

Toxicology News

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Internet Will Affect Future of Education & Expert Testimony

By Peter Stout

What if intimate seminars with internationally recognized experts were so accessible that one could experience interactive learning without traveling to a national meeting? What if continuing education (CE) opportunities were available on demand, without the expense or lost productivity of sending laboratory staff to other locations? What if one could provide courtroom testimony without leaving one's desk?

The internet is having a pervasive impact on society. For toxicologists and laboratories, it is an invaluable tool for gathering information and reporting results to clients or physicians. As yet, the internet has not affected the delivery of continuing education and expert opinions to the same degree. These important functions still largely depend on the expert going to the audience to present as faculty in a workshop or to the courtroom to testify.

In an era when requirements for continuing education appear to be increasing, the prospect of attending a workshop or participating in an event from your desk or any internet-accessible location is attractive. Any toxicologist, from bench worker to expert, who has testified is likely interested in "at-work" testimony with no more added equipment than a relatively inexpensive web camera and a headset. This article provides an overview of the applications of webcasting in these areas.

What is webcasting?

There are a variety of terms—webcasting, net meetings, web conferencing, web channels, webinars, web support, and others—that refer to interactive platforms for the presentation and sharing of information using internet connectivity. These web-based presentations offer the ability to greatly expand the access of individuals to participate in the

classroom. The cable TV medium allows for educational programs to be widely disseminated, but web-based "broadcasting" can be tailored to more focused groups, can be more cost-effective and affordable for smaller organizations, and has the invaluable addition of allowing interaction not possible with other broadcasting media.

To access webcasts from an individual's desktop, the help needed usually involves a computer support representative using a variety of tools (to the point of taking control of the computer from a remote location) to address an individual's issues directly. But the concept of the webinar or webcast permits the presentation of information to a much larger audience of potentially hundreds of online participants.

Online participants typically need no more than a high-speed internet connection (DSL or cable) to view webcasts. Some configurations of webcasts may call for running potentially dangerous programs such as ActiveX and JavaScript, which in a business computer environment may require information technology personnel to enable. As the user is typically accessing the webcast and not an unknown site, the risks of malicious software attacks are low. Generally, as the online audience grows larger, the more difficult it is for them to interact meaningfully with the presenters. Often audience interaction is limited to polling or instant text messaging (IM). With audiences in the tens of participants, interaction can involve sharing of files, "white boards" (interactive spaces for drawing), IM, or voice interaction from remote participants.

It is also possible for both presenters and audience members to be at multiple remote locations.

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LC/MS and LC/MS/MS are Tools That Warrant Caution

By Hans H. Maurer

Screening for and identifying drugs, poisons, or their metabolites is the first step in analytical toxicology, which may then be followed by quantification of the relevant compounds. Without doubt, gas chromatography/mass spectrometry (GC/MS), especially in the full-scan electron ionization (EI) mode, is still the reference method for comprehensive screening, providing the best separation power, specificity, and wide applications allowing detection of thousands of compounds in one step.

Liquid chromatography/mass spectrometry (LC/MS) and LC/MS/MS are less suitable for comprehensive screening, but allow target screening for a specific number of analytes, particularly those that are not amenable to GC/MS analysis because of hydrophilic or thermolabile properties (1, 2). In many cases, LC/MS(/MS)-based procedures are also applicable for quantification of these drugs (3). The pros and cons of GC/MS, LC/MS, and LC/MS/MS screening procedures are summarized in Table 1.

LC/MS(/MS) screening procedures

LC/MS(/MS) is increasingly employed for routine screening, especially in blood and plasma/serum analyses (1, 2). Several limitations of LC/MS screening should be kept in mind when establishing it in the laboratory. The choice of chromatographic system, and thus the separation power, is often limited because only certain volatile buffers and mobile-phase additives can be used. For example, GC/MS separation power can be enhanced by combinations of derivatization procedures to allow simultaneous screening of multiple analytes of different physicochemical properties such as acidic and basic analytes (1). In contrast, in LC/MS(/MS), mobile-phase limitations currently prevent the simultaneous identification of acidic and basic drugs.

