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References


Online Database for Documenting Clinical Pathology Resident Education, Andrew N. Hoofnagle, David Chou, and Michael L. Astion (Department of Laboratory Medicine, University of Washington, Seattle, WA; *address correspondence to this author at: Department of Laboratory Medicine, Campus Box 357110, 1959 NE Pacific St, Room NW120, University of Washington Medical Center, Seattle, WA 98115-7110, Phone: (206) 598-6131, e-mail: ahoof@u.washington.edu)

Background: Training of clinical pathologists is evolving and must now address the 6 core competencies described by the Accreditation Council for Graduate Medical Education (ACGME), which include patient care. A substantial portion of the patient care performed by the clinical pathology resident takes place while the resident is on call for the laboratory, a practice that provides the resident with clinical experience and assists the laboratory in providing quality service to clinicians in the hospital and surrounding community. Documenting the educational value of these on-call experiences and providing evidence of competence is difficult for residency directors. An online database of these calls, entered by residents and reviewed by faculty, would provide a mechanism for documenting and improving the education of clinical pathology residents.

Methods: With Microsoft Access we developed an online database that uses active server pages and secure sockets layer encryption to document calls to the clinical pathology resident. Using the data collected, we evaluated the efficacy of 3 interventions aimed at improving resident education.

Results: The database facilitated the documentation of more than 4700 calls in the first 21 months it was online, provided archived resident-generated data to assist in serving clients, and demonstrated that 2 interventions aimed at improving resident education were successful.

Conclusions: We have developed a secure online database, accessible from any computer with Internet access, that can be used to easily document clinical pathology resident education and competency.

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In 1999 the Accreditation Council for Graduate Medical Education (ACGME) approved 6 core competencies for residents, patient care, medical knowledge, practice-based learning and improvement, interpersonal and communication skills, professionalism, and systems-based practice (1). As for any medical specialty, clinical pathology residency programs are responsible for training their residents to meet these competencies. However, documentation of a resident’s progress toward competency is difficult.

Clinical pathology residents serve as liaisons between the laboratory and clinicians, providing interpretation and consultation regarding laboratory testing. As preparation for practice as board-certified pathologists, they are
given graded responsibility in managing hospital laboratories. Exposure to patient care usually occurs while residents are on call for the laboratory, providing consultation on issues ranging from test approval to blood product use. Residency directors are responsible for assessing resident competence, but providing accurate data for such assessment is often difficult.

When taking call for the laboratory, residents are exposed to expansive medical literature to help guide them in their decision-making. On-line tools such as laboratory information databases (2) and Young’s Effects Online (3) can provide a starting point, but site-specific questions are frequent. As the rotation of residents taking call progresses from month to month and year to year, similar questions arise and the benefit of previous efforts in assisting other clinicians is lost unless an archive has been developed. To facilitate the improved patient care possible with access to previous research by clinical pathology residents, we developed a database of calls handled by our residents.

When not taking call, residents are required to amass a knowledge base that is sufficient to qualify them to serve as medical directors of laboratories. Residents typically amass this knowledge via rotations through the different laboratory divisions. These rotations include time spent performing the tests alongside technologists, interpreting results that need pathologist input, advising medical management decisions, and facilitating the transfer of new technologies to live laboratory testing. Unfortunately, time spent on call can interfere with these experiences. We describe the web-accessible database we’ve established and a quality improvement project to free up time for rotating residents to learn the information they need to be proficient.

Clinical pathology residents typically reside outside the hospital while on call. In addition, the calls they receive may indicate problems with client service from part of the laboratory or the laboratory as a whole. The database therefore includes 2 important features. First, it is accessible from any computer in the world with Internet access, and data are secured with a firewall and secure sockets layer encryption. Second, server-side software generates legible, formatted reports of each call. These reports can be circulated to the pertinent laboratory directors even if the residents do not work with them directly. In addition, deidentified reports of work performed by the resident can be generated to serve as documentation of progress toward proficiency in clinical laboratory medicine.

In the process of deidentification, fields known to contain Personal Health Information (PHI) are “stripped” from this formatted output. No mechanism has been implemented, however, to easily remove these fields permanently because we consider the database an addendum to the patient’s medical record, which we maintain intact in electronic format as long as is feasible. Furthermore, there is no known method or algorithm to remove PHI from free text-fields.

