The Clinical Labs and Pathology as a Knowledge Hub: Technical, Political, and Service Considerations

Anand Dighe MD, PhD
Director, Core Laboratory
Assistant Professor, Harvard Medical School
Massachusetts General Hospital
Boston, MA
Information Management Concepts

- The information based society has arrived
- Organizations that will succeed in the global information environment are those that can identify, value, create, evolve, and share their information assets
- Most of what goes on in a hospital is actually decision making driven by information processing
- The critical limiting factor is the individual’s limited ability to process information and make decisions
Clinical Information Systems

A shift has occurred: Goal to create environments supporting decision making

• Prior emphasis
  – Electronic medical record, information retrieval and reporting, scheduling, billing

• New emphasis
  – Cost effectiveness, error prevention, safety and quality (e.g. outcomes matter)
  – Utilization of resources
  – Decision support at the point of care
  – Increased attention to sharing and standardization of knowledge, data warehousing
Recommended Care is Frequently Not Given

- In U.S. overall only 55% of patients get recommended level of care
- VA patients (that have access to decision support tools at point of care, mature EMR) get 67% of recommended care

Table 3. Adjusted Percentage of Recommended Care Received by Participants, According to Characteristic and Type of Care.†

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Acute Care</th>
<th>Chronic Care</th>
<th>Preventive Care</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adjusted Percentage (95% CI)</td>
<td>P Value †</td>
<td>Adjusted Percentage (95% CI)</td>
</tr>
<tr>
<td>Health insurance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>55.3 (50.8–59.8)</td>
<td>0.37</td>
<td>51.5 (45.8–57.1)</td>
</tr>
<tr>
<td>Medicaid</td>
<td>52.4 (47.5–57.3)</td>
<td>0.56</td>
<td>56.4 (52.5–60.7)</td>
</tr>
<tr>
<td>Medicare</td>
<td>53.3 (48.3–58.2)</td>
<td>0.62</td>
<td>59.3 (56.7–61.8)</td>
</tr>
<tr>
<td>Managed care</td>
<td>53.9 (51.6–56.3)</td>
<td>0.37</td>
<td>55.1 (52.6–57.5)</td>
</tr>
<tr>
<td>Private nonmanaged care</td>
<td>52.9 (50.6–55.2)</td>
<td>0.37</td>
<td>54.8 (52.0–57.6)</td>
</tr>
</tbody>
</table>

* The percentages have been adjusted for all variables listed in the table in addition to self-reported health status, number of visits to a health care provider, number of hospitalizations, number of acute and chronic conditions during the study period, and metropolitan statistical area. CI denotes confidence interval.
† P values were calculated after sampling and nonresponse weights had been applied.
‡ This group of participants was used as the comparison group in the multivariate analysis and the reference category for the calculation of P values.

Healthcare Trends

Goals
• Improve efficiency and quality
• Improve (and document) patient outcomes
• Reduce costs

Laboratory Trends
• Improve pre-analytic steps with systems approaches
  – Improve the ordering and utilization of lab tests
  – Auto-identification (RFID/bar codes) of specimens
  – Pre-analytic automation
• Centralize and automate core laboratory testing
• Decentralize high impact critical care testing to critical care areas and operating rooms under the auspices of the central lab
Pathology’s Role in Information Based Healthcare

“60-80% of medical decisions are made using pathology data”

• The future success of Pathology departments in the healthcare information marketplace is not assured.
• In order to prevent becoming marginalized/commoditized in future models of clinical care delivery laboratories must evolve. Laboratories must create systems to develop, archive and share critical laboratory knowledge throughout their institutions.
• We can do a lot more for our institutions than being data generators
• The focus of this talk will be Pathology’s role in what is to come…
Expectations are low…

Arch Pathol Lab Med 129, 1252, 2005
Consumers of Pathology Data

- Order entry systems
- Decision support system
- Interpretive software
- Result viewer applications (CIS)
- Patient personal medical records

None of these groups wants to own the pathology data
Core Competencies for Pathology Informatics

- Test dictionary maintenance
- Test menu development
- Data warehousing (LIS)
- Data exchange (HL7)
- Ordering guidelines
- Patient and specimen identification
- Order entry decision support
- Analysis of complex diagnostic data
- Interpreting complex testing

How to jump in the deep end…
The Hard Part: Navigating Your Organization

- Numerous groups in any healthcare organization are doing “informatics”
- Decision support, order entry systems, results viewing, medication administration, interpretive reporting applications all utilize laboratory data
- Way to succeed is to bring value
- Improve others ability to get the overall job done
- Important to collaborate, not to overreach
Lean Concepts

• Lean means right thing, right place, right time, right quantity.
  – Pathology informatics is the “right person” for many of the key informatics tasks in an organization

• Lean systems focus on maximizing the value stream while eliminating waste.