In electrospray ionization (ESI) and atmospheric pressure chemical ionization (APCI), the mass spectra are often limited compared with EI mass spectra in GC/MS. Some structural information can be obtained with LC/MS/MS by causing collision-induced dissociation (CID) through an increase in the orifice or fragmentor voltage in single-stage LC/MS instruments or through an increase in the collision energy in LC/MS/MS instruments. Nevertheless, the CID fragmentation can vary considerably among instruments, which restricts its utility.

Similarly, the reproducibility of product-ion

spectra measured in different apparatus types reported by some authors could not be confirmed by others (4). Another important problem in using LC/MS(/MS) is the possible reduction of ionization of an analyte by co-eluting compounds, the so-called ion suppression. In these cases, a relevant toxicant might be overlooked and the measurement uncertainty can increase (5).

LC/MS concepts

Several concepts have been developed for LC/MS(/MS) screening and were recently critically reviewed (1, 2, 4). Some of these reviews summarize the development of screening procedures for blood analysis based on different single-stage quadrupole LC/MS apparatus operated in the full-scan mode, whereas others describe a screening method for urine samples based on mono-isotopic masses of therapeutic drugs, as determined by full-scan time-of-flight-MS. Such full-scan-based methods are, in principle, applicable to the detection of any compound amenable to LC and ionization. They are, however, generally less sensitive than methods targeting a limited number of analytes.

Multi-analyte screening methods using classical triple-quadrupole LC/MS/MS in the multiple-reaction-monitoring mode have been reported, but these methods require a priori selection of precursor ions, so are limited to the target analytes. Multi-component LC/MS/MS screening procedures were described for some drugs of abuse after simple dilution of urine. Although a two-fold to five-fold variability of analytical sensitivity near the cut-off levels was reported, neither matrix effects nor the rate of false-negative results were systematically studied. The use of APCI seems questionable because considerable matrix suppression was reported for analysis of diluted urine.

The author's working group is developing universal single-stage LC/MS procedures for screening, library-assisted identification, and, in contrast to the other screening procedures, fully validated quantification of many drug classes, such as anesthetics, low-dosed hypnotics and opioids, benzodiazepines, sulfonylurea-type antidiabetics, neuroleptics, and beta-blockers, in blood plasma. These methods should be transferable to other laboratories using the same instrumentation, but their applicability on other instrumentation cannot necessarily be expected.

Conclusions and perspectives

GC/MS, especially in the EI full-scan mode, is still the method of choice for comprehensive drug screening, while LC/MS(/MS) has been demonstrated to be an ideal supplement for the detection of

Table 1. Pros and Cons of GC/MS, LC/MS, and LC/MS/MS Screening Procedures

Procedure	GC/MS (EI)	LC/MS (ESI)	LC/MS (APCI)	LC/MS/MS (ESI)	LC/MS/MS (APCI)
Applicability to target screening	Medium	Medium	Medium	High	High
Applicability to comprehensive screening and identification	High	Low	Low	Medium	Medium
Effort for sample preparation	High	Medium	Medium	Low/medium	Low/medium
Risk of matrix effect	Low	High	Medium	High	Medium
Chromatographic separation power	High	Low	Low	Medium	Medium
Specificity of mass spectra	High	Medium	Medium	High	High
Inter-apparatus reproducibility of mass spectra	High	Low	Low	Low/medium	Low/medium
Availability of reference mass spectra	High	Low	Low	Low/medium	Low
Sensitivity	Medium	Medium	Medium	High	High
Detectability of polar compounds	Low to medium after derivatization	High	Medium	High	Medium
Detectability of thermolabile compounds	Low to medium for degradation products	Medium/high	Medium/high	Medium/high	Medium/high
Quantification power	Medium/high	Medium/high	Medium/high	High	High
Price of apparatus	Low	Medium	Medium	High	High