The devoted server runs Windows 2000 Server with the Microsoft Access database queried via the Open Database Connectivity (ODBC) protocol. Active server pages are used to generate HTML-tagged pages for remote clients, and HTML forms are used to enter data (Fig. 1). This application has been used on Windows and Macintosh platforms running common browsers, including Internet Explorer and Firefox. Free text searching is available across all relevant fields. Records are uniquely identified by 3 of a total of 21 fields available, and a hidden field contains a time stamp of modifications to the records. Residents familiar with HTML are able to include links to outside web pages and publications. Log files are maintained that can be used to associate a user with each
edit. Therefore, database integrity is maintained over time.

The server generates reports in rich text format available for download by the client computer. The entire application was written and put online in 65 h and requires 15 min per week to monitor security and operational logs. Back-up of the database is performed nightly with Windows Server software. A simplified, adaptable version is supplied to academic training centers at no cost and is licensed by the University of Washington.

In the fall of 2005 the department made an effort to respond to resident and faculty concerns regarding the increased time commitment required of residents on call. Three changes were instituted to help alleviate the problem. First, the task of interpreting 1:1 mixing studies during work hours was shifted to the resident on the coagulation service, when one was assigned. Second, calls originating within the microbiology laboratories during work hours were directed to the senior postdoctoral fellow in clinical microbiology. Similarly, the third intervention directed work-hour calls from the chemistry laboratories to the senior postdoctoral fellow in clinical chemistry. We used the database to evaluate the success of these interventions.

During the first 21 months the database was online, it accrued 4712 calls. In our program 1 resident is on call 24 h a day, 7 days each week. This averages to 7.2 calls per day; of which 58% were received during business hours (8 AM to 5 PM), and 57% originated outside the laboratory. The resident covers calls for 2 hospitals and our community outreach services, which combined generate ~15 000 billable tests each weekday and a total of 90 000 per week. Because the volume of calls changes during the calendar year, we compared overlapping calendar months of the years before and after the interventions (n = 8 months per year). For this comparison, 3460 calls were available. The total number of calls received during work hours fell from 1067 to 963, which was not statistically significant (Table 1); however, the number of work-hour STAT organ donor evaluations decreased from an attending to the resident on call. The change in the number of work-hour STAT organ donor evaluations was likely due to a change in behavior by the organ procurement organization served by the department; however, no formal policy change was instituted. At least 2 of the interventions were demonstrated to benefit resident education.

As ACGME guidelines and protocols for documentation continue to grow, the database also provides documentation for the educational opportunities provided to each of the residents, thus facilitating the increasingly overwhelming task of complying with new recommendations while improving resident education. Other medical disciplines have used online documentation of resident learning. The Computerized Obstetrics and Gynecology Automated Learning Analysis, a software suite built by a group of Canadian training programs in obstetrics and gynecology, documents resident encounters with patients (4). The residents identify and enter into the database critical learning opportunities that warrant further re-

| Table 1. Work hour calls per day before and after interventions. * |
|---------------------------------|---------------|---------------|-------|
| 1:1 mix interpretation         | 0.43 (0.20)   | 0.10 (0.13)   | 0.002  |
| Test approval                   | 0.14 (0.12)   | 0.06 (0.06)   | 0.10   |
| Complaint                       | 0.04 (0.08)   | 0.01 (0.02)   | 0.16   |
| Consultation                    | 1.25 (0.53)   | 1.36 (0.32)   | 0.55   |
| Critical value                  | 0.16 (0.08)   | 0.09 (0.10)   | 0.03   |
| Lab error/pt safety             | 0.13 (0.11)   | 0.09 (0.11)   | 0.12   |
| Mislabeled specimen             | 0.06 (0.05)   | 0.30 (0.20)   | 0.004  |
| Missing lab result              | 0.02 (0.02)   | 0.05 (0.09)   | 0.17   |
| Other                           | 0.10 (0.10)   | 0.07 (0.09)   | 0.19   |
| Alloantibody notification       | <0.01         | <0.01         | 0.35   |
| Requisition clarification       | 0.23 (0.19)   | 0.18 (0.19)   | 0.42   |
| Send out                        | 1.24 (0.37)   | 1.16 (0.23)   | 0.32   |
| STAT test approval              | 0.15 (0.08)   | 0.15 (0.09)   | 0.92   |
| Transfusion reaction            | 0.09 (0.11)   | 0.12 (0.10)   | 0.51   |
| Organ donor evaluation          | 0.38 (0.22)   | 0.21 (0.12)   | 0.02   |

