PERSPECTIVES

Decoding Laboratory Test Names: A Major Challenge to Appropriate Patient Care

Elissa Passiment, EdM¹, James L. Meisel, MD², John Fontanesi, PhD³, George Fritsma, MS⁴, Samir Aleryani, PhD⁵, and Marisa Marques, MD⁶

¹American Society for Clinical Laboratory Science, Tysons Corner, VA, USA; ²Hospital Medicine Unit Section of General Internal Medicine Boston University Medical Center, Boston, MA, USA; ³Center for Management Science in Health University of California, San Diego, Medical School, La Jolla, CA, USA; ⁴Fritsma Factor, Precision Biologic, Dartmouth, Canada; ⁵Department of Pathology, Vanderbilt University Medical Center, Nashville, TN, USA; ⁶The University of Alabama at Birmingham Division of Laboratory Medicine, Birmingham, AL, USA.

Clinical laboratory tests have no value if clinicians cannot quickly order and obtain the results they need. We found that efforts to obtain even the most commonly ordered tests are often derailed by excessively complex nomenclature. Ordering the right laboratory tests is critical to diagnosis and treatment, but existing mechanisms for entering lab orders actively interfere with physicians' efforts to provide good clinical care. Rather than simplifying lab orders, the advent of computerized physician order entry (CPOE) systems—generally programmed by non-clinicians—has introduced new and vexing practical problems. Medical laboratories have filled their test menus, whether paper or electronic, with bewildering nomenclature and abbreviations, and have failed to appreciate the dangers of assigning perilously similar names to different tests. The efficient and efficacious patient care demanded by the quality care initiative requires progress beyond traditional solutions, such as convening naming conventions, to the development of innovative software with intelligent, real-time, clinically driven search functions that will allow these programs to help rather than hinder physicians.

KEY WORDS: laboratory tests; nomenclature; communication; naming protocol; health care costs.

J Gen Intern Med 28(3):453-8

DOI: 10.1007/s11606-012-2253-8

© Society of General Internal Medicine 2012

On general medicine ward rounds: “You said the BNP was normal. Why are we diuresing him for congestive heart failure?”

In a malpractice deposition: “Would a CRP test have been useful if you were concerned about osteomyelitis?” “So why did you order a Protein C?”

During resuscitation effort: “What was the result of this morning’s lactate?” “The only result I see here is an LD”

Received January 10, 2012

Revised July 2, 2012

Accepted October 8, 2012

Published online November 29, 2012

INTRODUCTION

This publication is the outcome of the Clinical Laboratory Integration into Healthcare Collaborative (CLIHCC)TM, a workgroup established by the Centers for Disease Control and Prevention (CDC). The CDC convened seven Institutes from 1984 to 2007 on critical issues in clinical laboratory practice (<http://wwwn.cdc.gov/dls/institutes/>), bringing together national and international experts to focus on the role of the laboratory in providing quality testing for improving patient outcomes. CDC had established several workgroups of laboratory and healthcare experts to address the Institutes’ recommendations. The topic of this paper has been identified by these experts as a clinically significant factor affecting patient outcomes.

The optimal selection of clinical laboratory tests is an important contributor to accurate diagnosis and patient care.¹⁻³ Central to this process is the physician’s ability to correctly decipher laboratory test nomenclature as seen on an order entry screen or requisition, so that she can correctly order the best possible test(s). Physicians believe this is important. A recent CDC survey investigated internal medicine and family medicine physicians’ access to electronic assistance in ordering appropriate laboratory tests. While only 10 % of the physicians surveyed had such electronic access, 60 % of that group, using a five point Likert scale, rated the electronic suggestions to be “very” to “extremely useful.” (Unpublished observations from 2012 CDC national survey)

The examples of the problems provided above illustrate the confusion between several commonly ordered tests. Centers for Medicare & Medicaid Services (CMS) Medicare Part B clinical laboratory claims (2009, obtained by CDC) demonstrate the potential magnitude of the problem. In the 2009 claims data, there were 26.1 million basic metabolic profiles (BMP) and 1.1 million brain natriuretic peptide (BNP), 2.4 million C-reactive protein (CRP) and 13,000 Protein C, and 17,000 lactic acid and 19.9 million lactate dehydrogenase.