more polar, unstable, or low-dosed drugs, especially in blood plasma. The current disadvantages must be overcome before the power of the technique can be fully realized. Two areas of improvement needed for LC/MS(MS) include the manufacturers' abilities to produce standardized apparatus to reproduce fragmentation, as has been done for GC/MS over the years, and development of universal (on-line) work-up procedures isolating most of the relevant analytes in order to reduce ion suppression and matrix effects.

References

1. Maurer HH. Position of chromatographic techniques in screening for detection of drugs or poisons in clinical and forensic toxicology and/or doping control [review]. *Clin Chem Lab Med* 2004;42:1310–24.
2. Maurer HH. Multi-analyte procedures for screening for and quantification of drugs in blood, plasma, or serum by liquid chromatography-single stage or tandem mass spectrometry (LC-MS or LC-MS/MS) relevant to clinical and forensic toxicology [review]. *Clin Biochem* 2005;38:310–8.
3. Maurer HH. Advances in analytical toxicology: the current role of liquid chromatography-mass spectrometry in drug quantification in blood and oral fluid

[review]. *Anal Bioanal Chem* 2005;381:110–8.

4. Maurer HH, Peters FT. Toward high-throughput drug screening using mass spectrometry. *Ther Drug Monit* 2005;27:686–8.
5. Peters FT. Method validation using LC-MS. In: Poletti A, ed. *Applications of liquid chromatography-mass spectrometry in toxicology*, London: Pharmaceutical Press, 2006: in press.

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Continued Oxycodone Abuse Creates Analytical Challenges

By Loralie J. Langman

Oxycodone (4,5 α -epoxy-14-hydroxy-3-methoxy-17-methylmorphinan-6-one) is a semisynthetic opiate agonist derived from the opioid alkaloid, thebaine. It is similar to other phenanthrene derivatives, such as hydrocodone and morphine (1). The Food and Drug Administration approved oxycodone in 1976 as a Schedule II prescription drug to control moderate-to-severe pain, including postoperative, postextractional, and postpartum pain, as well as that associated with cancer and syndromes such as restless legs and Tourette's.

It is available in the United States as immediate-release tablets, controlled-release tablets (OxyContin), and an oral solution. Rectal and intravenous formulations are available outside the United States. Oxycodone is an ingredient in a number of commonly prescribed pain-relief medications in smaller doses combined with other active ingredients like aspirin (Percodan) or acetaminophen (Percocet).

OxyContin, which contains oxycodone in various strengths as the only active ingredient, is designed for controlled release to minimize the number of tablets a patient must take for around-the-clock pain relief. OxyContin's intended application is the relief of moderate-to-severe pain of long duration, such as pain caused by rheumatoid arthritis and cancer.

Absorption and metabolism

The oral bioavailability of immediate-release oxycodone is 60–87%, which is greater than other opioid agonists due to low pre-systemic and first-pass metabolism (2, 3). The onset of analgesia occurs about 15 minutes after administration of the immediate-release preparation. The peak concentration occurs approximately 1 hour after administration of the oral solution and 1.3 hours after a single tablet (2, 3). The maximal analgesic effect is seen 1 to 2 hours post-dose.

Controlled-release oxycodone has the same relative oral bioavailability as the immediate-release tablets. Controlled-release tablets exhibit a biphasic absorption pattern with two absorption half-lives of 0.6 and 6.9 hours, which reflects a spike after the initial release from the tablet, followed by prolonged release (2, 3). The immediate-release effect of the controlled-release preparation is a major difference from other controlled-release opioid products. Peak plasma concentration and extent of absorption are

dose-proportional. Steady-state plasma concentrations are reached 24 to 36 hours after initiating dosing. Controlled-release doses of 10 mg every 12 hours lead to area-under-the-curve (AUC) and peak concentrations that are equivalent of those of immediate-release doses of 5 mg every 6 hours (2, 3).