* Mean (standard deviation). P values were determined by the Student t test using average calls per day across the overlapping 8 calendar months.
search. By identifying the gaps in their knowledge, residents were able to build a knowledge base and a set of resources for quickly answering difficult problems presented by their patients. Questionnaires revealed that residents who used the online database felt more comfortable with their abilities to succeed as lifetime learners than did residents at schools without such databases. Online tools are also used in otolaryngology, emergency medicine, and thoracic surgery residency programs (5–8). The database described herein similarly empowers clinical pathology residents and training programs.

In summary, we have developed an online database that is accessible from any computer with Internet access. This system can be used to document resident competency and simplify consultations with clinicians, improving patient care and laboratory service. As we have demonstrated, it can also be used to guide improvements in resident education. Above all, this online database will facilitate compliance with ACGME recommendations aimed at providing proficient physicians for the next century. Our future goals for the database are to expand its use by making it freely available to other institution, and to continue to study its impact on resident education and clinical service.

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References

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Tandem Mass Spectrometry for the Direct Assay of Enzymes in Dried Blood Spots: Application to Newborn Screening for Mucopolysaccharidosis II (Hunter Disease), Ding Wang,1 Tim Wood,2 Martin Sadilek,3 C. Ronald Scott,4 Frantisek Turecek,1* and Michael H. Gelb1,4* (Departments of 1 Chemistry, 3 Pediatrics, and 4 Biochemistry, University of Washington, Seattle, Washington; 2 Biochemical Genetics Laboratory, Greenwood Genetic Center, Greenwood, South Carolina; * address correspondence to M.H.G. at: Departments of Chemistry and Biochemistry, University of Washington, Campus Box 351700, Seattle, Washington 98195; fax 206-685-8665, e-mail gelb@chem.washington.edu; to F.T. at: Department of Chemistry, University of Washington, Campus Box 351700, Seattle, Washington 98195; fax 206-685-8665, e-mail turecek@chem.washington.edu)

Background: A treatment for mucopolysaccharidosis II (Hunter syndrome) has recently become available. Therefore, we developed a high-throughput assay method appropriate for newborn screening for the relevant enzyme, iduronate 2-sulfatase.

Methods: We synthesized a new iduronate 2-sulfatase substrate that can be used to assay the enzyme by use of tandem mass spectrometry together with an internal standard. The assay uses a dried blood spot on a newborn screening card as the enzyme source.

Results: When the assay was tested on dried blood spots, the iduronate 2-sulfatase activity measured for 13 patients with Hunter syndrome was well below the interval found for 57 randomly chosen newborns. The assay was more sensitive than previously reported iduronate 2-sulfatase assays.

Conclusions: This newly developed tandem mass spectrometry assay has the potential to be adopted for newborn screening of Hunter syndrome. This method also has the potential to be carried out in multiplex fashion to assay several different enzymes relevant to lysosomal storage diseases that are assayed in a single infusion into the mass spectrometer.

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We have been developing a panel of tandem mass spectrometry (MS/MS) assays of enzymes in dried blood spots (DBSs) for potential application to newborn screening of lysosomal storage diseases. Chamoles and coworkers showed that many lysosomal enzymes are active in rehydrated DBSs (1). The method involves addition of a designed, synthetic substrate for the selected enzyme to a buffer-rehydrated punch from a DBS. After incubation, the amount of enzyme-generated product is quantified, along with an isotope-labeled internal standard, by selective detection with electrospray ionization MS/MS (ESI-MS/MS). MS offers the advantages of analytical sensitivity, selectivity, and speed and is also ideally set up for multiplex analysis, whereby the products of many different enzymes may be quantified during a single infusion into the instrument. We previously developed a multiplex