Advancing High-Quality Cancer Care

Cancer Biomedical Informatics Grid Supports Personalized Medicine and the Electronic Health Record

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The electronic collection of cancer-related information and data is an important subject for oncologists. It's highly likely to be integral to the delivery of quality personalized cancer care. Two areas that address the collection and processing of electronic information for research, quality initiatives, and best-practice patient care are the cancer Biomedical Informatics Grid (caBIG™), led by the National Cancer Institute's (NCI) Center for Biomedical Informatics and Information Technology, and electronic health record (EHR) systems.

The caBIG initiative defines electronic content and uses predefined standards and interoperability (ie, the ability of one information tool or system to meaningfully exchange information with another) to enable the optimal management of cancer information. The initiative connects data searches, research tools, clinicians, scientists, and organizations in an open environment. While caBIG initially focused on cancer research, the infrastructure, products, and issues being addressed by the caBIG community are widely applicable for cancer care as well.

However, in the absence of EHRs, caBIG cannot deliver the full value of its rich information and tools to practicing oncologists. The integration of EHR systems and the resources and tools of caBIG is essential to a quality-driven collection and transfer of day-to-day cancer information and to the delivery of personalized cancer care.

The challenge for many practicing oncologists and other health care providers is to select an EHR system from the marketplace that improves practice outcomes, reduces costs, is not rapidly outdated or unsupported, and that formats and stores medical information for future as well as present use. The landscape of EHR systems is complex and uneven. Clinicians often experience uneven benefit from EHR systems and some conclude that overall progress has remained elusive.[1] Clinicians' attitudes toward EHRs are mostly cautious to negative.[2]

CaBIG Pilot Phase: Interoperable Clinical and Research Systems

caBIG recently concluded a successful pilot phase. During its pilot phase, it delivered more than 40 registry, analytic, and reporting tools, data sets, infrastructure hubs, and other products (Table 1).[3–5] These resources are applicable to basic, clinical, and translational research; provide foundational infrastructure such as common vocabularies, data elements, and standards; and facilitate grid computing. The initiative recently earned an informatics award in the category of global best practices in leading the world's IT revolution.[6] The National Institutes of Health is studying caBIG as a model for other National Institutes of Health medical research initiatives.[7–9] The United Kingdom's National Cancer Research Institute has committed to building its own informatics foundation on caBIG.[10] Attendance at the caBIG Annual Meeting climbed nearly 10-fold in 4 years.

A caBIG "middleware infrastructure," caGrid is predicted by some to be a functional model for a nationwide health care information network.[11] The design of caGrid—the decentralized, standards-based, Internet-deployed network that delivers the caBIG enterprise—synthesizes and extends research technologies and data sets.[12] Yet visualizing the national point-of-care health information system that is described by government leaders among others raises the question, "Can such a system proceed without interoperability standards?"[13]

The Internet's key attribute is its ability to provide virtually universal access to information that is interactive and up to date. It allows users to personalize the ways that they access, use, and store vast amounts of information.[14] caBIG extends this benefit by providing tools, data sets, and infrastructure that enable the synthesis of highly disparate information in support of personalized medicine. caBIG has also created a broad array of standards, guidelines, white papers, and training and documentation materials as well as educational materials and template agreements relating to open source software licensing, publications, and other issues.[4,5]

Table 1. Exemplary caBIG Tools and Applications

Tool	Description
C3D	C3D is a CTMS that collects clinical trial data using standard case report forms based on common data elements; C3D provides trial managers a secure and standardized framework for collecting, tracking, auditing, and electronically submitting trial data across multiple studies and sites; this web-based application can be hosted at NCICB or locally at an individual institution*
CDS	The CDS is a web-based data submission system for NCI-sponsored clinical trials; the CDS also provides trial stakeholders and partners a centralized, password-protected portal for viewing and generating reports on submitted data; as a part of the caBIG clinical trials management software suite, CDS can also reuse data collected in C3D
C3PR	C3PR is a web-based application that helps organize and manage participant registration data collected in multi-center clinical trials; integrates with C3D
caAERS	An open-source software tool that is used to collect, process, and report adverse events that occur during clinical trials; integrates with C3D
caMatch/BreastCancerTrials.org	A system for identifying patients who are potentially eligible for clinical trials; a web-based application for breast cancer is available[3]
Laboratory integration hub	The laboratory integration hub is an open source software tool used to collect, process and report laboratory data gathered during a clinical trial; integrates with C3D
Patient study calendar	PSC lets trial managers schedule treatment and care events for each participant in a clinical trial and follow their progress through each step of the trial protocol, from consent and registration through intervention and monitoring to long-term follow up; PSC is an open-source, standards-compliant software application that integrates with C3D
caTissue Core	caTissue Core is a tissue bank repository tool to collect, manage, process, annotate; and distribute biospecimens in many formats (ie, fixed tissue, frozen tissue, cell lines, and DNA, RNA or protein derived from them); a core solution for biospecimen inventory, tracking, and basic annotation; caTissue Core can be rapidly deployed by cancer centers that have no such system or to replace an aging legacy system; caTissue suite 1.0 is the comprehensive and integrated suite of tissue banking tools and applications, including caTissue Core, caTissue CAE, and caTIES
caTissue CAE	This clinical data mapping module retrieves data from basic medical records, drug treatments, surgery, radiology, tumor registries, and pathology laboratories and shares that data with the caTissue system; clinical descriptions are correlated to molecular data in a secure manner that maintains patient privacy; the system allows the integration of annotations from multiple sources within the cancer centers, providing a complete picture of a patient's disease
caTIES	This system automates the extraction of coded information from surgical pathology reports and presents it in a standardized format; users can query, browse, and acquire annotated tissue data and physical material
caTRIP	caTRIP connects existing data systems, including basic science data, to enhance patient care; the system leverages clinical, pathology, tissue, and basic science data, including data from existing patients, to inform the treatment of a new patient