Oxycodone is about 45% protein-bound (2, 3). Once absorbed, oxycodone is distributed to skeletal muscle, liver, intestinal tract, lungs, spleen, and the central nervous system. It has been found in breast milk.

Metabolism occurs in the liver, with excretion principally in the urine. Oxycodone plasma concentrations are higher in the elderly, females, and individuals with impaired renal or hepatic function. However, the clinical relevance of this difference is low when giving chronic oxycodone at individualized doses. Cytochrome P450 enzyme CYP2D6 is known to catalyze the O-demethylation of oxycodone to oxymorphone, and CYP3A4 is known to catalyze the N-demethylation of oxycodone to noroxycodone. This is followed by glucuronidation. The analgesic effect of oxycodone is primarily due to the parent compound; although, oxymorphone has analgesic effects, it is only present in low concentrations.

Dosages

Oxycodone, when given in equianalgesic doses, is as effective as morphine in relieving pain while causing less nausea, vomiting, and hallucinations. Oxycodone may be an alternative in patients who cannot tolerate morphine or hydromorphone. It produces potent euphoria, analgesia, and sedative effects, and has a dependence liability similar to that of morphine.

The usual adult oral dose is 2.5–5 mg as the hydrochloride salt every 6 hours, although patients with moderately severe pain may take 10–30 mg every 4 hours as needed after titration (2, 3). Opiate-tolerant patients with chronic cancer pain often require doses of 20–45 mg every 4 hours, with some patients requiring as much as 120 mg every 4 hours (4). Controlled-release tablets containing 10–80 mg are taken every 12 hours (5). Dosages may be adjusted every 1–2 days because steady-state plasma concentrations are usually reached in 24 to 36 hours (2, 3). In general, published pharmacokinetic studies involving oxycodone show that plasma concentrations are generally less than 100 ng/mL.

Fatal concentrations involving oxycodone and at least one other depressant drug have been reported at an average of 1.0 mg/L (0.4–2.7 mg/L). For oxycodone alone, the reported average is 1.2 mg/L (0.1–8.0 mg/L) in postmortem blood (5, 6).

Abuse

Oxycodone has high abuse potential because it is very effective when taken orally, is often readily available, and has a high degree of consistent potency. Oxycodone abuse was highly publicized throughout North America in 2001, with abuse and diversion serious problems in certain areas of the United States (7).

Since OxyContin's introduction in 1996, the Drug Abuse Warning Network has reported an increasing number of emergency department mentions and deaths associated with it (7). Emergency-room episodes more than tripled from 1996 to 2002, with approximately 22,397 episodes in 2002 compared with 3,190 in 1996 (8). Moreover, the prevalence of lifetime nonmedical use of oxycodone increased from an estimated 11.8 million users in 2002 to 13.7 million users in 2003 (8), an increase in abuse of almost 15% in a single year.

OxyContin produces opiate-like effects and is sometimes used as a substitute for heroin. It is commonly known as oxys, OCs, killers, poor man's heroin, oxycotten, and hillbilly heroin. Many abusers find ways to defeat the time-release action by chewing the tablets, crushing them to snort the powder, or even injecting it. Injection requires preparation similar to that for heroin: removal of the tablet coating by either sucking on it or scraping it with the teeth or a razor blade, followed by melting the remainder on a spoon, adding water, and injecting the solution. Snorting or injecting hastens absorption.

Some manufacturers are considering developing a new formulation containing an opioid antagonist designed to decrease the effects of oxycodone when given parenterally. The antagonist would be coated with a chemical to keep it from dissolution. But if the pills were crushed, the antagonist would be released, thus cancelling the drug's effect (9). Most individuals who abuse this drug do so to gain euphoric effects, relieve pain, or avoid withdrawal symptoms. Those who take the drug repeatedly can develop a tolerance or resistance.

