Introduction to Ultrasound Applications
For the Family Physician’s Office

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Director Global Health
JPS Family Medicine Residency

INMED COURSE 2016
Ultrasound Workshop for INMED

- 8:00   General Principles of using US equipment and image optimization
- 9:00   Thyroid
- 10:00  Vascular/Carotid/Venous
- 11:00  Abdominal US
- 1:00   FAST exam US
- 2:00   Renal/Urinary Tract
- 3:00   Limited Echo/Thoracic
- 4:00   Final Examination
US Imaging Applications

- **Women’s Health**
  - Obstetrics: Confirm of Intrauterine pregnancy, dating accuracy, evaluation of fetal growth, screening for anomaly, AFI, BPP, UA waveform
  - GYN indications: pelvic pain, pelvic mass, abnormal vaginal bleeding, evaluation of possible ectopic, endometrial evaluation

- **Abdominal Pain**
  - Cholelithiasis, Cholecystitis, Hepatoma, Liver Abscess, common duct obstruction, pancreatitis, intra-abdominal mass, appendicitis

- **ER-Trauma:** FAST exam, Ascites vs Air,

- **Urology applications:** Renal/bladder stones, Hydronephrosis, Renal perfusion, Testicular mass, Testicular torsion

- **Thyroid:** nodule/cyst evaluation, guidance for FNA

- **Testicular scan** (tumor, torsion)

- **Neonatal brain Imaging**

- **Musculo-Skeletal US**
  - Joint evaluation and injection guidance
  - Evaluation of shoulder pathology
  - Nerve evaluation (carpel tunnel)

- **US guidance for procedures**
  - Liver, Renal, soft tissue biopsy
  - Paracentesis, thoracentesis
  - Breast Biopsy
  - Central Venous catheter placement
  - Peripheral venous access

- **Vascular US**
  - Carotid US
  - Venous Doppler for DVT screening
  - AAA screening
Advantages of US

• Realtime Clinically Correlated imaging
• Functional and vascularity assessment
• Relatively low cost of equipment compared to CT or MRI
• No radiation exposure
• Low cost of supplies or usage compared to Xray
• Portability & bedside availability
• Durability of newer equipment/rechargable and battery operated
Limitations of US

- Air is the enemy
- Fails to penetrate dense bone
- Depth of penetration in large people
- Artifact issues
- Repair issues
Ultrasound “Windows”

• Probes designed to fit into specific anatomical windows
  – Endovaginal
  – Cardiac
  – Small Parts
  – Vascular
  – General Abdominal
  – OB Abdominal
Type of Probes

Curvilinear Probe: General OB and Abdominal applications

Linear, High Frequency Probe: vascular, small parts and MSK applications

Endo-Cavity Probe: Vaginal, Rectal applications. Very useful in early pregnancy

Cardiac Probe: Used for Echocardiography applications
Some Basic US Physics

- US of GB with stone

  - Attenuation
  - Enhancement
  - Shadowing
Brief Overview of M-Turbo Operation

• PLAY SHORT VIDEO FILE

Performing an Ultrasound Exam

SonoSite M-Turbo Product Training Part 3: How To Perform And Exam

This is part 3 of a four part product training series for the SonoSite M-Turbo® portable ultrasound system. This tutorial will outline the steps to optimize the ultrasound system to perform an examination.

For a non-companion and portable video library, please download the SonoApparell® app at http://www.sonomappe.com.
THYROID ULTRASOUND

• Who needs it?
  – 4 to 7% of adults have a palpable thyroid nodule
  – Up to 40% have a US visible nodule or cyst
  – Most nodules are benign (1 to 2 / 100 are CA)
  – Solitary Solid nodules should be suspect (10%)
  – Risk factors for malignancy: H&N radiation
Normal Thyroid Anatomy
Differentiating nodules

1. Cystic
2. Mixed
3. Solid

- Hyperecho
- Hypoecho
- Calcification
- Margin
- Halo
Typical Benign Nodule
Benign Nodule with “rim”
Malignant Nodule

