Informatics Applied: Improving Radiology Care

Mark Halsted, MD
Chief, Radiology Informatics Research Core
Associate Professor, Radiology and BioInformatics
Cincinnati Children’s Hospital Medical Center

Acknowledgements:

CCHMC Radiology Department
CCHMC IS Department
Craig Froehle, PhD, UC College of Business
Disclosure:

RadStream™ has been licensed for commercial distribution by AMICAS;
Dr. Halsted is helping AMICAS with marketing.
Radiology Workflow Problems per CCHMC:

- Interruptions
- Conveying Wet Reads and Critical Results
- Documenting Conveyances
- Follow-up Interesting Cases
- Ensuring Follow-up of Critical Cases
- Signing Contrast and other Orders
- Communications
Critical Results
Communication/Documentation
and
Case Prioritization:

RadStream™
Cincinnati Children’s Hospital

- 423-bed pediatric teaching hospital
- 16 regional patient care sites
- ~10,000 employees (>100% growth since 1998)
- 2004: 761,482 patients served
  - From 47 states and 53 countries
- CCHMC Radiology
  - 28 FTE radiologists
  - >250 full-time staff
  - Main hospital and 10 outpatient imaging clinics
  - 200,000 exams / year
CCHMC: Radiology for 10 Sites

Scale: 10 mi.
Outpatient “Stat” Exams
Who Gets Read First?

Problems
- Communications
- Who goes first?
- O/P sites unaware of traffic from other sites

Poor Communication Causes Interruptions
State of the Art Radiology

- CT
- MRI
- RADIOGRAPHY
- ULTRASOUND
- FLUORO
Cases Arrive in Random Order

- Faxed requisitions
- Hand-carried requisitions
- CT
- MRI
- X-Ray
- Ultrasound
<table>
<thead>
<tr>
<th>Patient Name</th>
<th>Patient ID</th>
<th>Mod</th>
<th>Procedure</th>
<th>Img</th>
<th>Study Time</th>
<th>Status</th>
<th>Online</th>
<th>Accession</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adams, Amy</td>
<td>CR</td>
<td>FOOT - 3V</td>
<td>1</td>
<td></td>
<td>Transcribed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bernard, Benny</td>
<td>CR</td>
<td>CHEST 1 VIEW</td>
<td>1</td>
<td></td>
<td>Completed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calvin, Connie</td>
<td>CR</td>
<td>CHEST 1 VIEW</td>
<td>1</td>
<td></td>
<td>Verified</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driver, Daisy</td>
<td>CR</td>
<td>TIBIA/FIBULA 2V</td>
<td>2</td>
<td></td>
<td>Transcribed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eggert, Ellen</td>
<td>CR</td>
<td>FEMUR 2V</td>
<td>2</td>
<td></td>
<td>Arrived</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fitzgerald, Francis</td>
<td>CR</td>
<td>FOOT - 3V</td>
<td>1</td>
<td></td>
<td>Completed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garrett, Gerald</td>
<td>CR</td>
<td>CHEST 1 VIEW</td>
<td>1</td>
<td></td>
<td>Transcribed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Homer, Heather</td>
<td>CR</td>
<td>CHEST 1 VIEW</td>
<td>1</td>
<td></td>
<td>Transcribed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ivers, Ilsa</td>
<td>CR</td>
<td>TIBIA/FIBULA 2V</td>
<td>2</td>
<td></td>
<td>Transcribed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jenkins, Jannelle</td>
<td>RF</td>
<td>FLUOROSCOPY, UP TO 1 HOUR</td>
<td>2</td>
<td></td>
<td>Completed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sanders, Sammy</td>
<td>CR</td>
<td>FEMUR 2V</td>
<td>3</td>
<td></td>
<td>Arrived</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loomis, Lana</td>
<td>US</td>
<td>Unspecified US</td>
<td>170</td>
<td></td>
<td>Verified</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mains, Marcus</td>
<td>CR</td>
<td>CHEST 1 VIEW</td>
<td>1</td>
<td></td>
<td>Completed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CR</td>
<td>CHEST 2 VIEWS</td>
<td>2</td>
<td></td>
<td>Completed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CR</td>
<td>LUMBAR SPINE 2 VIEW</td>
<td>2</td>
<td></td>
<td>Transcribed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CR</td>
<td>ELBOW 3+ VIEW</td>
<td>2</td>
<td></td>
<td>Transcribed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>RF</td>
<td>UPPER G ION</td>
<td>9</td>
<td></td>
<td>Transcribed</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Which Case to Read Next?**

- **Sammy Sanders**
- **Ellen Eggert**
Unexpected Findings: Contacting the MD
RadStream – How Does it Work?

• Tech enters acuity information – 5 clicks
• Algorithm creates constantly refreshing prioritized master index of all active cases
• Worklists customized, filtered, distributed in real time to all radiologists
• Shared worklists
• Radiologists assign cases
• Real time workload balancing
RadStream – How Does it Work?

