhydramine (Benadryl) PO/IM/IV 25-50 mg or                        |
| If severe/widely disseminated:                                          |
| Alpha-agonist (arteriolar and venous constriction): Epinephrine SC (1:1,000) 0.1-0.2 ml or if hypotension evident, then give epinephrine (1:10,000) slowly IV 1.0 ml, repeat |
| O₂ 6-10L/Min (via mask)                                                 |

| Facial/Laryngeal Edema                                                  | If not responsive to therapy or for obvious laryngeal edema (acute), seek appropriate assistance (code blue) Consider intubation |
| Alpha-agonist (arteriolar and venous constriction): Epinephrine SC (1:1,000) 0.1-0.2 ml or if hypotension evident, then give epinephrine (1:10,000) slowly IV 1.0 ml, repeat |
| O₂ 6-10L/Min (via mask)                                                 |

| Bronchospasm                                                            | Alternatively:  
|                                                                      | 1. Aminophylline:  
|                                                                      | 6.0mg/kg IV in D5W over 10-20 min (loading dose); then 0.4-1.0 mg/kg/hr, prn  
|                                                                      | 2. Call for assistance (CODE) for severe bronchospasm or if O₂ sats <88 persists |
| O₂ 6-10ml/min via mask                                                  |
| Monitor: ECG; O₂ saturation (pulse oximeter); BP                       |
| Beta agonist inhalers: Alupent, Brethaire, Albuterol                   |
| Epinephrine SC (1:1,000) 0.1-0.2 ml, if hypotensive give (1:10,000) slowly IV 1.0 ml Repeat prn up to a max. 1.0 mg |

| Hypotension with Tachycardia                                           | If poorly responsive:  
|                                                                      | Epinephrine SC(1:1,000) 0.1-0.2mL, if hypotensive give (1:10,000) slowly IV 1.0 ml, repeat prn up to max. 1.0 mg  
|                                                                      | Call Code Blue and/or transfer to Emergency Department for further care. |
| Legs up 60 degrees or more (preferred) or Trendelenberg position      |
| Monitor: ECG, pulse ox, BP                                             |
| O₂ 6-10L/Min (via mask)                                                |
| Rapid administration of large volumes of isotonic Ringer’s Lactate or NS |

<p>| Hypotension with Bradycardia-Vagal Reaction                            | Call Code Blue and/or transfer to Emergency Department for further care. |
| Monitor vital signs                                                    |
| Legs up 60 degrees or more (preferred) or Trendelenberg position       |
| Secure airway; give O₂ 6-10L/min(via mask)                             |
| Secure IV access; push fluid replacement with Ringer’s Lactate or NS   |
| Give atropine 0.6–1 mg IV slowly if patient does not respond quickly to above. |
| Repeat atropine up to a total dose of 0.04 mg/kg (2-3 mg) in adults.   |</p>
<table>
<thead>
<tr>
<th>Condition</th>
<th>Procedures/Internship</th>
<th>Note</th>
</tr>
</thead>
</table>
| Hypertension, Severe    | • Monitors in place, ECG, pulse ox., BP  
• Nitroglycerin 0.4mg tablet, sublingual (may repeat x3); topical 2% ointment, apply one inch strip  
• Sodium nitroprusside arterial line: infusion pump necessary to titrate  
• Transfer to ICU or emergency department  
• For pheochromocytoma-phentolamine 5.0mg (1.0mg in children) IV | **Call Code Blue and/or transfer to ED for further care.** |
| Seizures/Convulsions    | • 02 6-10L/min via mask  
• Consider diazepam (Valium) 5.0 mg or midazolam (Versed) 2.5 mg IV  
• If longer effect needed, obtain consultation; consider phenytoin (Dilantin) infusion 15-18 mg/kg at 50mg/min  
• Careful monitoring of vital signs required  
• Consider CODE for intubation if needed | **Call Code Blue and/or transfer to ED for further care.** |
| Pulmonary Edema         | • Elevate torso; rotating tourniquet (venous compression)  
• 02 6-10 L/min via mask  
• Diuretics-furosemide (Lasix) 20-40 mg IV slow, push  
• Consider Morphine (1-3 mg IV)  
• Corticosteroids optional | **Call Code Blue and/or transfer to ED for further care.** |
APPENDIX B

Protocol for Pregnant Women with RLQ Pain

1 – Complete abdominal ultrasound
   Include search of the RLQ for the appendix, gallbladder and bile duct eval, liver, kidneys.

2 – Complete pelvic ultrasound
   Include both transabdominal and endovaginal exam. Make sure UVJ’s are evaluated for possible stones. Evaluate for ureteral jets.

3 – OB US to include biometry

4 – Surgery needs to be consulted and spoken to before performing cross-sectional Imaging

5 – Cross-sectional imaging – discuss appropriate modality before performing any cross-sectional imaging. After hours we do not routinely perform MRI; Discuss case with attending before performing MRI or CT.

   1 – If CT: oral and IV contrast at 5mm with 2.5 mm recons, mA of 175 or less if possible (150 ma is usually ok)
   2 – If MRI: call MRI fellow on call if after-hours and discuss with attending.