An Open Source Web-based Application for Radiology Decision Support

William W Boonn MD and Curtis P Langlotz MD PhD

Department of Radiology
Hospital of the University of Pennsylvania
Philadelphia, PA
Disclosures

- Founder and President of MedicalPocketPC.com Inc.
- Principle and Co-founder of iVirtuoso Inc.
Clinical History

Reason for Exam: pain

Standard Reports:
Clinical History

Diagnosis: ENTERO QUTANIOUS FISCUA
History: Aortic Aneurysm, Thoracic Details: aortic thromb
Project Design

- Initial Survey – Clinical information needs of Radiologists
- Application Design and Testing
- Data collection – usage data, observer data
- Post-survey
Survey Methods

• Web based survey
• 139 total respondents
• Most from 6 academic medical centers
Career Stage

- Resident
- Fellow
- Attending
Practice type

- Academic: 130
- Private Practice: 10
- Multi-Specialty Group Practice: 1
- Government: 1
- Other (please specify): 1
When interpreting a radiology exam how often do you believe that you need more information than you have been given about a patient’s clinical history?
How important is this missing clinical information to your final interpretation?

Important (I would be willing to modify or change my radiological diagnosis based on additional clinical information)

Not important (I am confident in my radiological diagnosis and findings and am willing to leave the clinical correlation of my findings to the clinicians)

Other (please specify)
If you don’t currently have access to this information, how important is it that you have it in the future?

- I would likely use this clinical information system in my practice if it was readily available
- I wouldn’t use this additional information in my practice
- Other (please specify)
If you are not using additional clinical information systems to assist in your diagnosis what are your reasons?

- It takes too much time to look up additional clinical information: 50
- My institution/practice does not have this capability: 10
- I would rather make my diagnosis based on the radiological findings and leave the clinical correlation up to the clinician: 20
- Other (please specify): 30
Radiology Centric Web Portal

- Provide pertinent clinical information to the radiologist at time of image interpretation
- Optimized workflow with minimal interaction (login, patient search, etc)
- At-a-glance design interface
Open Source

- **Goal**: to provide an open source framework for intelligence and user interface
- **Limitations**: cannot be completely “plug-and-play” because each institution has their own set of clinical systems to query
- **Current status**: development is currently tightly integrated with clinical systems at HUP. When the application is fully functional we plan to create the open source framework based on the final project
Clinical Data

- Demographics
- Radiology relevant lab results
- Pathology reports
- Clinical history and documents
- Clinician contact information
# Radiology Labs

<table>
<thead>
<tr>
<th>Relevant</th>
<th>Not Relevant</th>
</tr>
</thead>
<tbody>
<tr>
<td>WBC</td>
<td>Chloride</td>
</tr>
<tr>
<td>Creatinine</td>
<td>Magnesium</td>
</tr>
<tr>
<td>Hemoglobin</td>
<td>MCV</td>
</tr>
<tr>
<td>INR</td>
<td>Serum Bicarbonate</td>
</tr>
</tbody>
</table>

…and many more
Clinical History and Documents

• Typical given histories:
  – “Pain”
  – “Eval”
  – “Colon CA”

• Available electronic clinical history sources
  – Discharge Summaries
  – Operative Notes
  – ER Charts
  – Intern sign out sheets
Proposed Architecture

- Modalities
- Lab / Path
- Emtrac
- HIS
- Discharge / Op Reports
- Other Clinical Systems
- RIS
- Clinical Web Portal
- Radiology Web Portal Server
- Radiology Web Portal Interface
- PACS
- Other Clinical Systems
Current Design

• Phase I
  – Launch using accession numbers
  – No prefetch or RIS integration

• Phase II
  – Enable prefetch to improve performance

• Phase III
  – Integration with RIS for optimized workflow
63 year female status post left ureteral stent placement and pyelonephritis with increasing creatinine.

Complete ultrasound examination of the retroperitoneum was performed. There are no prior scans available for comparison. The right kidney measures 6.0 x 5.7 x 11.8 cm. The right kidney shows mild cortical thinning with pelvic lipomatosis. There is no hydronephrosis.

The left kidney measures 7.5 x 5.5 x 13.6 cm. There is marked hydronephrogrphosis with a left ureteral stent visualized. The findings indicate that are less than adequate decompression of the dilated collecting system possibly due to stent obstruction or malfunction. There is no evidence of renal cysts, stones, contour deformation, masses. The bladder is collapsed. There is a stent visualized into the bladder as well.

Dr. Thiel was aware of the above findings on September 12, 2006 via subinterm Michael Zirpko.

Impression:
Marked hydronephrogrphosis of the left kidney with a left-sided ureteral stent, findings suggestive of stent malfunction.

Exam Type: ultra retroperitoneal complete
Exam Date: 9/12/2006
Exam Authors: C, C. C.