- STAT results routed to assistants for conveyance
- All conveyances and page attempts logged
- Radiologist pushes results - 1 click
- Radiologist reaches referring MD – 1 click
RadStream

• Better Communication
• Fewer Interruptions to workflow
  – Increased throughput
  – Decreased backlog
• Permanent Documentation of verbal reports
• Better, Faster Patient Care
  – Decreased average wait times for everyone
  – Interpret most urgent studies first
Outcomes Studies:

• What is the impact of adding Voice Recognition ("VR") to combined RIS/PACS?

• What is the impact of adding RadStream to combined RIS/PACS/VR?

• What is the effect of combining worklists in RadStream?
Methods:

1) Measure perceptions, operations in a single-vendor integrated RIS/PACS environment
   • 40,000 operations data points including live time-motion studies
   • 500 patient surveys
   • Staff surveys

2) Enable VR

3) Re-Measure

4) Launch RadStream

5) Re-Measure

6) Combine Worklists

7) Re-Measure
Methods

- Observed two radiologists 5-9pm weekdays (busiest period) for each measurement (20 hours @, pre & post)
- Tracked interruptions to regular workflow (start time & duration)
  - Walk-ins (docs & techs with questions)
  - Phone calls from outside and referring physicians
  - Other medical-related interruptions
  - Self-induced interruptions and attending to scheduled, supplemental duties were tracked but **not** included in calculations
Interruptions in Stat Box

Results

• Durations increased with VR (P=.05) but returned to pre-VR levels after RadStream

• No significant change in perceptions (low N) or interarrival times (large SD), but means trending in desirable directions

<table>
<thead>
<tr>
<th>Perceived Interruptions</th>
<th>Pre-VR</th>
<th>Post-VR</th>
<th>Post-RadStream</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiologists</td>
<td>5.79</td>
<td>5.42</td>
<td>5.14</td>
</tr>
<tr>
<td>Technologists</td>
<td>4.36</td>
<td>4.48</td>
<td>4.89</td>
</tr>
</tbody>
</table>

7-pt scales, unmatched t-tests, P<.05, n’s same as previous page
Interruptions
– Outpatient Imaging Centers

• Pre- and Post-VR: All stat read results faxed, and positive results verbally conveyed
• Post-RadStream: All notification of results automated

• Savings estimate: 2-3 hours per day per radiologist
Process Flow Times

Methods

Identified key process points common to all patient types

1. End of procedure (image available for reading)
2. Report dictated by radiologist (preliminary if by res/fellow)
3. Dictation transcribed (and available for sign-off)
4. Electronic sign-off by radiologist

Queried various system databases for process point timestamps; data cleaned and merged to obtain

- Pre-VR: 6,215 exams over 15 consecutive days
- Post-VR: 6,093 exams over 14 consecutive days
- Post-RadStream: 7,493 exams over 15 consecutive days
- Post-Combined Worklists: 15,600 exams over 30 consecutive days

Why Combine Worklists?
Medians: ED (Overnight Delay)

<table>
<thead>
<tr>
<th></th>
<th>Pre-VR</th>
<th>Pre-RadStream</th>
<th>Post-RadStream</th>
<th>RS with Combined Worklists</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sign-off</td>
<td>3.06</td>
<td>2.1</td>
<td>1.54</td>
<td>1.09</td>
</tr>
<tr>
<td>Transcription</td>
<td>0.87</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Reading</td>
<td>0.84</td>
<td>0.37</td>
<td>0.38</td>
<td>0.31</td>
</tr>
</tbody>
</table>
Why signoff times improved?

? Change from “just get something out there and correct it later”

…to…

“Now I’ve got time to correct and sign it the first time.”
Medians: Inpatients (Batch Read)

<table>
<thead>
<tr>
<th>Category</th>
<th>Sign-off</th>
<th>Transcription</th>
<th>Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-VR</td>
<td>3.01</td>
<td>0.48</td>
<td>1.7</td>
</tr>
<tr>
<td>Pre-RadStream</td>
<td>0.41</td>
<td>0</td>
<td>1.71</td>
</tr>
<tr>
<td>Post-RadStream</td>
<td>0.35</td>
<td>0</td>
<td>0.99</td>
</tr>
<tr>
<td>RS with Combined</td>
<td>0.01</td>
<td>0</td>
<td>0.96</td>
</tr>
<tr>
<td>Worklists</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Median Outpatient (60% of Dept Volume)

<table>
<thead>
<tr>
<th></th>
<th>Sign-off</th>
<th>Transcription</th>
<th>Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-VR</td>
<td>2.47</td>
<td>0.73</td>
<td>0.91</td>
</tr>
<tr>
<td>Pre-RadStream</td>
<td>0</td>
<td>0</td>
<td>0.95</td>
</tr>
<tr>
<td>Post-RadStream</td>
<td>0</td>
<td>0</td>
<td>0.59</td>
</tr>
<tr>
<td>RS with Combined Worklists</td>
<td>0</td>
<td>0</td>
<td>0.42</td>
</tr>
</tbody>
</table>
Annual Documented Critical Result
Conveyance - ~185,000 Total Cases
RadStream - Status

- AMICAS launch embedded version Q1 2008
- Standalone version to follow
In an integrated RIS/PACS:

• Voice Recognition worsens patient and radiologist perceptions of the radiology experience
• VR improves operations

• RadStream™ reverses much of the perceptions damage done by VR, reducing interruptions while further improving operations, communication, and documentation

• Combining worklists with RadStream further improves efficiency
RadStream - Conclusion

- RadStream:
  - Decreases Interruptions
  - Improves Communication
  - Enhances Followup, Documentation
  - Improves and Speeds Patient Care
MedTracer™:
Test Result Delivery to
Ensure Follow-up and Improve Safety

...With or Without an EMR
Importance of Following Through

• Dr. Smith, radiologist, sees concerning lesion on x-ray and recommends follow-up CT scan
• Dr. Jones, primary physician, reads x-ray report but forgets to order CT
• Six months later, concerning lesion becomes an unresectable tumor

• Who is liable?
  – Both doctors!
What does MedTracer do?

- No EMR needed
- Filtered, Instant Results Delivery
- Automatic Results Conveyance (Email, PDA, IM, Pager)
  - Coming Soon: One Click Ordering
What does MedTracer do?

• Single Sign-On test result interface – including indexed radiology results
• Notify if study not done to ensure follow-up
• Reduces medical legal risk
Patient: [ ] MRN: [ ]

Please select the reports you want to track:
Selecting a higher level category selects everything beneath that category. Expand the menu to select specific reports.

- Pathology Reports
- Operative Reports
- Radiology Reports
- Lab Results
- Discharge Summary (coming soon)
- Clinic Notes (coming soon)

Add your comments to the reports for this case:
These comments will be included as part of the email that the system will send to you when new results are available.

Continue

Send Feedback to the MedTracer Development Team

Please follow CCHMC HIPAA Policies regarding the use and disclosure of protected health information.
©2005, Cincinnati Children's Hospital Medical Center
<table>
<thead>
<tr>
<th>Remove</th>
<th>Report Type</th>
<th>Start Tracking</th>
<th>End Date</th>
<th>Notify via</th>
<th>Recent Results</th>
<th>Notify If Not Done</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>CT NEURO</td>
<td></td>
<td>4/15/2008</td>
<td>email, page</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Send Feedback to the MedTracer Development Team

Please follow [CCHMC HIPAA Policies](#) regarding the use and disclosure of protected health information.

©2005, Cincinnati Children's Hospital Medical Center
<table>
<thead>
<tr>
<th>*** Previous Comments About Patient: ***</th>
</tr>
</thead>
<tbody>
<tr>
<td>Likely teratoma in sacral spinal canal</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>RADIOLOGY REPORT</strong></th>
</tr>
</thead>
</table>

View Radiology Images of this patient on PACS-Web:

**MRN =**

**PATIENT NAME =**

**REPORT TYPE =** Radiology

**OBSERVATION DATE AND TIME**

**EXAMINATION:** MRI Brain W/O Contrast

**Preliminary Report***

**CLINICAL HISTORY:** Complicated migraines.

**PROCEDURE COMMENTS:** Standard MR Brain imaging protocol. MRA of the carotid arteries and circle of Willis also performed.

**FINDINGS:** In the region of the pituitary gland there is a 15 mm anteroposterior x 10 mm craniocaudal x 11 mm transverse ovoid lesion which is slightly hyperintense to CSF on sagittal T1 FLAIR, isointense to gray matter on coronal FLAIR, and isointense to CSF on T2 images. There is a small septation anteriorly within the lesion. It is well circumscribed. There is no appreciable mass effect on adjacent structures.

The ventricles and extra-axial spaces are within normal limits in size and shape. There is no mass lesion or evidence of intracranial hemorrhage, and parenchymal signal and morphology are normal. There are normal flow voids in the intracranial vessels.

**MRA of the carotid arteries and circle of Willis show normal anatomy without pathologic alteration.**

**IMPRESSION:**

1. Complex fluid containing pituitary cyst.
2. Otherwise normal MRI of the brain.
3. Normal MRA of the circle of Willis and carotid arteries.

**Interpreted By:** DAVID NIELSEN, M.D.

Please go to http://medtracer.ohmc.org to view or modify your tracing case.
Please review and edit your selections for this patient, then click to "Submit".

Row Color Indicates: Requested Today Requested Today and Requested Previously

<table>
<thead>
<tr>
<th>Remove</th>
<th>Report Type</th>
<th>Start Tracking</th>
<th>End Date</th>
<th>Notify via</th>
<th>Recent Results</th>
<th>Notify If Not Done</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>CT NEURO</td>
<td></td>
<td>4/15/2008</td>
<td>email, page</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Submit

Send Feedback to the MedTracer Development Team

Please follow CCHMC HIPAA Policies regarding the use and disclosure of protected health information.
©2005, Cincinnati Children's Hospital Medical Center
EXAMINATION(CT) - CT HEAD W/O CONTRAST
IMPRESSION: No local infiltrates.
EXAMINATION(CT) - CT HEAD W/O CONTRAST
IMPRESSION: Postoperative changes consistent with right subdural hematoma evacuation. There is a persistent, small collection, but decreased mass-effect and midline shift.