Diversion

Because of oxycodone's potent analgesic effects, it is often used in pain clinics, where concerns have arisen about the drug's diversion from legitimate medical use. Pharmaceuticals such as OxyContin can be diverted in many ways. The most widely used diversion technique at the street level is doctor shopping. Individuals who may or may not have a legitimate ailment requiring pain relief visit numerous doctors, sometimes in several states, to acquire large amounts of drugs to abuse or sell to others. Other illicit methods of distribution include diver-

sion from pharmacies, such as by theft or sale without a prescription; improper prescribing by physicians; or patients selling their supply on the street.

Analysis

This diversion and oxycodone awareness ultimately led to a large increase in the number of urine drug screens ordered. However, opiate immunoassays are generally not well-suited for the detection of 6-keto-opioids, such as oxycodone, due to the low antibody cross-reactivity of the commercial opiate kits. As a result, these immunoassays are not adequate for detection or monitoring of oxycodone use.

To address these concerns, urine specimens could be analyzed specifically for oxycodone by gas chromatography/mass spectrometry (GC/MS) or other robust methods. Oxycodone can be extracted from biological fluids by either liquid/liquid extraction or, more recently, solid-phase extraction. For greater sensitivity and detection, enzymatic hydrolysis with beta-glucuronidase can be used to increase the recovery of oxycodone from biological fluids. Methods used for detection include commercial immunoassays, thin-layer chromatography, liquid chromatography, automated liquid chromatography (Remedi), liquid chromatography/mass spectrometry, GC, and GC/MS. However, many smaller laboratories cannot afford the high cost and technical expertise needed to operate the equipment associated with these technologies. Some manufacturers have responded to this need by developing oxycodone-specific immunoassay kits with proposed cut-off values of 100 or 300 ng/mL.

The analysis and quantification of oxycodone are becoming increasingly important as its use and abuse become more widespread. Oxycodone poses an analytical challenge because its toxicity and therapeutic efficacy are directly affected by an individual's metabolic profile. Prospective analytical testing may include pharmacogenetic typing of individuals because oxycodone is metabolized to oxymorphone by cytochrome (CYP) 450 2D6. This enzyme is polymorphic with a prevalence of three mutations, *3, *4, and *5, in about 10% of the general population (10). In fact, 95% of individuals classified as poor drug metabolizers have one or more of these mutations. They are more likely to experience severe toxicity or therapeutic failure. Thus, pharmacogenomics, in the near future, might become an integral part of pain management to individualize oxycodone and other drug therapy with minimized adverse reactions.

References

1. Maddocks I, Somogyi A, Abbott F, Hayball P, Parker D. Attenuation of morphine-induced delirium in pal-

- liative care by substitution with infusion of oxycodone. *J Pain Symptom Manage* 1996;12:182–9.
- Oxycodone. Physicians' desk reference, 59th ed. Montvale, New Jersey: Thomson PDR; 2005:2818–24.
 - OxyContin/Oxy-IR. Compendium of pharmaceuticals and specialties, 40th ed. Ottawa, Ontario, Canada: Canadian Pharmacists Association; 2005:1511–3.
 - Glare PA, Walsh TD. Dose-ranging study of oxycodone for chronic pain in advanced cancer. *J Clin Oncol* 1993;11:973–8.
 - Baselt RC. Disposition of toxic drugs and chemicals in man, 7th ed. Foster City, California: Chemical Toxicology Institute, 2005.
 - Drummer OH, Syrjanen ML, Phelan M, Cordner SM. A study of deaths involving oxycodone. *J Forensic Sci* 1994;39:1069–75.
 - New DAWN, Drug Abuse Warning Network: <http://dawninfo.samhsa.gov/>. Accessed Feb. 3, 2006.
 - U.S. Department of Health & Human Services, Office of Applied Sciences: <http://oas.samhsa.gov/>. Accessed Feb. 3, 2006.
 - Fraser A, Jannetto P, Gock S, Wong S. The North American oxycodone story 2001–2002. *TIAFT Bulletin* 2002;32:13–5.
 - Linder MW, Prough RA, Valdes R Jr. Pharmacogenetics: a laboratory tool for optimizing therapeutic efficiency. *Clin Chem* 1997;43:254–66.