Hypoechoic

Fine Calcification
<table>
<thead>
<tr>
<th>Feature</th>
<th>Benign</th>
<th>Malignant</th>
</tr>
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<tbody>
<tr>
<td><strong>Internal contents</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solid</td>
<td>I(C)</td>
<td>I(C)</td>
</tr>
<tr>
<td>Cystic</td>
<td>P(C)</td>
<td></td>
</tr>
<tr>
<td>Mixed</td>
<td>P(C)</td>
<td></td>
</tr>
<tr>
<td><strong>Echogenicity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypoechoic</td>
<td>I(C)</td>
<td>I(C)*</td>
</tr>
<tr>
<td>Isoechoic</td>
<td>I(U)</td>
<td>I(U)</td>
</tr>
<tr>
<td>Hyperechoic</td>
<td>P(U)</td>
<td></td>
</tr>
<tr>
<td><strong>Margin</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Well defined</td>
<td>P(C)</td>
<td></td>
</tr>
<tr>
<td>Poorly defined</td>
<td></td>
<td>P(C)</td>
</tr>
<tr>
<td><strong>Halo</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thick, incomplete</td>
<td></td>
<td>P(C)</td>
</tr>
<tr>
<td>Thin, complete</td>
<td>P(C)</td>
<td></td>
</tr>
<tr>
<td><strong>Calcification</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peripheral (eggshell)</td>
<td>P(U)</td>
<td></td>
</tr>
<tr>
<td>Internal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coarse</td>
<td>I(U)</td>
<td>I(U)</td>
</tr>
<tr>
<td>Fine</td>
<td></td>
<td>P(C)</td>
</tr>
</tbody>
</table>

*I, indeterminate; P, probable; C, commonly encountered; U, uncommon*
US Guided FNA

25 Gauge Gentle or no suction

Follow with US

Avoid Carotid
Malignant: Taller than Wide
Malignant: Infiltrating Margins
Infiltrating Thyroid CA
Benign Multinodular Goiter
Benign Hyperplastic Nodule
Medullary CA Nodule
Suspicious Nodule: Irreg border with micro-calcifications
Dx & CPT Codes for Thyroid US

- Palpable Nodule
- Hx of Nodule
- Hx of radiation
- Hypo/Hyper Thyroidism

- **CPT: CPT 76536  (avg payment: 109.64)**
  - Ultrasound, soft tissues of head and neck (e.g., thyroid, parathyroid, parotid), real time with image documentation
FNA with US Guidance

CPT 10022

- Fine needle aspiration; with imaging guidance

- 2009 Medicare Fee Schedule,
  - National Average
  - Facility $ 64.20  Non-Facility $ 130.20

- Hospital Outpatient APC  $ 295.46
Vascular Workshop

• Brief Overview of Carotid US
• Brief Overview of Venous US (for DVT Screening)
Carotid US Evaluation

Brief Overview
Carotid US: Indication

• Evaluation of SYMPTOMATIC patients
  – Neurologic symptoms
  – TIA
  – Cervical Bruit
  – patients with symptomatic carotid stenoses of 70-80% diameter reduction or greater will benefit from carotid arterectomy

• Screening
  – Cardiac surgery
  – High risk patients

• F/u known Carotid Stenosis
Technique

- Basic Components of Exam:
  - Plaque characterization
  - Grading stenosis of the ICA by Peak Systolic Velocity criteria
  - Waveform analysis
Technique

• Head slightly hyperextended
  – Turned to contralateral side
• Anterior or posterior approach

• Proper Transducer:
  – 7.5 to 10 MHZ linear array transducer
Carotid Artery: ICA vs ECA
Looking at Plaque
ICA Area Reduction
ICA Critical Stenosis
## Criteria for Grading Carotid Stenosis