NOTE. These tools as well as all other caBIG products are available on the caBIG Web site.[4,5]
Abbreviations: C3D, Cancer Central Clinical Database; CTMS, clinical trials management system; CDS, Clinical Data System; C3PR, Cancer Central Clinical Participant Registry; caAERS, cancer Adverse Event Reporting System; caTissue CAE, caTissue Clinical Annotation Engine; caTIES, cancer Text Information Extraction System; caTRIP, cancer Translational Research Informatics Platform.
*Several commercial and open source vendors are also pursuing caBIG compatibility, which will enable interoperability with the components listed later in this Table.

caBIG and Clinical Research

The goals of cancer cooperative groups and the overall conduct of clinical research are supported by caBIG. The enterprise should improve the effectiveness of clinical trials by simplifying the analysis and sharing of information. In 2007, various caBIG clinical trials support tools and applications are being integrated to support multifaceted clinical trial processes. These tools are designed to facilitate the integration not only of data from different trials and different centers, but also of data of varied types, enabling efficient and powerful analysis. Specifically, modules that support the tracking of patients over multiple protocols, the reporting of adverse events, the automatic import of clinical laboratory data, and the generation of patient study calendars will be integrated with caBIG compatible clinical trials management systems, beginning with the Cancer Central Clinical Database.

New technologies are also being introduced in 2007 to fulfill the recommendations of the Clinical Trials Working Group (CTWG). This national body of cancer research experts advised the NCI leadership on ways to strengthen the design and conduct of clinical trials, particularly to support the goal of incorporating molecular medicine into oncology clinical practice. The June 2005 CTWG report included the recommendation,

subsequently adopted, that NCI "promote the establishment of national clinical trial information technology infrastructures that are fully interoperable with NCI's bioinformatics grid."[15] Examples of new work in caBIG resulting from the CTWG recommendations include a core library of harmonized and standardized phase II and III electronic case report forms to speed data capture and enable the comparison and aggregation of information across the NCI's clinical trial portfolio, a clinical trials database that will contain information on all NCI-supported clinical trials, and an investigator and site credential repository. These products are designed to enable a seamless exchange of trial data between regulatory agencies, private entities, cancer centers, and the community practices that participate in cooperative group clinical research. These technologies are interoperable with the comprehensive set of modular, standards-based software applications described previously. Ultimately, a standardized clinical trial platform will facilitate the continuing development of modular clinical trial management applications that are interoperable among the various research stakeholders, enabling the integration of the clinical research infrastructure into emerging standard EHR systems.

The attributes involved in caBIG clinical trial deliverables support cancer research and translational medicine and have significant implications for the future in these areas. Researchers today face the opportunity to advance treatment beyond cytotoxic agents to targeted therapies based on clinical trials that focus on tumor biology. To be valid, these trials must be appropriately designed, set the standards and definitions for the data accurately, and involve comprehensive information sharing and collaborative participation across organizations. caBIG will deliver the clinical trials infrastructure necessary to meet the challenges and the opportunities presented by molecular medicine, enhancing the ability of the clinical trials community to move forward in this vital area of clinical practice.