• Lean is a way of thinking that focuses on constantly shortening the order to delivery time by maximizing the flow of information and material while reducing cycle time.

• A total system of organizational learning:
  1. Never make the same mistake twice
  2. Turn implicit (tribal) knowledge into explicit knowledge.
  3. Do not reinvent the wheel – reuse knowledge.
The Science of Networks

• Most stable and robust real-world networks adopt a particular configuration (a scale free network with multiple hubs)
  – Animal relationships in an ecosystem
  – The Internet
  – Social networks
  – Molecules involved in cellular metabolism

• Goal for hospital information network should be a creating hubs of knowledge that can be shared easily

• Pathology informatics should be a key hub in the organization focusing on systems to
  • Catalog knowledge
  • Maintain knowledge
  • Share knowledge
What are the nodes of the Pathology hub?

In scale-free networks the size of each hub is determined by its inherent value and time of entry.

Information hubs provide:
- Stability of expertise
- Efficiency of delivery
It’s not just about doing the lab test. We should aim to provide an array of information intensive services and become the hub for collection and dissemination a wide variety of lab related knowledge to help improve outcomes.
Process Management: A Clinical Encounter

Patient seeks care → Clinician Working Memory → Tests Ordered/Interpreted

Supplies
What Can We Supply to Our Clinician?

**Long term memory**

*Knowledge | Patient data*

---

**Clinician Working Memory**

---

**External memory**

*Knowledge (files, texts, literature, guidelines, consultants) | Patient data (medical record)*

---

Patient seeks care → Clinician Working Memory → Tests Ordered/Interpreted
Long Term (Clinician) Memory

We can provide:
- Lectures
- Guides
- Utilization audits

Æ A mixed record at best. Improvements in test utilization, when observed, were often transient

From a systems perspective human memory is largely non-modifiable

Clinician memory content is highly variable due to training variations, practice experience

The “knowledge performance gap” – mismatch between what physicians know and how they actually behave in practice
External Memory Options

External memory that we can provide:

- Test information
- Testing guidelines
- Patient information
- Past test results
- Interpretive info

What are the essentials of providing external memory?
Considerations in Providing External Memory

- Retrieval efficiency is essential
- Content should be centralized
- Should not be maintained by individual clinicians due to:
  - Redundancy
  - Variability

How can we provide external memory to improve the lab ordering process?
Order Entry Decision Support

Decision support takes many forms

- Requisition design
- Reflex algorithms
- Computerized Provider Order Entry (CPOE)
- Static ordering guidelines
- Interactive/dynamic algorithms (with knowledge of other labs or symptoms, get “smart” recommendations)
  - Based on low recent albumin level recommend free Dilantin level when clinician orders test
- Advanced search functionality

The heart of pathology based decision support is the individual TEST
Applying Lean Concepts to Decision Support

• Eliminate waste
  – Catalog laboratory test information once

• Maximize the flow of information
  – Make test information available to all consumers of lab test data using collaborative tools (XML/web services)

• Where to catalog laboratory data?
  – The LIS?
Laboratory Information System

- LIS was designed to support laboratory results reporting workflow and analyzer outputs
- The LIS was never designed to support higher level decision support or test interpretation
- However, the LIS does have a subset of the information we need so must play a role in the solution
How to “fix” the LIS: Middleware

- Middleware products specialize in one function or another (voice recognition, template reporting, digital image management, interpretive reporting, result reporting)
- Unlike AP or CP LIS vendors middleware vendors are not selling legacy systems so they can use latest technologies, adapt to real workflow, innovate, and invest in new products
- Increasingly will take over functions of the core LIS products
What do we need?