A variety of difficulties arise in the ordering process.⁴⁻⁶ We believe we have identified two root causes of these problems: the multiplicity of names and abbreviations used

Table 1. Commonly Ordered Tests

Key Name	Synonyms	Abbreviation (s)
Alkaline Phosphatase	Alkaline phosphomonoesterase Alkaline phosphohydrolase Alkaline phenyl phosphatase	ALP, Alk Phos, AP, AKP
Beta HCG	BHCG (serum qualitative) Beta-Chorionic Gonadotropin	BHCG, HCGB, Beta-HCG
Basic Metabolic Panel	Chem 7 Chemistry Screen	BMP
Brain Natriuretic Peptide	Natriuretic Peptide B-type Natriuretic Peptide Brain Type Natriuretic Peptide	BNP
Complete blood count with differential	Hematology profile Blood count Hemogram CBC with diff CBC with differential CBC with differential and platelets	CBC w/diff & PLT CBC diff plts CBC CBC d/p
Bilirubin, Direct	Conjugated bilirubin	CBR, DBILI, BILD, DB
Glucose	Random glucose Fasting glucose Blood sugar	GLU, Gluc, BS, PLGLUC, GLUCA, GLUF
Hepatitis B surface antibody	HBs Antibody Antibody to Hepatitis B Surface Ag Hepatitis B Surface Antibody-Quant Hepatitis Bs Ab	HBsAb, Anti-HBs
Hepatitis C antibody	HCV Ab Screen Anti-HCV HCV Antibody non-A, non-B Hepatitis	HCV
Lactate	Lactic Acid L-Lactate	LA
Lactate Dehydrogenase	Lactic Dehydrogenase Total Lactate Dehydrogenase	LD LDH
Coagulation Tests		
Anticardiolipin antibody	Anti-cardiolipin antibody Antiphospholipid antibody Anti-phospholipid antibody	ACA ACL APA APL
Factor XII activity assay	Factor XII assay Factor XII functional assay Hageman Factor assay	FXII
Lupus anticoagulant assay	Lupus anticoagulant Lupus antibody Anti-phospholipid antibody Lupus inhibitor Dilute Russell viper venom time Tissue thromboplastin inhibitor Dilute prothrombin time Kaolin clotting time Non-specific inhibitor	LA LAC LI APL DRVVT dRVVT TTI KCT DPT
Protein C	Protein C Activity Protein C Functional Protein C Total Antigen Protein C Immunologic	Prot C Prot C F

for a given laboratory test; and the complexity of the test nomenclature itself, including the absence of a standardized naming protocol, resulting in inappropriate or inaccurate names for tests. A recent study showed incorrect test ordering

as a major contributor to errors in diagnosis and a major driver of escalating costs in health care.⁷ One scenario occurs when the test ordered is inappropriate, e.g., the test selected is incorrect or unnecessary.⁸ In other instances, nomenclature

confusion has led to the failure to order assays that would produce a diagnosis quickly and accurately.⁹ This report demonstrates the intricacies of laboratory test names and test abbreviations, using examples and literature citations.

ILLUSTRATING THE BREADTH AND DEPTH OF THE PROBLEM

Commonly ordered, routine laboratory tests illustrate the breadth of the problem, and tests associated with a subspecialty area of medicine, coagulation disorders, illustrate its depth (Table 1). We compiled a list of commonly ordered clinical laboratory tests from the test names, synonyms and key abbreviations used by physicians working in the inpatient and ambulatory settings of selected academic medical centers

and community sites. Data were obtained from the test directory of the Pathology Department at Vanderbilt University Medical Center (VUMC), as a prototypical academic medical center offering laboratory outreach services; and from informal telephone and email queries of hospitalists and primary care physicians affiliated with multiple medical centers in eastern Massachusetts. The list of coagulation tests and abbreviations were selected from the Special Coagulation test menu of the University of Alabama at Birmingham Hospital. MeSH headings are used when available. Abbreviations employ all capital letters unless there is a convention specifying lower case letters or other characters.

The lists of tests are illustrative, not comprehensive. Assays for this report were selected on the basis of common usage and nomenclature complexity. The common name was selected by author consensus and does not reflect any

Figure 1. The Clinic Process is an example of how a clinician would decide what test to order for her patient. The Laboratory Process illustrates the decisions needed to present a laboratory test to clinicians for their use.

official designation, as no international consensus exists except where indicated by specific references.