History:
63 yo female s/p partial colon resection with ileostomy 3/06 for 2/2 colon cancer and s/p ureteral stent for stricture placed on 3/06 and replaced on 4/06 who presents with 10 days of urgency, frequency, and dysuria for 10 days. Pt also with fevers, chills, night sweats and rigors. Treated with levofloxacin but lcr came back growing MRSA with sensitivities to gent/m/p/zos/n/rim/trim/tetr/sul/bac/mon/vanco.

9/13 ul/og placed temporary stent, plan for permanent stent on 9/18

Op Notes and Transcripts

ED Visits
No ED Visits were found for this patient.
**HPI (from Signout Sheet)**

Last Edit Date: 4/20/2007  
Last Edit Author: [View Patient Signout Sheets]

88 female h/o colon ca s/p hemicolecotony remote and 4/06 subtotal colectomy with tah/bso, now SFU last dosed 4/4/07 (3rd dose) p/t chemo yesterday (held) for dehydration then called to ED for K+ 2.2 after week n/v/watery diarrhea, no blood, recieved 120 total K+ overnight with 3L NS total. ekg with U waves. K+ 3.0 on 4/4/07  

within past year, nl tsh and cortisol

**Op Notes and Transcripts**

<table>
<thead>
<tr>
<th>Date</th>
<th>Document Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>ChartOne</td>
<td>12/18/2006</td>
</tr>
<tr>
<td>ChartOne</td>
<td>Discharge Summary</td>
</tr>
<tr>
<td>ChartOne</td>
<td>12/18/2006</td>
</tr>
<tr>
<td>ChartOne</td>
<td>Discharge Summary</td>
</tr>
<tr>
<td>ChartOne</td>
<td>6/12/2006</td>
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<tr>
<td>ChartOne</td>
<td>Dsch Summary</td>
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<tr>
<td>ChartOne</td>
<td>5/9/2006</td>
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<tr>
<td>ChartOne</td>
<td>Dsch Summary</td>
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<tr>
<td>PDF</td>
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<td>ChartOne</td>
<td>EMG Report</td>
</tr>
<tr>
<td>ChartOne</td>
<td>4/21/2006</td>
</tr>
<tr>
<td>ChartOne</td>
<td>Dsch Summary</td>
</tr>
<tr>
<td>ChartOne</td>
<td>4/17/2006</td>
</tr>
<tr>
<td>ChartOne</td>
<td>Operative Report</td>
</tr>
<tr>
<td>ChartOne</td>
<td>4/15/2006</td>
</tr>
<tr>
<td>ChartOne</td>
<td>Operative Report</td>
</tr>
<tr>
<td>ChartOne</td>
<td>12/7/2004</td>
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<tr>
<td>ChartOne</td>
<td>Dsch Summary</td>
</tr>
<tr>
<td>ChartOne</td>
<td>10/24/2003</td>
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<tr>
<td>ChartOne</td>
<td>Dsch Summary</td>
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**ED Visits**

<table>
<thead>
<tr>
<th>Service Date</th>
<th>Description of Service</th>
</tr>
</thead>
</table>
Reason for Exam: ABD ASSESSMENT PAIN

Radiological Report:

HPI (from Signout Sheet)

Last Edit Date: 4/20/2007
Last Edit Author: LLEWELLYN K, R.N., A.A.
[View Patient Signout Sheets]

88 female h/o colon ca s/p hemicolecetomy remote and 4/06 subtotal colectomy with tah/bso, now 5FU last dosed 4/4/07 (3rd dose) p/t chemo yesterday (held) for dehydration then called to ED for K+ 2.2 after week n/v/watery diarrhea, no blood, received 120 total K+ overnight with 3L NS total. ekg with U waves. K+ 3.0 on 4/4/07

within past year, nl tsh and cortisol
### Labs

<table>
<thead>
<tr>
<th>Test</th>
<th>Most Recent</th>
<th>Prior 1</th>
<th>Prior 2</th>
<th>Other Prior</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRE</td>
<td>0.8</td>
<td>0.9</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>HGB</td>
<td>8.61</td>
<td>9.21</td>
<td>9.71</td>
<td></td>
</tr>
<tr>
<td>WBC</td>
<td>17.0 H</td>
<td>16.1 H</td>
<td>11.9</td>
<td></td>
</tr>
<tr>
<td>PT</td>
<td></td>
<td></td>
<td></td>
<td>11.4</td>
</tr>
<tr>
<td>INR</td>
<td></td>
<td></td>
<td></td>
<td>1.0</td>
</tr>
</tbody>
</table>

### HPI (from Signout Sheet)

No Signout Sheets were found for this patient.

### Op Notes and Transcripts

<table>
<thead>
<tr>
<th>Date</th>
<th>Document Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/17/2007</td>
<td>Operative Report</td>
</tr>
</tbody>
</table>

### ED Visits

No ED Visits were found for this patient.