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Internet Education

Continued from page 1

Small-scale events can be conducted from your desktop with little more than an inexpensive web camera. The potential advantages of these technologies are likely to drive greater availability and ease-of-use in the near future.

Webcasts can take various forms. A “live streaming” webcast can include video, audio, and slides as well as IM and voice interaction. An “archival” webcast may be a recording of a live webcast event or an edited production prepared specifically for archival hosting. Thus, it is a digital record hosted on a server that can be made available to online attendees on demand. Obviously, an archival webcast does not offer the audience participation of a live event, but it offers the advantage that users can access it almost whenever and wherever they want.

Hosting issues

The host of a webcast faces numerous choices. The major issue for live events is bandwidth and reliability of the connection. Many providers of webcast-

ing services will not deal with hotel internet services and require establishing a “dedicated” line for the event, which is an additional expense and planning detail. The host must decide on the quality of video and audio, which can range from hiring professional videographers to using a simple camcorder.

Other costs are associated with the number of viewers of a live streaming event, on-site support, and the number of users of an archival event. Charges can involve per-minute plans or per-port plans. For example, the host can purchase a set number of minutes to cover 50 users viewing 60 minutes of material or purchase 50 ports for 50 users to participate in as much material as desired. A per-minute plan is more applicable to a one-time event and a port-type plan is appropriate for a regularly recurring seminar series or event. Some providers quote costs per event and per attendee.

Providers vary in the services they offer, including the kinds of prequalification questions that can be asked of attendees during registration, the level of attendee participation (most offer IM by attendees), and the level of e-commerce capabilities (the ability to charge fees and control attendees).

What web-based tools mean for the profession

The e-learning industry has been estimated to be a \$7.5 billion per year market (1). John T. Chambers, the chief executive officer of Cisco Systems, said that e-learning is “the next big killer application for the internet” that is going to be so much more important than e-mail that it will make “e-mail usage look like a rounding error (2).” It has enormous potential for improving the quality and availability of professional education for toxicology.

A recent survey by Wainhouse Research found that more than 61% of corporations are using web-based tools to replace traditional in-person events and more than 87% are using web-based tools for “new tasks” not being done before to reach audiences that previously were not considered (3). It should be said that the survey subjects were companies currently using webcasting services from WebEx, so these are companies already comfortable with the concept.

Workshops are an increasingly important component of national forensic toxicology meetings. In a 2005 survey of the American Academy of Forensic Sciences toxicology section, 96% of respondents replied that annual meeting workshops are important and 80% said they “strongly agree” or “agree” that they would attend regional workshops if offered (4).

The organizing committee for the 2005 Society of Forensic Toxicology Meeting followed up the meeting with a small informal, non-scientific survey.

All respondents (23) replied that they would attend workshops that were available as a webcast. All respondents replied that they would attend the same number or more workshops in 2006 as in 2005. Finally, all but two respondents (both of whom were retired or independent consultants) indicated that there were additional people at their institutions who would not attend the physical meeting, but would attend webcasts if they were offered. Many toxicologists seem to be interested in having educational opportunities available via webcasts. The American Association for Clinical Chemistry already offers courses by webcasting and uses web-based tools for other CE.