How We Got Here

In the CDC survey of physicians' challenges mentioned above, over half of respondents found the multiplicity of names of laboratory tests to be "somewhat" to "extremely problematic." Ordering a laboratory test engages a very intricate process that presents challenges to the laboratory practitioners offering the service and the physicians ordering the appropriate test(s). Figure 1 uses Vitamin D to illustrate the process. With multiple clinical laboratory assay names representing identical, similar or related analytes, local laboratory personnel propose tests, names and abbreviations, and then pare options to fit a laboratory requisition or computerized order entry form. The labora-

tory information system (LIS) coder then selects or creates representative names, abbreviations and mnemonics that fit within LIS vendor parameters. Correct test selection, and ultimately patient outcome, relies on limited expert consensus, local laboratory personnel, coder selections, clinician reasoning, and characteristics of order entry.

Table 1 demonstrates the variability in laboratory test nomenclature for the same test and the major challenge faced by physicians in ordering laboratory tests. In some cases, the test name is *based upon the disease* with which it is associated. An example is rheumatoid factor, an antibody that was discovered to be associated with rheumatoid arthritis and inappropriately named for the disease, even though it is neither highly sensitive nor highly specific for this condition.¹⁰ However, the test name suggests a definitive diagnosis, when in actuality, at best, the laboratory result may just support a clinical impression formed by the physician.

Figure 2. Mapping of Hemoglobin A1c for interconnectivity between electronic medical records and laboratory information systems.

Test names can also reflect *a reagent used in the performance of the test*. While anticardiolipin antibodies (ACA) are named for cardiolipin, a reagent used in screening tests for syphilis and first extracted from animal hearts, ACA tests are performed to try to determine if the cause of unexplained thrombosis or repeated miscarriages is antiphospholipid syndrome.

Other methods of naming tests include those based on the *name of its developer*. A well-known example is the Lowry assay for quantitation of protein, named after Dr. Oliver Lowry. Test names are sometimes associated with the *person who was first described as having a disease*. Coagulation factor XII deficiency is also known as Hageman factor deficiency, after John Hageman who was found to be deficient in factor XII.¹¹

There are also often *multiple abbreviations* for individual laboratory tests. Much of the variation can be attributed to laboratory information systems (LIS) that identify a laboratory test by providing unique abbreviations based upon the number of characters permitted by the system, a complicated, arbitrary and non-standardized process. Over time, laboratory personnel began to use their LIS abbreviations when reporting test results. Physicians using that laboratory in turn started associating the LIS abbreviations with certain tests. The abbreviations have become part of the vernacular; so both the laboratorian and physician may talk about ordering an FBS, or FGLU, FGLUC, GLUF, FG, etc. rather than saying “fasting glucose”. The abbreviations may be so different as to not match anything a physician has seen from one health care setting to another.¹² Therefore, the physician might not know which test abbreviation represents something as simple as a serum glucose.

The lack of naming convention adds complications to ordering one of the most common of test panels, the complete blood count (CBC) with differential. As seen in the list of synonyms in Table 1, the CBC *test panel name may or may not include a particular component*, e.g., the platelet count or even the white blood cell (WBC) differential itself. In addition, the components of a differential vary between laboratories, leading to discrepancies between what a physician thought she ordered and the results she received. Only trial and error would tell the physician what the test name really included.

Lupus anticoagulant is another example of *inappropriate test naming*. The test is not for an anticoagulant. It is actually a procoagulant, and is primarily found in patients who do not have systemic lupus erythematosus (SLE). Table 1 also illustrates the multitude of synonyms in use for this test, most of which still do not adequately describe the relationship between the test and the disorder.

The problem is exacerbated by the “mapping” of laboratory tests to electronic medical records programs. In this process, laboratory directors decide how their tests’ natural-language nomenclature or LIS names will be linked to what will appear on the test menu. Depending on those decisions, mapping may be as simple as one-to-one; or as complex as one-to-many, many-to-one, or many-to-many (see Fig. 2).

Why It Hasn’t Been Fixed. The complexity of laboratory test names and abbreviations compromises the physician’s ability to appropriately utilize laboratory services, delays patient care and wastes health care resources. To resolve the confusion, consensus conferences have occasionally been convened to reduce the number of different names for tests.^{13–15} Such an endeavor occurred in the switch of names for coagulation factors.¹⁶ These were originally named for the person first identified with the deficiency of a particular coagulation factor; subsequently, each factor was identified with a discreet Roman numeral. Most often, however, no consensus conference to address unwanted diversity in nomenclature has been held, or if it was, the recommended name change failed to be incorporated into clinical practice. In addition, the proliferation of molecular methods and genetic studies in medicine has expanded the number of stakeholders that would have to be brought to the table with each standardization effort. Even if consensus could be reached by multiple stakeholders today, the nomenclature would become obsolete with a next round of scientific research.