An integrated suite of tools for managing and analyzing tissue specimens will also be released in 2007. caBIG has already released pioneering imaging tools that facilitate image collaboration, display and review, and change detection, as well as tools that support the use of imaging as a biomarker. The cumulative delivery of products reflects the commitment of caBIG to bring the fruits of the molecular medicine revolution to the cancer patient in the form of innovative new therapies.

caBIG and Interconnection With EHRs

The true significance of interoperable caBIG tools is that they interconnect not just with each other, but also with any other caBIG compatible, commercially available or locally developed software. But most important for oncologists, caBIG can connect to compatible EHR systems as well. For example, a practitioner seeking to better manage a patient study calendar could implement the patient study calendar itself or connect it to a compatible in-house clinical system. For translational research, the cancer Translational Research Informatics Platform (caTRIP) aims to solve the difficult translational research problem of outcomes analysis. When a patient enters the clinic, the oncologist should be able to look across a cohort of patients with similar characteristics to help inform treatment. caBIG solves this problem by leveraging caGrid to perform distributed queries across caTissue Core, Clinical Annotation Engine, the Duke Tumor Registry, and the caIntegrator Single Nucleotide Polymorphism database. The user interface is metadata driven, providing a flexible way to build queries and mine results.

Indeed, the use of electronic medical records opens broad new avenues for data-intensive research in understanding cancer. In recognition of this, the NCI has launched a pilot project designed to use linked databases to support ongoing basic, clinical, and population-based cancer research. The NCI Community Cancer Centers Program (NCCCP) is a pilot program created to bring the latest scientific advances and the highest level of innovative and integrated multispecialty care to a larger population of patients with cancer.[16] Community hospital-based cancer centers that offer multispecialty cancer care (medical, surgical, and radiation oncology) will compete through a request for proposal process to be one of approximately six centers to participate in this 3-year $9-million pilot. Results from the program will help provide recommendations to develop a community-based platform and information network for expanded access to a greater number and cross-section of patients. One of the specific goals of the NCCCP is increased knowledge of infrastructure requirements, necessary interfaces, and applicability of specific components of caBIG for community hospital settings.

The Path Forward

To achieve the full benefits of integrated, interoperable systems, oncology practices and cancer institutions can migrate toward caBIG compatibility through several paths and stages. Those without any electronic systems in place can explore the implementation of specific caBIG products, including suites of tools, or can purchase commercial products that are caBIG compatible. Those with systems currently in place can explore how to add the interfaces that enable caBIG interoperability. Those contemplating new systems, whether commercially built or developed in-house, can become familiar with the requirements of caBIG compatibility to avoid locking in solutions that cannot migrate to interoperability.[17] They can insist that commercial vendors offer caBIG compatible products.

At a more basic level, anyone can build specific forms or tools using the foundational resources that are freely available. One of the major problems confronting oncologists and the biomedical data management community is the panoply of ways that similar or identical concepts are described. Such inconsistency in data descriptors (metadata) makes it nearly impossible to aggregate and manage even modest-sized data sets to answer basic questions. The NCI, together with

partners in the research community, developed common data elements that are used as metadata descriptors for NCI-sponsored research and for the applications of caBIG. The cancer Data Standards Repository (caDSR) is a database and tool set that the NCI and its partners use to create, edit, and deploy common data elements. Any organization or commercial vendor that is creating EHRs or is defining data elements can go to the caDSR to see if standard data elements already exist and, if so, incorporate them into their systems. The caDSR is accessible online.[18]

The American Society of Clinical Oncology (ASCO) recently convened an EHR Workgroup to direct ASCO's EHR initiatives and to evaluate areas of need in this rapidly changing field of medicine (see the May 2006 issue of the *Journal of Oncology Practice*).Workgroup members are drawn from the ASCO Quality Advisory Group, Information Technology Committee, Clinical Practice Committee, and Cancer Research Committee. The Workgroup has established a dedicated area about EHRs on the ASCO Web site,[19] and a new IT Help Desk column in the *Journal of Oncology Practice*. Through these and other ongoing efforts, the time is opportune for physician involvement in EHR decisions and the opportunity to integrate caBIG in the daily practice of oncology.

We predict that the resources of caBIG and an oncology-enabled EHR infrastructure will strengthen both clinical research and care, and hasten the delivery of quality personalized care. The expertise of the cancer community can drive the integration of information systems to bridge these areas. Understanding the mission and conduct of basic and clinical cancer research and how research can be integrated with care—both locally and community wide—is necessary for effective collaboration, communication, and tools development.

Oncologists lead the cancer teams that implement the changes necessary for optimum information collection, management, and sharing for the health of patients and often, the community practice is the patient's central resource. How information is used at every level of patient care has an impact on the quality of that care. Quality of care is a challenge that every practitioner is vested in, both today and for the future.

For further information, visit the NCI caBIG Community Web site[20] and ASCO EHR Workgroup[19] for updated information.

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