- Need middleware that enhances LIS capabilities but maintains a connection with LIS
- Need to incorporate the Lean concepts of eliminating waste, maximizing information flow to the various data consumers:
  - Decision support unit
  - Inpatient order entry
  - ED order entry
  - Outpatient order entry
  - Online laboratory handbook
  - Pharmacy decision support
“Pathology Inside”

• “PathConnect” middle layer permits Pathology to maintain control over content, presentation, and maintenance of laboratory tests
• Middle layer interacts with AP and CP LIS systems to always have current dataset
• Allows Pathology data to be easily shared with other applications via a connectivity layer (web services/XML)
PathConnect Middleware

Allows the cataloging of data needed for decision support in a way that it can be shared with other parts of the organization.
Web Services Support Information Flow

- Provides data exchange standardization (XML/web services) to permit information flow
- Not a rigid standard like HL7, but a standardized way to exchange information
Lab Ordering Screen

User Interface Built Entirely from Database

- Provider order entry calls middleware web service to build test dictionaries
- Data behind the interface can be readily updated
• Provider order entry calls middleware web service to build test dictionaries
• Data behind the interface can be readily updated
• Complex decision trees can be represented in database and readily updated
Building Software That Gets Smarter

“I’ve been at MGH for 30 years and I have yet to see a project get to version two.”
– Dick Emrich, MGH LIS Director

• When designing software or systems think a long time about the underlying data model before writing a line of code or buying anything
• A strong vocabulary and data model can make getting to version two unnecessary
  – Having the intelligence of the system driven by the data model allows for rapid improvements in the system performance without software upgrades or overhauling the system
• Monitoring actual use is critical to understanding how to improve the data structure
  – Create open database structure and create monitoring reports for use on Day 1
“Pathology Inside”

• “PathConnect” middle layer permits Pathology to maintain control over content, presentation, and maintenance of laboratory tests
• Middle layer interacts with AP and CP LIS systems to always have current dataset
• Allows Pathology data to be easily shared with other applications via a connectivity layer (web services/XML)
**Essentials of an online laboratory handbook**

- Easily accessible in normal clinician workflow
- MUST be locally updated and maintained and not include generic test information
- Smart searching to allow searching by test name, synonym or disease
- Provides information regarding appropriate test usage and basic interpretive information

**Important Information**

**CLINICAL UPDATE - COAGULATION TESTING**
Prothrombin Time (PT) test changed to more sensitive reagent

<table>
<thead>
<tr>
<th>Contact Information</th>
<th>Phlebotomy Information</th>
<th>Print this Handbook</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical Values</td>
<td>Phlebotomist Competency</td>
<td>Reference Ranges</td>
</tr>
<tr>
<td>Ordering Collection Materials</td>
<td>Pneumatic Tube System Guidelines</td>
<td>Setting Up a Research Study</td>
</tr>
</tbody>
</table>

**Laboratory Policies and Procedures**

- Anatomic Pathology
- Blood Transfusion Service
- Chelsea HealthCare Center
- Chemistry-Main Lab
- Chemistry-Acute Care
- Chemistry-Immunodiagnostics
- Chemistry-Pediatric Microchemistry
- Coagulation
- Cytochemistry (BWH)
- Diabetes
- Diagnostic Molecular Pathology
- ED Laboratory
- Hematology
- Histocompatibility (Tissue Typing/HLA)
- Immunology
- Microbiology

- Neurogenetics
- Neurochemistry-Amino Acid Lab
- Revere HealthCare Center
- Yawkey Oncology Laboratory
- Pathology Service
- Laboratory Medicine
<table>
<thead>
<tr>
<th>Test Name</th>
<th>Lab</th>
<th>Specimen</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cytomegalovirus antibody (IgG)</td>
<td>Microbiology</td>
<td>Blood 10 ml Red</td>
<td>Single serum samples are for immunity status only.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Torch titers are tested as a single sample on children &lt;1 year old.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mother's blood sample should be sent with child's. CMV IgM requests</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>are sent out via Chemistry Lab.</td>
</tr>
<tr>
<td>Cytomegalovirus antibody (IgM)</td>
<td>Chemistry (Sendouts)</td>
<td>5 ml Red</td>
<td></td>
</tr>
<tr>
<td>Cytomegalovirus antigenemia assay</td>
<td>Microbiology (Virology)</td>
<td>Blood 10 ml Lavender</td>
<td>TEST OF CHOICE FOR BLOOD. Send specimen to laboratory at ROOM TEMPERATURE</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>immediately after collection. Specimens are processed Monday - Friday</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>and must be received before 3pm on Friday. The test is not performed on</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>weekends or holidays. Positive results called back to requesting</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>physician.</td>
</tr>
<tr>
<td>Cytomegalovirus culture</td>
<td>Microbiology (Virology)</td>
<td>5 ml urine in sterile</td>
<td>Send to lab ON ICE between 8:30AM to</td>
</tr>
<tr>
<td></td>
<td></td>
<td>container, tissue</td>
<td>11:00PM, Monday - Friday. Specimens received after these hours will be</td>
</tr>
<tr>
<td></td>
<td></td>
<td>in VTM (transport medium),</td>
<td>processed on the next working day. Tested by cell culture. Culture</td>
</tr>
<tr>
<td></td>
<td></td>
<td>sputum trap, swab in VTM.</td>
<td>AVAILABLE only by prior arrangement with laboratory. Positive results</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>called back to requesting physician.</td>
</tr>
</tbody>
</table>
Details