Two other major efforts to standardize nomenclature have been made: Logical Observation Identifier Names and Codes (LOINC) and Systematized Nomenclature of Medicine (SNOMED)-Clinical Terms. LOINC was developed by the Regenstrief Institute in the 1990’s, as “a database to facilitate the exchange and pooling of results for clinical care, outcomes management, and research.”^{17–21} SNOMED, created by the College of American Pathologists in 1965 as logic-organized codes for key pathology terms, was later expanded to include terminology for the entire medical record.^{22,23} Both are systems for data exchange between electronic information systems²⁴; neither was designed to facilitate clinical decision making to order laboratory tests.

Future Directions

Appropriate laboratory ordering could be greatly aided by using sophisticated search technology, as seen with BING and GOOGLE, which in many ways emulate the way people “think.” Such tools present multiple, related options to an individual who is searching for a word or phrase. Advanced computational machine learning methods, such as Bayesian Network or Markov Decision Support, would be able to interpret the type of clinician, patient and patient conditions and intelligently identify the most likely tests. The technology might seek and “offer” possibilities in ranked order of likelihood, much as the familiar query: “Did you mean...?” Using interactive design fundamentals, the support would include inherent feedback, such as identifying the individual tests included in a BMP, conditions that might either preclude the ordering of the test or affect the interpretation of the results, and potential alternatives. The interface would support, not automate,

clinicians' thought processes. The underlying logic of the system must be robust and meet very high levels of certainty.²⁵

The goal is to have an interface the clinician finds convenient, "respectful," flexible and fast in helping to identify and then order the correct laboratory test(s). In other words, it should be as close to the type of interaction the clinician would expect from a knowledgeable and helpful human. This type of interaction involves a number of different analytic domains that humans perform relatively seamlessly (if not accurately or consistently).

A search engine-like approach would continuously update itself as it "learns" and recalculates the rank or weight of a term, criteria and/or assumption. The approach would eliminate the need for mandatory changes or standardizations that might become obsolete with new advances in the science of medicine. Future work of CLIHC™ will examine the principles and domains of this form of communication and interconnectability as they pertain to the needs of physicians and patients utilizing medical laboratory services.

Acknowledgements: This report was supported in part from a contract (GS-10F-0261K) funded by the Centers for Disease Control and Prevention/Agency for Toxic Substances and Disease Registry.

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention/Agency for Toxic Substances and Disease Registry.

The use of trade names in this report is for identification purposes only and does not imply endorsement by the Centers for Disease Control and Prevention (CDC) or the U.S. Department of Health and Human Services.

This information is the exclusive property of the federal government; however, we are searching for partners to continue development of this information. Please contact the author if you are interested in partnering on this project.

Conflict of Interest: Dr. Meisel has a financial interest in Medvance Solutions, Inc., which facilitates the communication of clinical laboratory results from physicians to patients.

Corresponding Author: Elissa Passiment, EdM; American Society for Clinical Laboratory Science, 1861 International Drive, #200, Tysons Corner, VA, USA (e-mail: elissap@ascls.org).

REFERENCES

1. Surks MI, Chopra LJ, Mariash CN, Nicoloff JT, Solomon DH. American thyroid association guidelines for use of laboratory tests in thyroid disorders. *JAMA*. 1990;263:1529-1532.
2. Laboratory Support to HIV Diagnosis and Monitoring of Antiretroviral Therapy. WHO Project 2004; http://www.searo.who.int/LinkFiles/BCT_Reports_HLM-384.pdf accessed September 30, 2012.
3. Emmons MF. Integrated patient data for optimal patient management: the value of laboratory data in quality improvement. *Clin Chem*. 2001;47(8):1516-20.
4. Sucov A, Bazarian JJ, deLahunta EA, Sillane L. Test ordering guidelines can alter ordering patterns in an academic emergency department.