### SP/Micro Text

Date: 04/20/2007 05:59 AM  
Drawn Date: 04/19/2007 01:09 PM  
Name: WESTON, JAMES (36000) 01/02/2007  
QUANTITATIVE CULTURE-BRONCHIAL Collected: 04/19/07 1309  
Source: BRONCHIAL WASHING Mini  
------------------- GRAM STAIN -------------------  
04/20/2007 0559  
NO BACTERIA SEEN.  
FEW WHITE BLOOD CELLS  
------------------- PRELIMINARY REPORTS -------------------  
04/20/2007 0902  
NO GROWTH

### SP/Micro Results

<table>
<thead>
<tr>
<th>Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>M BQUANT</td>
<td>04/20/2007 05:59 AM</td>
</tr>
<tr>
<td>M UC</td>
<td>04/19/2007 07:40 AM</td>
</tr>
<tr>
<td>M UC</td>
<td>04/17/2007 08:04 AM</td>
</tr>
<tr>
<td><strong>Name:</strong></td>
<td>Demario Amell</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><strong>MRN(s):</strong></td>
<td>HUP 0002245</td>
</tr>
<tr>
<td></td>
<td>PMC 00033245</td>
</tr>
<tr>
<td><strong>DOB:</strong></td>
<td>3/18/</td>
</tr>
<tr>
<td><strong>Sex:</strong></td>
<td>F</td>
</tr>
<tr>
<td><strong>Race:</strong></td>
<td>Black</td>
</tr>
<tr>
<td><strong>Facility:</strong></td>
<td>HUP</td>
</tr>
<tr>
<td><strong>Nurse Station:</strong></td>
<td>RP6</td>
</tr>
<tr>
<td><strong>Tel Extension:</strong></td>
<td>662-3860-2</td>
</tr>
<tr>
<td><strong>Room:</strong></td>
<td>6021B</td>
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<tr>
<td><strong>Primary HS:</strong></td>
<td>(215) 308-3193</td>
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<tr>
<td><strong>Covering HS:</strong></td>
<td>(215) 308-3188</td>
</tr>
</tbody>
</table>
SP/Micro Text
Type: SP FINAL REPORT
Date: 01/04/05
Drawn By: Dr. Smith

SURGICAL PATHOLOGY REPORT
DATE OF SURGERY: 04/05
DATE RECEIVED IN LAB: 04/05

CLINICAL INFORMATION:
69 year old female for TAH/BSO for endometrial carcinoma
PRE-OP DIAGNOSIS: As above
POST-OP DIAGNOSIS: As above
OPERATION: TAH/BSO

SPECIMEN:
1. Uterus, tubes, ovaries, cervix, TSH/BSO:
2. Right external iliac lateral group, biopsy:
3. Right external iliac medial group, biopsy:
4. Right obturator nodes, biopsy:
5. Right periaortic nodules, no tumor seen.
6. Left external iliac nodes, no tumor seen.
7. Left external iliac nodes, no tumor seen.
8. Endocervix, no tumor seen.
9. Right and left ovary and fallopian tube, no tumor seen.

MICROSCOPIC DIAGNOSIS:
A. **Endometrial adenocarcinoma**, with papillary serous features with psammoma bodies, and poorly differentiated, spindle cell and clear cell areas, with lymphatic invasion, invading superficial myometrium (less than 10 percent).
B. Leiomymata.
C. Endometrial polyps.
D. Right and left ovary and fallopian tube, no tumor seen.
E. Endocervix, no tumor seen.

Metastatic adenocarcinoma involving one of five lymph nodes (1/5).
Data

- Data access time
- Usage data
- Observer data
Data Access Time

• Comparison of Radiology Portal to conventional EMR system (MedView)
• Elapsed time for the following:
  – Open browser and login
  – Access the appropriate patient
  – Obtain WBC count
  – Access most recent pathology report
  – Access available patient clinical history
# Data Access Time

<table>
<thead>
<tr>
<th></th>
<th>Medview (EMR)</th>
<th>Radiology Portal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Browser and Login</td>
<td>3.2</td>
<td>2.4</td>
</tr>
<tr>
<td>Access Patient Page</td>
<td>21.7</td>
<td>8.9</td>
</tr>
<tr>
<td>Get WBC count</td>
<td>7.1</td>
<td>0</td>
</tr>
<tr>
<td>Clinical History</td>
<td>18.2</td>
<td>0</td>
</tr>
<tr>
<td>Pathology Results</td>
<td>27.7</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>77.9</strong></td>
<td><strong>11.3</strong></td>
</tr>
</tbody>
</table>
Data Access Time

- **Pathology results**
- **Clinical history**
- **WBC**
- **Patient page**
- **Login**

Time (seconds)