• Differs based on audience.

• More interpretive info for clinicians, more specimen info for PCAs and phlebotomists
Monitoring Usage (Lab Handbook)

- Determine who’s eyes are on the site
- Assess marketing efforts
- Use monitoring data to improve content, navigation, and search algorithms

Summary (MGH Lab Handbook)

[TIP] This stat is based on all traffic recorded to date.

[TIP] Don’t forget about the rest of stats we offer. Look to the left menu to get visitor/browsing/came from/keyword stats.

Connect to CIS, POE

Archives (2008), In Press
Learning from Users: Search Monitoring

Monitoring user searches (what was typed into the lab search engine):
- Gives insight into how users are looking for lab tests
- Allows rapid cycle improvements

- Realize that past searches all have value.
- Lab handbook data now used for POE applications
- Data capture/review should be part of all search applications
- Smart search should be a focus of all complex applications
- User interface should be built once and then changes to database used to improve system
It's not just about doing the lab test. We should aim to provide an array of information intensive services and become the hub for collection and dissemination a wide variety of lab related knowledge to help improve outcomes.

Information Processing in the Laboratory Testing Process

Computerized Provider Order Entry (CPOE)
- Test panels
- Redundancy alerts
- Clinical guidelines

Test Result Auto-verification

Middleware
- Interference checking
- Rules-based auto-dilution
- Automated add-ons

Info Buttons
- Guidelines
- Literature
- Online resources

Pathology Interpretative Services

Pre-analytic
- Ordering
- Collection

Analytic
- Processing/Analysis

- Institutional Reflex Algorithms
- Electronic Technical Support

Post-Analytic
- Reporting
- Interpretation

- Enhanced Electronic Medical Record systems

Automated Specimen Collection Process
- RFID/bar coding
Bar Coded Patient Wristbands Reduce Errors

- MGH patient wristband has 1D and 2D bar codes
- At MGH scanning the 1D bar code instead of typing it in dropped the glucometry patient ID error rate from 1-3% to zero
### Comparison of Auto-ID Implementations

<table>
<thead>
<tr>
<th>Retail</th>
<th>Healthcare</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Industry giant sets standards</td>
<td>• No industry giant: no standards</td>
</tr>
<tr>
<td>• Bar codes on products</td>
<td>• Bar codes on many things</td>
</tr>
<tr>
<td>• Checkout</td>
<td>• Point of care</td>
</tr>
<tr>
<td>• Same work flow</td>
<td>• New work flow</td>
</tr>
<tr>
<td>• Minor monetary consequences of error</td>
<td>• Life impacting errors are possible</td>
</tr>
<tr>
<td>• Success: reduced labor costs, increased customer and revenue growth</td>
<td>• Success: better patient care, error avoidance</td>
</tr>
</tbody>
</table>

Bar codes generally work best in situations where the bar code scanner is stationary and the products are moving (checkout, specimen accessioning). Problematic when the scanner is mobile AND the products are mobile (POCT).
Strategy: Maximize Use of Auto identification Technologies

Auto Identification Technology: technology by which a physical object can be automatically identified.