5. Shalev V, Chodick G, Heymann AD. Format change of a laboratory test order form affects physician behavior. *Int J Med Inform*. 2009;78(10):639-44.
6. Miyakis S, Karamanof G, Lontos M, Mountokalakis TD. Factors contributing to inappropriate ordering of tests in an academic medical department and the effect of an educational feedback strategy. *Postgrad Med J*. 2006;82(974):823-9.
7. Valenstein PN, Walsh MK, Stankovic AK. Accuracy of send-out test ordering: a College of American Pathologists Q-Probes study of ordering accuracy in 97 clinical laboratories. *Arch Pathol Lab Med*. 2008;132(2):206-10.
8. Perraro F, Rossi P, Liva C, Bulfoni A, et al. Inappropriate emergency test ordering in a general hospital: preliminary reports. *Qual Assur Health Care*. 1992;4(1):77-81.
9. Laposata M, Dighe A. "Pre-pre" and "post-post" analytical error: high incidence patient safety hazards involving the clinical laboratory. *Clin Chem Lab Med*. 2007;45(6):712-9.
10. Shmerling RH, Delbanco TL. How useful is the rheumatoid factor? An analysis of sensitivity, specificity, and predictive value. *Arch Intern Med*. 1992;152(12):2417-20.
11. Ratnoff OD, Margolius A Jr. Hageman trait: an asymptomatic disorder of blood coagulation. *Trans Assoc Am Physicians*. 1955;68:149-54.
12. Inoue Y, Nakamura J. Codes and names for clinical laboratory tests and shared interlaboratory databases. *Rinsho Byon*. 1997;45(6):577-80.
13. Pontet F, Magdal PU, Fuentes-Arderiu X, Petersen U, X, et al. Clinical laboratory sciences data transmission: the NPU coding system. Joint Committee on Nomenclature, Properties and Units (C-SC-NPU) of the IFCC and IUPAC. *Stud Health Technol Inform*. 2009;150:265-9.
14. Nomenclature announcement: Redefined Nomenclature for Members of the Carcinoembryonic Antigen Family1. *Experimental Cell Research*. 1999; 252: 243-249
15. Larsen P, Alexander N, et al. Revised nomenclature for tests of thyroid hormones and thyroid-related proteins in serum. *Arch Pathol Lab Med*. 1988;112:132.
16. Wright IS. Special report: the nomenclature of blood clotting factors. *Can Med Assoc J*. 1962;86:373-374.
17. Huff SM, Rocha RA, McDonald CJ, et al. Development of the Logical Observation Identifier Names and Codes (LOINC) vocabulary. *J Am Med Inform Assoc*. 1998;5(3):276-92.
18. McDonald CJ, Huff SM, Suico JG, et al. LOINC, a universal standard for identifying laboratory observations: a 5-year update. *Clin Chem*. 2003;49(4):624-33.
19. McDonald CJ, Huff SM, Suico JG, Hill G, Leavelle D, Aller R, Forrey A, Mercer K, DeMoor G, Hook J, Williams W, Case J, Maloney P. LOINC, a universal standard for identifying laboratory observations: a 5-year update. *Clin Chem*. 2003;49(4):624-33.
20. <http://loinc.org/> accessed September 30, 2012.
21. <http://loinc.org/background>, accessed September 30, 2012.
22. Wang AY, Barrett JW, Bentley T, et al. Mapping between SNOMED RT and clinical terms version 3: A Key Component of the SNOMED CT development process. *Proc AMIA Symp*. 2001; 741-745.
23. <http://www.ihtsdo.org/snomed-ct/> accessed September 30, 2012.
24. Baorto DM, Cimino JJ, Parvin CA, Kahn MG. Using Logical Observation Identifier Names and Codes (LOINC) to exchange laboratory data among three academic hospitals. *Proc AMIA Annu Fall Symp*. 1997;96-100.
25. NISTIR 7432: Common Industry Specifications for Usability Requirements, Information Access Division, Information Technology Laboratory, National Institute of Standards and Technology, June 2007.

TEST DIRECTORIES OF OTHER MAJOR REFERENCE LABORATORIES (REFERENCES)

26. Vanderbilt Pathology Laboratory Services. www.LabVU.com, accessed September 30, 2012.
27. ARUP Laboratories. www.aruplab.com, accessed September 30, 2012.
28. Lab Tests on Line. www.labtestsonline.org, accessed September 30, 2012.
29. Mayo Medical Laboratories. <http://www.mayomedicallaboratories.com>, accessed September 30, 2012.