<table>
<thead>
<tr>
<th>Diameter Stenosis</th>
<th>Description</th>
<th>Peak Systolic Velocity, m/s</th>
<th>Peak Diastolic Velocity, m/s</th>
<th>ICA/CCA Peak Systolic Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Normal</td>
<td>&lt; 0.9</td>
<td>&lt; 0.5</td>
<td></td>
</tr>
<tr>
<td>0–15%</td>
<td>Mild</td>
<td>&lt; 1.1</td>
<td>&lt; 0.5</td>
<td></td>
</tr>
<tr>
<td>15–50%</td>
<td>Moderate</td>
<td>&lt; 1.5</td>
<td>&lt; 0.5</td>
<td>&lt; 2</td>
</tr>
<tr>
<td>50–70%</td>
<td>Severe</td>
<td>&gt; 1.5</td>
<td>&gt; 0.5</td>
<td>&gt; 2</td>
</tr>
<tr>
<td>&gt;70%</td>
<td>Critical</td>
<td>&gt; 2.25</td>
<td>&gt; 0.75</td>
<td>&gt; 3</td>
</tr>
<tr>
<td>100%</td>
<td>Occlusion</td>
<td>0</td>
<td>0</td>
<td>N.A.</td>
</tr>
</tbody>
</table>
CPT Coding for Carotid US

• **CPT 93880**
  – Duplex scan of extracranial arteries; complete bilateral study
  – Professional (-26) $ 31.02
  – Technical $ 153.16

• **CPT 93882**
  – Duplex scan of extracranial arteries; unilateral or limited study
  – Professional (-26)$ 20.56
    Technical $ 143.18
Take Home Points

• In practical terms the aim is to divide patients with possible carotid artery disease into the following groups:

  1. those with normal findings.

  2. those with mild, clinically irrelevant disease - that is a diameter reduction of less than 50 % and smooth, echogenic plaques.

  3. patients with haemodynamically significant disease - greater than 50 % diameter reduction.

  4. patients with clinically significant disease - greater than 70 % diameter stenosis, or obviously ulcerated plaque.
Venous Thrombo Embolism: The Silent Killer

- **Estimates** of between 650,000 to 900,000 fatal and nonfatal VTE events occurring in the US annually
- **LE DVT** is by far the major culprit
- **Prompt** diagnosis and treatment can dramatically reduce the morbidity and mortality of the disease

- **BEST** screening tool for VTE: **VENOUS ULTRASOUND**
Venous Doppler for DVT

TECHNIQUE

A typical sonographic venous study of the legs is a bilateral examination of the external iliac veins at the groin, the common femoral veins, the greater saphenous veins as they empty into the common femoral vein, superficial femoral, profunda femoral, and popliteal veins.
Patient Position

• In the sonographic examination of veins of the lower extremity, the patient lies supine initially, rotated slightly toward the side being examined with the leg modestly abducted and externally rotated. Others examine the patient without a table tilt. Care is taken to remove any tightly restrictive clothing from the abdomen.
Scanning Technique: Compression is a GOOD thing!

- The veins are principally examined by grey scale on transverse scan for response to compression by the transducer (Figure 5). Thereafter, the same veins are studied in longitudinal scan in grey scale, color, and by spectral analysis, using respiratory and augmentation maneuvers, as appropriate.
Secondary Signs

- Secondary signs looked for are venous phasicity,
- a prompt response to augmentation,
- and in the common femoral vein, the response to a Valsalva maneuver
Normal Expansion with Valsalva

Normal Compression of common femoral
CLOT: Loss of Compression
Enlargement of Vein
LOSS OF NORMAL VENOUS FLOW
How Good is US for DVT?

• In general, ultrasound for deep venous thrombosis is highly sensitive and specific, ranging from 93-99%, respectively.

• Sensitivity is reduced for small focal non-occlusive disease, particularly in an orthopedic population.
CPT Coding for DVT Screen

• **CPT 93970**
  – Duplex scan of extremity veins including responses to compression and other maneuvers; complete bilateral study

• Professional $ 34.98 (-26)

• Technical (-TC) $ 153.28

• **CPT 93971**
  – Duplex scan of extremity veins including responses to compression and other maneuvers; unilateral or limited study
    – Professional $ 23.08 0266 (-26)
Indications for DVT Screen

• Clinical signs and/or symptoms of acute or new onset DVT such as extremity swelling, tenderness, inflammation and/or erythema.

• Investigation for DVT as the source of the pulmonary embolism

• Unexplained lower extremity edema with high pre-test probability of DVT (e.g., status-post major surgical procedure or postpartum)
Indications (cont)

• High risk patients: hip surgery, multiple trauma, malignancy, etc.
• Post-Thrombotic (Post Phlebitic) Syndrome - Evaluation is medically necessary in patients with symptoms of post-thrombotic syndrome.
• Recurrent DVT - Evaluation is medically necessary in patients with signs or symptoms of recurrent DVT.
Indications (cont)

• Objective tests of venous function may be indicated in patients with ulceration, thickening and discoloration suspected to be secondary to venous insufficiency in order to confirm this diagnosis, by documenting venous valvular incompetence, prior to treatment.