EXAMINATION(MRI) - MRI BRAIN W/O-W/CONTRAST
IMPRESSION:
1. Large right subdural hematoma, compressing the right lateral ventricle. The temporal horn of the right lateral ventricle is slightly enlarged compared to the left. There is about 7 mm of midline shift.
2. Increased FLAIR signal in the sulci adjacent to the superior aspect of the right subdural hematoma most likely represents a small amount of subarachnoid hemorrhage.
3. Small left convexity subdural hematomas in the parietal and frontal region. These are not causing mass-effect.
4. There is dural enhancement along the bilateral subdural hematomas, but not elsewhere. This is not unusual in the setting of subdural hematoma, and dural lymphoma is considered less likely.
5. The right transverse sinus appears to be hypoplastic, but there is no evidence of thrombosis on the conventional and contrast-enhanced sequences.
6. No obvious vascular malformation or aneurysm is seen by conventional sequences or MRA.

EXAMINATION(MRI) - MRI BRAIN W/O-W/CONTRAST
IMPRESSION:
1. Large right subdural hematoma, compressing the right lateral ventricle. The temporal horn of the right lateral ventricle is slightly enlarged compared to the left. There is about 7 mm of midline shift.
2. Increased FLAIR signal in the sulci adjacent to the superior aspect of the right subdural hematoma most likely represents a small amount of subarachnoid hemorrhage.
3. Small left convexity subdural hematomas in the parietal and frontal region. These are not causing mass-effect.
4. There is dural enhancement along the bilateral subdural hematomas, but not elsewhere. This is not unusual in the setting of subdural hematoma, and dural lymphoma is considered less likely.
5. The right transverse sinus appears to be hypoplastic, but there is no evidence of thrombosis on the conventional and contrast-enhanced sequences.
6. No obvious vascular malformation or aneurysm is seen by conventional sequences or MRA.

EXAMINATION(CT) - CT HEAD W/O CONTRAST
IMPRESSION: Interval development of subdural extra-axial collection of mixed attenuation with associated findings as above. Incidental sinus finding. Discussed with Dr. Chequette of the ED on 10 October at approximately 8:15 p.m.

EXAMINATION(NM) - PET CT SKULL TO MID-THIGH
IMPRESSION:
1. Isodense subdural hematoma along the right lateral convexity measuring 1.8 cm in width with associated mass-effect on the adjacent brain and mild midline shift. Correlation with dedicated brain imaging is recommended. This finding was discussed with Dr. Weiss at 9:30 pm on 10/10/07.
2. Interval decrease in size of the mediastinal mass with interval increase in metabolic activity.
3. A small focus of increased uptake within the inferior parietal lobe, corresponding to a suspected low density lesion on the CT. This finding is new from the previous examination. Etiology is uncertain.

COMMENT: On the nondiagnostic localization CT images:
1. An isodense subdural collection is seen along the right lateral convexity measuring 1.8 cm in maximum axial width. Associated mass-effect is noted on the adjacent brain with moderate associated midline shift at the level of the lateral ventricles.
2. An anterior mediastinal mass is seen, measuring approximately 4.7 x 3.2 cm.
3. A left subclavian line is seen with its tip at cavoatrial junction.
4. A 5 mm nodule is seen within the right lower lobe along the diaphragm (image 97). No associated uptake is seen on the PET scan.
Patient is status post right frontal craniotomy. Some air attenuation is identified within the extra-axial space due to the craniotomy site and along the superficial aspects of the craniotomy site. The amount of intracranial air has slightly diminished.

Soft tissue swelling is seen external to the craniotomy site, similar to the prior study. The patient is status post evacuation of the right-sided subdural collection. Persistent collection remains, mixed attenuation, measuring approximately 1.5 x 10 mm in greatest dimension. The collection appears slightly larger than on the prior study (low density component). There is right-to-left midline shift, measuring 5 mm slightly more prominent than on the prior study. Ventricles are stable. Persistent effacement of right convexity sulci is noted.

Impression:
Status post right ward subdural collection evacuation. Some residual remaining as described. Slight increase in midline shift of the low density component is present with slight increase in right-to-left midline shift.

Other findings as detailed.

**Approved by LETCH, JAMES M.D.
The attending radiologist has reviewed the images and agrees with this report.

**PROCEDURE COMMENTS: Routine noncontrast head CT.

FINDINGS: There has been evacuation of the complex subdural hematoma that extended adjacent to the right cerebral hemisphere. There is a persistent, small, mixed attenuation collection consistent with postoperative changes, as well as some residual. However, there is decreased mass...
Development Status

• Prototype has run at CCHMC since December 2005
• 60 users
• 5300 subscriptions watching 8000 results per day
• 23,000 results successfully conveyed

• Actively seeking beta sites
Document Management Tool:

Doc Management™
### Radiology IV Record

**Date:**

<table>
<thead>
<tr>
<th>VASCULAR ACCESS</th>
<th>2</th>
<th>4</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TIME/IN</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DILATION</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CATHETER</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>LOCATED</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SECURED</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PT RESPONSE</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>INSERTED BY</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>COMMENT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>VASCULAR ACCESS DISCONTINUED</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TIME/IN</strong></td>
<td></td>
</tr>
<tr>
<td><strong>LOCATED</strong></td>
<td></td>
</tr>
<tr>
<td><strong>SECURED</strong></td>
<td></td>
</tr>
<tr>
<td><strong>PT RESPONSE</strong></td>
<td></td>
</tr>
<tr>
<td><strong>COMMENT</strong></td>
<td></td>
</tr>
</tbody>
</table>

**SITE APPEARANCE:**

<table>
<thead>
<tr>
<th>TIME/IN</th>
<th>RAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.8.9</td>
<td></td>
</tr>
</tbody>
</table>

**LOCATION:**

<table>
<thead>
<tr>
<th>TIME/IN</th>
<th>RAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>758/100</td>
<td></td>
</tr>
</tbody>
</table>

**INFILTRATION SCALE:**

<table>
<thead>
<tr>
<th>GRADE</th>
<th>CLINICAL CRITERIA &lt; 4 KG</th>
<th>CLINICAL CRITERIA &gt; 4 KG</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No symptoms</td>
<td>No symptoms</td>
</tr>
<tr>
<td>1</td>
<td>Skin Blanched</td>
<td>Skin Blanched</td>
</tr>
<tr>
<td></td>
<td>Edema &lt; 1 cm in any direction</td>
<td>Edema &lt; 2.5 cm in any direction</td>
</tr>
<tr>
<td></td>
<td>Cool to touch</td>
<td>Cool to touch</td>
</tr>
<tr>
<td></td>
<td>With or without pain</td>
<td>With or without pain</td>
</tr>
<tr>
<td>2</td>
<td>Skin Blanched, transmuted</td>
<td>Skin Blanched, transmuted</td>
</tr>
<tr>
<td></td>
<td>Edema &gt; 4 cm in any direction</td>
<td>Edema &gt; 5 cm in any direction</td>
</tr>
<tr>
<td></td>
<td>Cool to touch</td>
<td>Cool to touch</td>
</tr>
<tr>
<td></td>
<td>With or without pain</td>
<td>With or without pain</td>
</tr>
<tr>
<td>3</td>
<td>Skin Blanched, transmuted</td>
<td>Skin Blanched, transmuted</td>
</tr>
<tr>
<td></td>
<td>Edema &gt; 10 cm in any direction</td>
<td>Edema &gt; 15 cm in any direction</td>
</tr>
<tr>
<td></td>
<td>Cool to touch</td>
<td>Cool to touch</td>
</tr>
<tr>
<td></td>
<td>Mild – moderate pain</td>
<td>Mild – moderate pain</td>
</tr>
<tr>
<td>4</td>
<td>Skin Blanched, transmuted</td>
<td>Skin Blanched, transmuted</td>
</tr>
<tr>
<td></td>
<td>Skin tight, leaking or with blistering</td>
<td>Skin tight, leaking or with blistering</td>
</tr>
<tr>
<td></td>
<td>Skin discolor, bruised, swollen</td>
<td>Skin discolor, bruised, swollen</td>
</tr>
<tr>
<td></td>
<td>Gross edema &gt; 2 cm in any direction</td>
<td>Gross edema &gt; 5 cm in any direction</td>
</tr>
<tr>
<td></td>
<td>Deep pinching tissue extema</td>
<td>Deep pinching tissue extema</td>
</tr>
<tr>
<td></td>
<td>Circulatory impairment</td>
<td>Circulatory impairment</td>
</tr>
<tr>
<td></td>
<td>Moderate – severe pain</td>
<td>Moderate – severe pain</td>
</tr>
<tr>
<td></td>
<td>Infiltration of any blood product, instient, venipuncture</td>
<td>Infiltration of any blood product, instient, venipuncture</td>
</tr>
</tbody>
</table>

**PHLEBITIS SCALE:**

<table>
<thead>
<tr>
<th>GRADE</th>
<th>CLINICAL CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No symptoms</td>
</tr>
<tr>
<td>1</td>
<td>Pain at access site with or without pain</td>
</tr>
<tr>
<td>2</td>
<td>Pain at access site with swelling and/or edema</td>
</tr>
<tr>
<td>3</td>
<td>Pain at access site with swelling and/or edema</td>
</tr>
<tr>
<td></td>
<td>Swelling occurs</td>
</tr>
<tr>
<td>4</td>
<td>Pain at access site with swelling and/or edema</td>
</tr>
<tr>
<td></td>
<td>Swelling occurs</td>
</tr>
<tr>
<td></td>
<td>2.5 cm in length</td>
</tr>
<tr>
<td></td>
<td>Persistent drainage</td>
</tr>
</tbody>
</table>

**INITIALS & SIGNATURE/DIRECTIVES:**

<table>
<thead>
<tr>
<th>DP</th>
<th>DIA</th>
<th>KTR (C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>I</td>
<td>E</td>
</tr>
</tbody>
</table>

**LOCATION:**

- R1 = Right hand
- LH = Left hand
- WS = Wrist
- LT = Left wrist
- RFA = Right forearm
- LFA = Left forearm
- RAC = Right antecubital
- LAC = Left antecubital
- RA = Right ankle
- LA = Left ankle