- Bar coding
- Magnetic stripe cards (credit cards)
- Biometric (fingerprint and retinal scans)
- Voice recognition
- Optical character recognition
- *Radiofrequency identification*
Radiofrequency Identification (RFID) is Everywhere

- Hospital (IDs for door access)
- Train (Subway pass)
- Car (FastLane Mass Pike)

Hospital ID

Mass Pike Toll Booth Transponder

MBTA Subway Pass
Active RFID: (Radianse Indoor Positioning System in MGH ORs)

- Reader
- Tag (~$10)
  - Patients
  - Surgical staff
  - Cleaning crew
  - Equipment (e.g. ultrasound machines)

After tags of patient and surgeon have left OR38 >> alert cleaning staff to clean OR38 via text pager
If ultrasound machine is not in OR53 and needed for the next case >> Alert RN via text pager to find ultrasound machine and bring it to OR53

→ Results: reduced time between cases, increased number of cases in same amount of time

Build it with a strong data model and then build in intelligence using real world data and usage as a guide.
It’s not just about doing the lab test. We should aim to provide an array of information intensive services and become the hub for collection and dissemination a wide variety of lab related knowledge to help improve outcomes.
A busy clinician will have test results for their patients available every few seconds.

Does my patient have a protein S deficiency?
Does my patient have a risk of thrombosis?
Should I refer my patient to a hematologist?
Should I consider giving blood products?
What’s the next test I should do to work up this abnormality?
Could these results be due to a medication my patient is taking?
Daily Rounds to Interpret Complex Test Results

- Physician orders **non-routine** tests within certain areas of the laboratory (examples: coagulation, immunology, hematology, toxicology)
- Test results as numbers **and** a narrative interpretation by the pathologist are provided to the clinician
- The interpretation includes a patient specific differential diagnosis and recommendations for future testing
Payment Requirements for Interpretive Services

**CMS Carrier Manual:**

1. The interpretation must be requested by the patient's attending physician
   - A hospital's standing order policy can be used as a substitute for the individual request

2. The interpretation is a written narrative report included in the patient's medical record

3. The interpretation requires the exercise of medical judgment by the consultant **physician**

[http://cms.hhs.gov/manuals/]
Seamless integration of interpretive services with the Laboratory Information System

Automate the process with the use of interpretive software and a direct HL7 interface of tests and interpretations to facilitate the efficient production of a high quality, reproducible interpretation.

Clinicians request and view interpretations

Pathologists create interpretations
<table>
<thead>
<tr>
<th>Name</th>
<th>Patient ID</th>
<th>Case #</th>
<th>Type</th>
<th>Origin Inst</th>
<th>Date</th>
<th>Status</th>
<th>Priority</th>
<th>Tag</th>
<th>Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEST. PATIENT</td>
<td>2472862</td>
<td>25958</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/15/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST. PATIENT</td>
<td>2494728</td>
<td>26035</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/20/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST. PATIENT</td>
<td>2537684</td>
<td>26053</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/21/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST. PATIENT</td>
<td>2559043</td>
<td>25991</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/16/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST. PATIENT</td>
<td>261762</td>
<td>26054</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/21/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST. PATIENT</td>
<td>2622049</td>
<td>26101</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/22/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST. PATIENT</td>
<td>2624411</td>
<td>25918</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/15/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST. PATIENT</td>
<td>2657299</td>
<td>25959</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/15/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST. PATIENT</td>
<td>2632663</td>
<td>26056</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/22/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST. PATIENT</td>
<td>2757229</td>
<td>26056</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/22/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST. PATIENT</td>
<td>2774505</td>
<td>26057</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/22/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST. PATIENT</td>
<td>2799689</td>
<td>26085</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/21/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST. PATIENT</td>
<td>2802310</td>
<td>26009</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/11/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST. PATIENT</td>
<td>2833061</td>
<td>25950</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/15/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST. PATIENT</td>
<td>2970958</td>
<td>26036</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/21/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST. PATIENT</td>
<td>3013149</td>
<td>25951</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/15/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST. PATIENT</td>
<td>3047956</td>
<td>25952</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/15/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST. PATIENT</td>
<td>3065499</td>
<td>25937</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/15/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST. PATIENT</td>
<td>3078649</td>
<td>25963</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/16/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST. PATIENT</td>
<td>3146764</td>
<td>26012</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/23/2002</td>
<td>Reviewed By:</td>
<td>1912</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST. PATIENT</td>
<td>3132680</td>
<td>25954</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/15/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST. PATIENT</td>
<td>3221330</td>
<td>25905</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/15/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST. PATIENT</td>
<td>3231639</td>
<td>26113</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/23/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST. PATIENT</td>
<td>3247298</td>
<td>26010</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/17/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST. PATIENT</td>
<td>3277169</td>
<td>25966</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/16/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST. PATIENT</td>
<td>3298958</td>
<td>26029</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/21/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST. PATIENT</td>
<td>3313729</td>
<td>26011</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/17/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST. PATIENT</td>
<td>3323956</td>
<td>25957</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/16/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST. PATIENT</td>
<td>3370617</td>
<td>26070</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/22/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST. PATIENT</td>
<td>3448913</td>
<td>26114</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/23/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST. PATIENT</td>
<td>3451029</td>
<td>25993</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/15/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST. PATIENT</td>
<td>3479623</td>
<td>26037</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/21/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Click to expand view of labs
<table>
<thead>
<tr>
<th>Date</th>
<th>09/14/03</th>
<th>09/12/03</th>
<th>09/22/03</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>02:36</td>
<td>02:36</td>
<td>02:45</td>
</tr>
<tr>
<td>PT</td>
<td>11.4</td>
<td>11.2</td>
<td></td>
</tr>
<tr>
<td>PTT</td>
<td>29.3</td>
<td>31.2</td>
<td></td>
</tr>
<tr>
<td>FIB</td>
<td>344</td>
<td>344</td>
<td>310</td>
</tr>
<tr>
<td>PTTLA</td>
<td>NEGLA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACL IGM</td>
<td>5.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACL IGG</td>
<td>9.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FVIII</td>
<td>165</td>
<td></td>
<td></td>
</tr>
<tr>
<td>APCRS</td>
<td>1.6 L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HCY</td>
<td>7.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROT C FUNCT</td>
<td>98</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROT S FUNCT</td>
<td>41 L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROT S FREE</td>
<td>43 L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATIII</td>
<td>92</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ALB</td>
<td>4.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ALK PHOS</td>
<td>72</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T BILI</td>
<td></td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>D BILI</td>
<td></td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>SGOT</td>
<td>24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SGPT</td>
<td>22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BUN</td>
<td>11</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>CREAT</td>
<td>0.9</td>
<td>1.0</td>
<td></td>
</tr>
</tbody>
</table>
Software selects comments based on:

- Labs
- Patient demographics
- Past history of comment use
- Interpreter
Protein S is decreased. Elevations in factor VIII can decrease protein S, but the factor VIII level is currently not elevated. Elevations in C4b-binding protein, which occurs during an acute phase reaction, decreases protein S. However, there is no evidence for an acute phase reaction because fibrinogen and factor VIII, which are acute phase reactants, are currently not elevated. Discontinuation of coumadin within 10 days prior to specimen collection is associated with this pattern of results. Estrogen use decreases protein S; however, it is presumed that this male patient has not been receiving estrogen. A hereditary protein S deficiency is possible, particularly if the patient has a personal or family history of venous thrombosis. If a hereditary deficiency is suspected, the protein S assays may be repeated any time when the patient is stable and has not received coumadin for at least 10 days. If indicated, measuring protein S in first-degree family members or any relative with a history of venous thrombosis may be informative, because hereditary protein S deficiency has autosomal dominant inheritance.

2. This patient was evaluated for activated protein C resistance. A value was obtained consistent with activated protein C resistance, and as a result, a DNA-based test for the factor V Leiden mutation will be performed using the sample which has already been collected.

3. The results of the other requested studies are normal.
Protein S is decreased. Elevations in factor VIII can decrease protein S, but the factor VIII level is currently not elevated. Elevations in C4b-binding protein, which occurs during an acute phase reaction, decreases protein S. However, there is no evidence for an acute phase reaction because fibrinogen and factor VIII, which are acute phase reactants, are currently not elevated. Discontinuation of coumadin within 10 days prior to specimen collection is associated with this pattern of results. Estrogen use decreases protein S, however, it is presumed that this male patient has not been receiving estrogen. A hereditary protein S deficiency is possible, particularly if the patient has a personal or family history of venous thrombosis. If a hereditary deficiency is suspected, the protein S assays may be repeated any time when the patient is stable and has not received coumadin for at least 10 days. If indicated, measuring protein S in first-degree family members may be informative, as they may have autosomal dominant inheritance.