Bilateral limb edema, especially when signs and or symptoms of congestive heart failure, exogenous obesity and/or arthritis are present, should rarely be an indication for venous studies.
Abdominal Ultrasound for Primary Care

INMED Workshop 2015
Abdominal Ultrasound

• Hepato-Biliary
  – Liver
  – Gallbladder
  – Common Duct
  – Intrahepatic Ducts

Pancreas
Renal
Fast Exam
AIUM Standard for Complete Abdominal Ultrasound Exam

1. Liver

   The examination of the liver should include long-axis and transverse views. The liver parenchyma should be evaluated for focal and/or diffuse abnormalities. If possible, the echogenicity of the liver should be compared with that of the right kidney. In addition, the following should be imaged:

   a. The major hepatic and perihepatic vessels, including the inferior vena cava (IVC), the hepatic veins, the main portal vein, and, if possible, the right and left branches of the portal vein.
Liver (cont)

• The hepatic lobes (right, left, and caudate) and, if possible, the right hemidiaphragm and the adjacent pleural space.

• For vascular examinations of the native or transplanted liver, Doppler evaluation should be used to document blood flow characteristics and blood flow direction. The structures that may be examined include the main and intrahepatic arteries, the hepatic veins, the main and intrahepatic portal veins, the intrahepatic portion of the IVC, collateral venous pathways, and transjugular intrahepatic portosystemic shunt stents.
• A routine gallbladder examination should be conducted on an adequately distended gallbladder whenever possible. In most cases, fasting before elective examination will permit adequate distension of a normally functioning gallbladder. In infants and children, fasting may not be necessary in all cases. The gallbladder evaluation should include long-axis and transverse views obtained in the supine position. Other positions such as left lateral decubitus, erect, and prone may be helpful to evaluate the gallbladder and its surrounding areas completely. Measurements may aid in determining gallbladder wall thickening. If the patient presents with pain, tenderness to transducer compression should be assessed.
• The intrahepatic ducts can be evaluated by obtaining views of the liver demonstrating the right and left branches of the portal vein. Doppler imaging may be used to differentiate hepatic arteries and portal veins from bile ducts. The intrahepatic and extrahepatic bile ducts should be evaluated for dilatation, wall thickening, intraluminal findings, and other abnormalities. The bile duct in the porta hepatis should be measured and documented. When visualized, the distal common bile duct in the pancreatic head should be evaluated
3. Pancreas

- Whenever possible, all portions of the pancreas—head, uncinate process, body, and tail—should be identified. Orally administered water or a contrast agent may afford better visualization of the pancreas.

The following should be assessed in the examination of the pancreas:

- Parenchymal abnormalities.
- The distal common bile duct in the region of the pancreatic head.
- The pancreatic duct for dilatation and any other abnormalities, with dilatation confirmed by measurement.
- The peripancreatic region for adenopathy and/or fluid.
4. Spleen

- Representative views of the spleen in long-axis and transverse projections should be obtained. Splenic length measurement may be helpful in assessing enlargement. Echogenicity of the left kidney should be compared to splenic echogenicity when possible. An attempt should be made to demonstrate the left hemidiaphragm and the adjacent pleural space.
5. Bowel

- The bowel may be evaluated for wall thickening, dilatation, muscular hypertrophy, masses, vascularity, and other abnormalities. Sonography of the pylorus and surrounding structures may be indicated in evaluation of the vomiting infant. Graded compression sonography aids in the visualization of the appendix and other bowel loops. Measurements may aid in determining bowel wall thickening.
6. Peritoneal Fluid

- Evaluation for free or loculated peritoneal fluid should include documentation of the extent and location of any fluid identified.
- For evaluating peritoneal spaces for bleeding after traumatic injury, particularly blunt trauma, the examination known as focused abdominal sonography for trauma (FAST, also known as focused assessment with sonography for trauma) may be performed.
Peritoneal Fluid (FAST)