**DRESSING:**

- R = Sterile
- H = Handled
- U = Unsterile

**PATIENT RESPONSE:**

- 0 = Calm
- 1 = Cooperative
- 2 = Separating appropriately
- 3 = Consulting
- 4 = Not answerable
- 5 = Uncooperative
- 6 = Cooperative and answerable
- 7 = Unanswerable
- 8 = Frustration
- 10 = Uncooperative

**KEY:**

- e = Ejection IV
- P = Palpate
- S = Suction
- D = Discharge from CCU

**REASON FOR REMOVAL:**

- Discharge from CCU
- Site changes
- See progress notes

**SECURED:**

- R = Right
- L = Left
- RA = Right arm
- LA = Left arm

**Dressing:**

- S = Surgical
- H = Handled
- U = Unsterile

**ORDER:**

<table>
<thead>
<tr>
<th>TIME/IN</th>
<th>RAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>758/100</td>
<td></td>
</tr>
</tbody>
</table>

**LOC:**

- CCU = Central line
- CVC = Central venous catheters
<table>
<thead>
<tr>
<th>Select</th>
<th>Date</th>
<th>Time</th>
<th>Exam ID</th>
<th>MRN#</th>
<th>Patient</th>
<th>DOB</th>
<th>Procedure</th>
<th>Modality</th>
<th>Orders</th>
<th>View By</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5/5/2007</td>
<td>08:20</td>
<td>200005</td>
<td>20000002</td>
<td>Moberg, Bruce A</td>
<td>1/31/1999</td>
<td>CT HEAD W/CONTRAST</td>
<td>CT</td>
<td>0</td>
<td>Active</td>
</tr>
<tr>
<td></td>
<td>5/5/2007</td>
<td>08:00</td>
<td>100001</td>
<td>10000001</td>
<td>Householder, Monica J</td>
<td>12/31/2003</td>
<td>CT HEAD W/CONTRAST (L)</td>
<td>CT</td>
<td>3</td>
<td>Active</td>
</tr>
<tr>
<td></td>
<td>5/5/2007</td>
<td>08:15</td>
<td>200012</td>
<td>20000002</td>
<td>Moberg, Bruce A</td>
<td>1/31/1999</td>
<td>CT HEAD W/CONTRAST</td>
<td>CT</td>
<td>0</td>
<td>Active</td>
</tr>
<tr>
<td></td>
<td>5/5/2007</td>
<td>08:30</td>
<td>200002</td>
<td>20000002</td>
<td>Moberg, Bruce A</td>
<td>1/31/1999</td>
<td>MR HEAD W/CONTRAST (L)</td>
<td>MR</td>
<td>2</td>
<td>Active</td>
</tr>
<tr>
<td></td>
<td>5/5/2007</td>
<td>09:00</td>
<td>300003</td>
<td>30000003</td>
<td>Snyder, Mary</td>
<td>2/1/2000</td>
<td>CT C-SPINE (L)</td>
<td>CT</td>
<td>0</td>
<td>Active</td>
</tr>
<tr>
<td></td>
<td>5/5/2007</td>
<td>09:15</td>
<td>300013</td>
<td>30000003</td>
<td>Snyder, Mary</td>
<td>2/1/2000</td>
<td>MR HEAD W/CONTRAST</td>
<td>MR</td>
<td>0</td>
<td>Active</td>
</tr>
<tr>
<td></td>
<td>5/5/2007</td>
<td>09:30</td>
<td>400004</td>
<td>40000004</td>
<td>Brown, Michele D</td>
<td>9/6/2001</td>
<td>CT HEAD W/CONTRAST (L)</td>
<td>CT</td>
<td>0</td>
<td>Active</td>
</tr>
<tr>
<td></td>
<td>5/5/2007</td>
<td>10:00</td>
<td>500005</td>
<td>50000005</td>
<td>Williams, William T</td>
<td>8/22/2002</td>
<td>MR HEAD W/CONTRAST (L)</td>
<td>MR</td>
<td>0</td>
<td>Active</td>
</tr>
<tr>
<td></td>
<td>5/5/2007</td>
<td>11:00</td>
<td>600006</td>
<td>60000006</td>
<td>Scott, Jason B</td>
<td>3/30/2005</td>
<td>MR HEAD W/CONTRAST</td>
<td>MR</td>
<td>0</td>
<td>Active</td>
</tr>
<tr>
<td></td>
<td>5/5/2007</td>
<td>11:15</td>
<td>700007</td>
<td>70000007</td>
<td>Martin, Sally</td>
<td>5/3/2002</td>
<td>CT HEAD W/CONTRAST (L)</td>
<td>CT</td>
<td>0</td>
<td>Active</td>
</tr>
<tr>
<td></td>
<td>5/5/2007</td>
<td>11:45</td>
<td>800008</td>
<td>80000008</td>
<td>Johnson, Crystal A</td>
<td>7/10/2005</td>
<td>CT HEAD W/CONTRAST</td>
<td>CT</td>
<td>0</td>
<td>Active</td>
</tr>
<tr>
<td></td>
<td>5/5/2007</td>
<td>12:00</td>
<td>900009</td>
<td>90000009</td>
<td>Riley, Steven F</td>
<td>8/14/2006</td>
<td>CT C-SPINE (L)</td>
<td>CT</td>
<td>2</td>
<td>Active</td>
</tr>
</tbody>
</table>
Householder, Monica J  F  12/31/2003  10000001
5/5/2007  100001  CT HEAD W/CONTRAST (L)