- **Medview**
- **Radiology Portal**
Usage Data

• Queried audit logs of EMR and Portal systems
• Usage data from 10/06 until 5/07
• Radiology Portal officially launched to department 2/07
Usage Data

RadPortal Patients

MedView Patients
Usage Data

Total patients

<table>
<thead>
<tr>
<th>Date</th>
<th>Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/1/2006</td>
<td>4000</td>
</tr>
<tr>
<td>11/1/2006</td>
<td>3500</td>
</tr>
<tr>
<td>12/1/2006</td>
<td>3000</td>
</tr>
<tr>
<td>1/1/2007</td>
<td>4000</td>
</tr>
<tr>
<td>2/1/2007</td>
<td>4500</td>
</tr>
<tr>
<td>3/1/2007</td>
<td>5000</td>
</tr>
<tr>
<td>4/1/2007</td>
<td>4700</td>
</tr>
<tr>
<td>5/1/2007</td>
<td>4500</td>
</tr>
</tbody>
</table>
Observer Data

- 3 clinical services were observed
  - Body CT
  - Chest CT
  - Chest X-ray
- Data collected before and after release of Radiology Portal
- Same personnel were observed in each section for consistency
Observer Data

Clinical Data access using EMR or Radiology Portal

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Before Radiology Portal</th>
<th>After Radiology Portal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body CT</td>
<td>11.9%</td>
<td>22.8%</td>
</tr>
<tr>
<td>Chest CT</td>
<td>3.2%</td>
<td>4.0%</td>
</tr>
<tr>
<td>CXR</td>
<td>2.2%</td>
<td>2.4%</td>
</tr>
</tbody>
</table>
Observer Data

- Time to launch:
  - Before Radiology Portal: 56.6
  - After Radiology Portal: 24.2

- Time spent viewing data:
  - After Radiology Portal: 183
  - After Radiology Portal: 99.5
Works in progress

Prefetch
Data Access Time

- Time (seconds)
- Medview
- Radiology Portal

- pathology results
- clinical history
- WBC
- Patient page
- login
Works in progress

Integration with RIS
Usage Data

Total patients

0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000
Future Directions: Follow-up
Follow-up case

- Low density mass in the left kidney with variable areas of enhancement
- Differential Diagnosis
  - Benign
    - Atypical complicated cyst
    - Multilocular Cystic Nephroma
  - Malignant
    - Cystic Renal Cell Carcinoma
    - Metastasis
    - Lymphoma
- Recommend follow-up with MRI, possible biopsy
How often do you obtain clinical follow up on cases?

- On all questionable or interesting cases: 40
- If it is needed for a compliance report: 10
- When I remember and have time: 60
- Rarely: 10

Total = 110
How do you obtain your clinical follow up?

- I communicate (phone / email / etc) with the referring clinician: 70
- I check follow up images or pathology reports: 100
- N/A: 10
- Other (please specify): 10
How do you obtain your clinical follow up? (Text comments)

“Ask residents/fellows to get follow up”

“The report goes into the void and there is next to no follow up unless an egregious error is made.”
How do you keep track of cases that require follow up?

- Handwritten: 71
- PDA: 17
- Web Database: 2
- Spreadsheet: 7
- Desktop Database: 11
- RIS-based solution: 3
- PACS-based solution: 8
- Other: 9
How do you keep track of cases that require follow up? (Text comments)

“Short-term memory”

“I just remember them”

“Place responsibility on clinician in report”
Follow-up module

- Automated follow-up of tagged or interesting cases based on user-defined Triggers
- User notification
Follow-up Triggers

- **“Next imaging study”**
  - CT abdomen → CT, MR, or US of abdomen
- **“Lab / Path results”**
  - Surgical pathology for biopsy results
    - Microbiology results
- **“Clinical Report”**
  - Operative report
  - Discharge Summary
- **“Time”**
  - Remind me to check up on this patient in 3 days, 2 weeks, or 6 months, etc
Follow-up notification

![Follow-up notification interface](image)
Follow-up Architecture

Triggers:
- Next Imaging Study
- Surgical Pathology

Notification:
- Email
- Portal
Follow-up Architecture

- Modalities
- Lab / Path
- HIS
- Emtrac
- Discharge / Op Reports
- Other Clinical Systems
- Clinical Web Portal
- Radiology Web Portal Server
- Radiology Web Portal Interface
- PACS
- RIS
Follow-up Architecture
Final Diagnosis: Multilocular Cystic Nephroma

MRI

Case courtesy: BrighamRad
Conclusions
Thank you

Stephen Kratowicz – Web Applications Group
Nisha Mehta, MD
Nancy Knight, PhD

SIIM Research and Development Committee
An Open Source Web-based Application for Radiology Decision Support

William W Boonn MD and Curtis P Langlotz MD PhD

Department of Radiology
Hospital of the University of Pennsylvania
Philadelphia, PA