The objective of the abdominal portion of the FAST exam is to screen the abdomen for free fluid. Longitudinal and transverse plane images should be obtained in the RUQ through the area of the liver with attention to fluid collections peripheral to the liver and in the subhepatic space. Longitudinal and transverse plane images should be obtained in the left upper quadrant through the area of the spleen with attention to fluid collections peripheral to the spleen. Longitudinal and transverse images should be obtained at the periphery of the left and right abdomen in the areas of the left and right paracolic gutters for evidence of free fluid.
FAST (cont)

- Longitudinal and transverse midline images of the pelvis are obtained to evaluate for free pelvic fluid. Analysis through a fluid-filled bladder (which if necessary can be filled through a Foley catheter, when possible) may help in evaluation of the pelvis.
7. Abdominal Wall

- The examination should include images of the abdominal wall in the location of symptoms or signs. The relationship of any identified mass with the peritoneum should be demonstrated. Any defect in the peritoneum and abdominal wall musculature should be documented. The presence or absence of bowel, fluid, or other tissue contained within any abdominal wall defect should be noted. Images obtained in upright position and/or with use of the Valsalva maneuver may be helpful. Doppler examination may be useful to define the relationship of blood vessels with a detected mass.
8. Kidneys

• An examination of native or transplanted kidneys should include long-axis and transverse views of the kidneys. The cortices and renal pelvises should be assessed. A maximum measurement of renal length should be recorded for both kidneys. Decubitus, prone, or upright positioning may provide better images of the native kidneys. When possible, renal echogenicity should be compared to the adjacent liver or spleen. The kidneys and perirenal regions should be assessed for abnormalities.
Kidneys (cont)

- For a vascular examination of native or transplanted kidneys, Doppler imaging can be used:
- To assess renal arterial and venous patency.
- To evaluate suspected renal artery stenosis. For this application, angle-adjusted measurements of the peak systolic velocity should be made proximally, centrally, and distally in the extrarenal portion of the main renal arteries when possible. The peak systolic velocity of the adjacent aorta should also be documented for calculating the renal to aortic peak systolic velocity ratio. Spectral Doppler evaluation of the intrarenal arteries may be of value as indirect evidence of proximal stenosis in the main renal artery.
Kidney (cont)

- For vascular examinations of transplanted kidneys, Doppler evaluation should be used to document vascular patency and blood flow characteristics. The structures that may be examined include the main renal artery and vein, arterial and venous anastomoses, the iliac artery and vein, and the intrarenal arteries.
9. Urinary Bladder and Adjacent Structures

• When performing a complete ultrasound evaluation of the urinary tract, transverse and longitudinal images of the distended urinary bladder and its wall should be included, if possible. Bladder lumen or wall abnormalities should be noted. Dilatation or other distal ureteral abnormalities should be documented. Transverse and longitudinal scans may be used to demonstrate any postvoid residual, which may be quantitated and reported.
10. Adrenal Glands

• When possible, usually in the neonate or young infant, long-axis and transverse images of the adrenal glands may be obtained. Normal adrenal glands are less commonly shown by ultrasound imaging in adults.
Major Vessels

Aorta

- Representative images of the aorta should be obtained. When evaluation of the aorta is specifically requested, see the AIUM Practice Guideline for the Performance of Diagnostic and Screening Ultrasound of the Abdominal Aorta.

Inferior Vena Cava

- Representative images of the IVC should be obtained. Patency and abnormalities may be evaluated with Doppler imaging. Vena cava filters, interruption devices, and catheters may need to be localized with respect to the hepatic and/or renal veins.
Coding and Billing

• Complete Abdominal US
  – Related Dx: TNTC but especially abdominal pain, RUQ pain, dyspepsia/fatty food intolerance/post-prandial pain, abnormal LFT, Hep B, Hep C, Alcoholic liver, hematuria, dysuria, flank pain, renal colic, and many others
Limited or Focused Abd Exams

• Liver: Parenchyma, tumor, ducts
• Gall Bladder and CBD: stones, size, wall

• CPT 76705
  – Ultrasound, abdominal, real time with image documentation; limited
    (eg, single organ, quadrant, follow-up)
  –
Limited K.U.B.