- **Patient Information**

- **Document Dashboard**

<table>
<thead>
<tr>
<th>Select</th>
<th>Document</th>
<th>Procedure</th>
<th>Distribution</th>
<th>Status</th>
<th>Printed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Flushing Lines Order</td>
<td>CT HEAD W/CONTRAST (L)</td>
<td>Hasted, Mark</td>
<td>Created</td>
<td></td>
</tr>
<tr>
<td></td>
<td>M Record</td>
<td>CT HEAD W/CONTRAST (L)</td>
<td>Abhp, Chris</td>
<td>Approved</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Contract Media Order</td>
<td>CT HEAD W/CONTRAST (L)</td>
<td>Hasted, Mark</td>
<td>Approved</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Contract Media Order</td>
<td>CT HEAD W/CONTRAST (L)</td>
<td>Hasted, Mark</td>
<td>Approved</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Contract Media Order</td>
<td>CT HEAD W/CONTRAST (L)</td>
<td>Hasted, Mark</td>
<td>Received Order</td>
<td>2110</td>
</tr>
</tbody>
</table>

Contract Media Order has been sent for approval.
**Patient Information**

**Document Dashboard**

<table>
<thead>
<tr>
<th>Select</th>
<th>Document</th>
<th>Procedure</th>
<th>Distribution</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Flushing Lines Order</td>
<td>CT HEAD W/CONTRAST (L)</td>
<td>Haight, Mark</td>
<td>Created</td>
</tr>
<tr>
<td></td>
<td>M Record</td>
<td>CT HEAD W/CONTRAST (L)</td>
<td>Abip, Chris</td>
<td>Approved</td>
</tr>
<tr>
<td></td>
<td>Contrast Media Order</td>
<td>CT HEAD W/CONTRAST (L)</td>
<td>Haight, Mark</td>
<td>Approved</td>
</tr>
<tr>
<td></td>
<td>Contrast Media Order</td>
<td>CT HEAD W/CONTRAST (L)</td>
<td>Haight, Mark</td>
<td>Approved</td>
</tr>
<tr>
<td></td>
<td>Contrast Media Order</td>
<td>CT HEAD W/CONTRAST (L)</td>
<td>Haight, Mark</td>
<td>Approved</td>
</tr>
<tr>
<td></td>
<td>Contrast Media Order</td>
<td>CT HEAD W/CONTRAST (L)</td>
<td>Haight, Mark</td>
<td>Received Order</td>
</tr>
</tbody>
</table>
### Document Management

**Welcome, Mark Halsted**

#### Search Results

This lab result was successfully added:

**Householder, Monica J**  
SSN: 000000001  
DOB: 12/31/2003  
CT HEAD VAR/CONTRA (L)

#### Contract Media Orders

<table>
<thead>
<tr>
<th>Exam Time</th>
<th>Lab Result</th>
<th>Lab Date</th>
<th>Requested</th>
<th>Result</th>
<th>Result Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>05/21/2007</td>
<td>Creatinine</td>
<td>0.9</td>
<td>[ ]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>05/21/2007</td>
<td>BUN</td>
<td>3.0</td>
<td>[ ]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Injection Rate:**
- **Rate:** 24 Gauge
- **Volume:** Unknown Rate
- **Site:** Left Hand

#### CT1 with Contrast

**Standard Dose**
- **Body:** ml Body
- **Neuro:** ml Neuro
- **TTL mL Optiway 320**

**Split Bake Dose**
- **Body:** ml Body
- **Neuro:** ml Neuro
- **TTL mL Optiway 320**

**Angle Dose**
- **Body:** ml Body
- **Neuro:** ml Neuro
- **TTL mL Optiway 320**

**Ventriculogram Dose**
- **Body:** ml Body
- **Neuro:** ml Neuro
- **TTL mL Optiway 320**

#### CT2 with Contrast

**Standard Dose**
- **Body:** ml Body
- **Neuro:** ml Neuro
- **TTL mL Optiway 320**

**Split Bake Dose**
- **Body:** ml Body
- **Neuro:** ml Neuro
- **TTL mL Optiway 320**

**Angle Dose**
- **Body:** ml Body
- **Neuro:** ml Neuro
- **TTL mL Optiway 320**

**Ventriculogram Dose**
- **Body:** ml Body
- **Neuro:** ml Neuro
- **TTL mL Optiway 320**

**Enter Additional Instructions**

### Patient Information

**Document Dashboard**

- **Select Document**
  - Planning Lines Order
  - IV Reward
  - Contract Media Order