A value was obtained for protein C resistance. A value was obtained for protein C resistance, and a result DNA based test for the mutation was performed using the sample which has already been sent. The results indicate that the individual has a mutation that has a 90% chance of being normal. The results are consistent with a normal phenotype.
<table>
<thead>
<tr>
<th>Name</th>
<th>Patient ID</th>
<th>Case #</th>
<th>Type</th>
<th>Org Inst</th>
<th>Date</th>
<th>Status</th>
<th>Priority</th>
<th>Tag</th>
<th>Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEST PATIENT</td>
<td>3449313</td>
<td>26104</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/23/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST PATIENT</td>
<td>3451023</td>
<td>25939</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/15/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST PATIENT</td>
<td>3479323</td>
<td>26037</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/21/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST PATIENT</td>
<td>3492510</td>
<td>26012</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/16/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST PATIENT</td>
<td>3510774</td>
<td>26105</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/22/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST PATIENT</td>
<td>3537513</td>
<td>26106</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/22/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST PATIENT</td>
<td>3547543</td>
<td>26107</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/22/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST PATIENT</td>
<td>3590533</td>
<td>26108</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/22/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST PATIENT</td>
<td>3593610</td>
<td>26013</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/17/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST PATIENT</td>
<td>3633725</td>
<td>25921</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/12/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST PATIENT</td>
<td>3660176</td>
<td>26014</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/17/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST PATIENT</td>
<td>3669888</td>
<td>26025</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/18/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST PATIENT</td>
<td>3692115</td>
<td>26109</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/22/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST PATIENT</td>
<td>3715955</td>
<td>26110</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/22/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST PATIENT</td>
<td>3791210</td>
<td>26071</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/22/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST PATIENT</td>
<td>3794108</td>
<td>26072</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/21/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST PATIENT</td>
<td>3807733</td>
<td>26111</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/22/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST PATIENT</td>
<td>3818312</td>
<td>26073</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/22/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST PATIENT</td>
<td>3828156</td>
<td>26112</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/22/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST PATIENT</td>
<td>3836940</td>
<td>25932</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/17/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST PATIENT</td>
<td>3854475</td>
<td>26015</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/18/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST PATIENT</td>
<td>3966323</td>
<td>26074</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/21/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST PATIENT</td>
<td>3987405</td>
<td>26113</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/22/2012</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST PATIENT</td>
<td>3984000</td>
<td>26114</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/22/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST PATIENT</td>
<td>3985912</td>
<td>26075</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/21/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST PATIENT</td>
<td>3987649</td>
<td>26076</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/21/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST PATIENT</td>
<td>3995620</td>
<td>26038</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/21/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST PATIENT</td>
<td>3981550</td>
<td>26016</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/18/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST PATIENT</td>
<td>3962363</td>
<td>26115</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/23/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST PATIENT</td>
<td>3955308</td>
<td>26077</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/22/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST PATIENT</td>
<td>3967708</td>
<td>26036</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/18/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEST PATIENT</td>
<td>3972110</td>
<td>25968</td>
<td>Coagulation Interpretation</td>
<td>MGH</td>
<td>10/16/2002</td>
<td>New</td>
<td>Routine</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

209 cases

Current User: Dighe, Anand (ASD)
Enhanced Result Reporting

Interpretation of complex results

Link to MGH Lab Test Handbook
### Test Details - Protein S

<table>
<thead>
<tr>
<th>Lab</th>
<th>Result</th>
<th>Inpatient Req</th>
<th>Outpatient Req</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coagulation</td>
<td>1-7 days</td>
<td>Coagulation (70130)</td>
<td>Clinical Labs (83608)</td>
</tr>
</tbody>
</table>

#### Specimen

5 ml Blue. When requesting the Hypercoagulation Panel please submit 2 blue top tubes.

#### Important Information

Deliver specimens ON ICE. Automatically performed as part of the Hypercoagulation Panel. This assay measures the activity of Protein S. Patients must be off of coumadin for at least 10 days prior to testing. Patient must not be on hirudin or argatroban. If the functional Protein S assay is low then the antigenic assay, and a Factor VIIIIC and fibrinogen level will be performed. Factor VIIIIC levels >200% will falsely decrease in vitro functional Protein S levels.

### Additional Resources

- Laboratory Evaluation of Hypercoagulability [PDF]
Information Management in the Laboratory Testing Process

- Determine your core competencies
- Develop a data model that permits active knowledge sharing with the organization, rapid improvement cycles
- Utilize SMART searching to help clinicians find the pathology information that will guide decision making
- Monitor how users interact with your information
“The key to success is to bake knowledge into the jobs of highly skilled workers – to make knowledge so readily accessible that it can’t be avoided”

Glaser and Davenport, HBR
Thanks