• Evaluation for renal colic, hematuria
  – CPT Code 76700
  – Reimbursement: 188.00
Reimbursements

The following provides 2009 national Medicare physician fee schedule (MPFS) and hospital outpatient facility payment rates for the diagnostic ultrasound and related ultrasound guidance procedures CPT codes commonly performed by emergency medicine physicians. Payment will vary by geographic regions.

2009 Medicare reimbursement for diagnostic ultrasound and ultrasound-guided procedures commonly performed by emergency medicine physicians (reflects national rates, unadjusted for locality).

<table>
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<th>CPT²/HCPCS Code</th>
<th>Physician</th>
<th>Facility</th>
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<td>Professional Component using a -26 modifier</td>
<td>Medicare Physician Fee Schedule Amount³</td>
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<tr>
<td>CPT 76604</td>
<td>$ 27.77</td>
<td>0265</td>
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<tr>
<td>Ultrasound, chest (includes mediastinum), real time with image documentation</td>
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<tr>
<td>CPT 76705</td>
<td>$ 30.30</td>
<td>0266</td>
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<td>Ultrasound, abdominal, real time with image documentation; limited (eg, single organ, quadrant, follow-up)</td>
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<tr>
<td>CPT 76775</td>
<td>$ 30.30</td>
<td>0266</td>
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<tr>
<td>Ultrasound, retroperitoneal (eg, renal, aorta, nodes), real time with image documentation; limited</td>
<td></td>
<td></td>
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<tr>
<td>CPT 76815</td>
<td>$ 32.46</td>
<td>0265</td>
</tr>
<tr>
<td>Ultrasound, pregnant uterus, real time with image documentation, limited (eg, fetal heart beat, placental</td>
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Diagnostic Evaluation for an Abdominal Aortic Aneurysm

• Palpable or pulsatile abdominal mass.
• Unexplained lower back pain, flank pain, or abdominal pain.
• Follow-up of a previously demonstrated abdominal aortic aneurysm.
• Follow-up of patients with an abdominal aortic and/or iliac endoluminal stent graft.
Screening Evaluation for an Abdominal Aortic Aneurysm

- Men 65 years or older.
- Women 65 years or older with cardiovascular risk factors.
- Patients 50 years or older with a family history of aortic and/or peripheral vascular aneurysmal disease.
- Patients with a personal history of peripheral vascular aneurysmal disease.
- Groups with additional risk include patients with a history of smoking, hypertension, and certain connective tissue diseases (eg, Marfan syndrome).
Screening Examination for an Abdominal Aortic Aneurysm

Abdominal aorta:

– Longitudinal images (along the long axis of the vessel):
  • Proximal
  • Mid
  • Distal

– Transverse images (perpendicular to the long axis of the vessel):
  • Proximal (near diaphragm);
  • Mid
  • Distal.
Aorta Screen

Suspect in:
- Elderly
- Smokers
- Vasculo-paths
Liver/Gallbladder

Liver Parenchyma

Interface with Kidney

Gallbladder and ducts
Gallbladder

Stones: shadow

Cholecystitis: Thickening of GB wall, edema of wall
**Technique** The FAST exam is performed as part of the initial evaluation of the trauma patient in the emergency center. It consists of four separate views of four anatomic areas (see diagrams below):

1. The right upper abdomen (Morison's space between liver and right kidney)  
2. The left upper abdomen (perisplenic and left perirenal areas)  
3. Suprapubic region (perivesical area)  
4. Subxyphoid region (pericardium)
Step 1 and 2

Blood between liver and R. Kidney RUQ

Blood around spleen on LUQ
Step 3 and 4

Blood around the heart in a patient stabbed in the left chest with a knife.

Blood anterior to bladder
Video Clip of Abdominal Exam

SYSTEMATIC ULTRASOUND EXAMINATION OF THE ABDOMEN
Other Fun things to TRY

• Arterial Lines
  – Checking for collateral flow
  – Visualizing the vessel
  – Confirming intra-luminal position

• Carpel Tunnel Evaluation and Treatment
  – Identify the Median Nerve
  – Guided injection into the tunnel

• Evaluating Lumps and Bumps with guidance