- **Select Radiology Order**
  - Selected Radiologist
  - page MD

- **Distribution**
  - Printed, Marked

- **Status**
  - Approved, Completed

- **Printed**
  - 18:13

### Technology

- **App: Ohio**
- **Patient:** Mark Halsted
- **Order:** CT HEAD VAR/CONTRA (L)

### Document Management

- **Select Document**
  - Planning Lines Order
  - IV Reward
  - Contract Media Order

- **Select Radiology Order**
  - Selected Radiologist
  - page MD

- **Distribution**
  - Printed, Marked

- **Status**
  - Approved, Completed

- **Printed**
  - 18:13

### Patient Information

- **Document Dashboard**
  - **Select Document**
    - Planning Lines Order
    - IV Reward
    - Contract Media Order
  - **Select Radiology Order**
    - Selected Radiologist
    - page MD
  - **Distribution**
    - Printed, Marked
  - **Status**
    - Approved, Completed
  - **Printed**
    - 18:13
Contract Media Order has been sent for approval.

Householder, Monica J F 12/31/2003 10000001
5/5/2007 1000001 CT HEAD w/CONTRAST (L)
Householder, Monica J   F   12/31/2003   10000001
05/05/2007   100001   CT HEAD w/CONTRAST (L)

Weight: 50.0kg
Height: 33.1cm
Allergy: No Drug/Contrast Allergy
No Food Allergy
No Product/Latex Allergy

Tech/RN: Chris Alsip, RT

BUIN: 08/21/2007 Lab result not available
Creatinine: 08/21/2007 0.9
Comments:

Order: CT with Contrast
Split Bolus Dose: 125.0 mL Optiray® 320 to be administered IV during CT scan.
(Standard Optiray dose is 2 mL/kg for CT)

<table>
<thead>
<tr>
<th>Gauge</th>
<th>Injection Rate</th>
<th>Injection Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 Gauge</td>
<td>Unknown Rate</td>
<td>Right Antecubital</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Body Optiray</th>
<th>Body Saline</th>
<th>Neuro Optiray</th>
<th>Neuro Saline</th>
</tr>
</thead>
<tbody>
<tr>
<td>83.8 mL</td>
<td>0.0 mL</td>
<td>41.3 mL</td>
<td>0.0 mL</td>
</tr>
</tbody>
</table>

Electronic Signature Code: ●●●● [Approve] [Deny]
Contrast Media Order has been sent for approval.

Householder, Monica J   F   12/31/2003   10000001
5/6/2007   100001   CT HEAD W/CONTRAST (L)

### Patient Information

### Document Dashboard

<table>
<thead>
<tr>
<th>Select</th>
<th>Document</th>
<th>Procedure</th>
<th>Distribution</th>
<th>Status</th>
<th>Printed</th>
</tr>
</thead>
<tbody>
<tr>
<td>✅</td>
<td>Contrast Media</td>
<td>CT HEAD W/CONTRAST (L)</td>
<td>Halsted, Mark</td>
<td>Approved</td>
<td>Yes</td>
</tr>
<tr>
<td>✅</td>
<td>Flushing Lines</td>
<td>CT HEAD W/CONTRAST (L)</td>
<td>Halsted, Mark</td>
<td>Created</td>
<td>No</td>
</tr>
<tr>
<td>✅</td>
<td>IV Record</td>
<td>CT HEAD W/CONTRAST (L)</td>
<td>Alsip, Chris</td>
<td>Approved</td>
<td>Yes</td>
</tr>
<tr>
<td>✅</td>
<td>Contrast Media</td>
<td>CT HEAD W/CONTRAST (L)</td>
<td>Halsted, Mark</td>
<td>Received Order</td>
<td>1959</td>
</tr>
</tbody>
</table>
PHYSICIAN'S ORDER FORM

Radiology (CT/MR/Radiography) Contrast Media Orders

_______ mL Optiray® 320 __ 160 __ to be administered IV prior to __ Intravenous Pyelogram __ C-line check
   (Standard Optiray dose is 3 mL/kg for IVP, no standard dose for C-line check)

100 ___ mL Optiray® 320 X 160 __ to be administered IV during CT scan
   (Standard Optiray dose is 2 mL/kg for CT)

_______ mL Omnipaque® 180 to be administered intravenously for CT Venography
   (Standard dose is 1.5 mL)

_______ mL Magnevist® to be administered IV during MR scan
   (Standard Magnevist dose is 0.2 mL/kg for MR)

Additional Instructions:
05/05/2007 Continue 0.1
05/05/2007 BUN 3

Cadence: 612.0x792.0
Doc Management Status:

• Launched July 2007
  – MRI, CT
  – Replaces forms for IV Contrast, IV Flush, IV site, GA check, Sedation, etc.

• Outcomes studies underway
  – Subjective improvement in Efficiency, Patient Safety, and Joint Commission Compliance

• Actively seeking beta sites
We’re Solving Radiology Workflow Problems at CCHMC:

- Interruptions
- Conveying Wet Reads and Critical Results
- Documenting Conveyances
- Follow-up Interesting Cases
- Ensuring Follow-up of Critical Cases
- Signing Contrast and other Orders
- Communications