As webcasting becomes more common in CE, important concerns will need to be considered in the planning of courses regarding who has access to the web-based information, the scientific acceptability of the information presented, and the potential for the information to be taken out of context. The larger the audience for an event, the larger the potential for misinterpretation and misuse of the information and the greater the demands on the organizers to present high-quality, scientifically acceptable material. E-learning is not likely to replace more traditional learning opportunities, but should be seen as providing another tool to deliver educational opportunities that might not be possible otherwise.

Web-based testimony tools

A forensic toxicologist's typical experience in providing testimony support for laboratory results involves driving many miles to sit in a courthouse for an extended period, only to have the defense realize that "the lab guy is here" and plead out. The witness must then drive many miles back home to contend with the backlog of cases that developed while he or she was traveling. It is difficult to overstate the potential appeal for a laboratory professional to give expert or witness-of-fact testimony that allows for interaction with the courtroom without leaving the laboratory. Such an ability would improve both lab and courtroom efficiency. If laboratory personnel are at the bench more, more samples are getting processed and backlogs are not being created.

A growing number of courtrooms are exploring remote testimony and virtual courtrooms. The College of William and Mary's Courtroom 21 project (www.courtroom21.net) is an ongoing international demonstration and experiment to determine how technology can best improve all components of the legal system. They have done considerable work on determining what is necessary for a virtual courtroom and the introduction of evidence in a digital fashion. They also have begun a certification program to pro-

vide a quality standard for court personnel responsible for audio and video systems.

A current example of the use of remote conferencing in providing testimony is occurring in the state of Kentucky. A pilot project began in 1998 and since then a statewide system has grown to include internet-based systems in 46 of the state's 120 counties. All forensic disciplines have used this method of testimony, but the system has been most useful for toxicology and drug analysis testimony. This is largely due to the testimony load that comes with cases involving driving-under-the-influence and confiscated materials. The system results in many fewer requests for testimony because having a laboratory professional immediately available reduces the gamesmanship associated with subpoenas to the laboratory. For the Eastern Regional Laboratory, court appearances dropped 50%. Every factor associated with court appearances, such as time and cost, was reduced by 50%. Case production increased because analysts spent more time at the bench.

The systems chosen in Kentucky have been dictated largely by the quality of the connection available, which is usually a rural vs. urban difference. Most courtroom systems have some sort of video-recording capability that simply needs a codec unit (for compressing and decompressing data) to transmit the live signal to its destination. A typical setup for a lab costs in the thousands of dollars and consists of a codec, monitor, and microphone. More elaborate systems require additional technology, and there may be some minor construction costs for creating a "witness box" and proper lighting.

The strengths of the system are obvious in cost savings, improved efficiency, and improved ability of the laboratory to provide the support needed by the court system. Weaknesses of the system have revolved largely around lag times and smooth image movement during transmission that can be distracting for all involved. Limited band width has a direct effect on the quality of the image/audio and ISDN systems have long-distance phone connection issues that can be troublesome. Continuous improvements in the availability of wider bandwidth and better compression technologies will reduce, if not eliminate, these issues.

Conclusions

The potential for web-based interactive tools to alter how toxicology professionals pursue continuing education is substantial. Web-based tools can provide access to higher quality instruction more broadly through the profession than the classical national-meeting-based model. Web-based instruction cannot replace the interaction available at a live meeting and

should not attempt to replace the national meeting. The benefit is the greater ability for more individuals to participate in more interaction with peers. In an age of ever-increasing regulation and requirements for continuing education, the ability to provide continuing education to keep staff current in a manner that does not disrupt production is advantageous to all involved.

As acceptance of web-based testimony grows, the efficiency of courtrooms and forensic laboratories will benefit. The possibility of no longer losing time and production to travel and wait times is exciting. The possibility that fewer cases will be dismissed because laboratory witnesses will always be available to introduce evidence and that the court system's efficiency will be improved has tremendous implications for all of us.

References

1. O'Leonard K. Best practices in online customer training. White paper by Bersin and Associates, December 2004. Available at www.bersin.com.
2. Friedman TL. Foreign affairs: next, it's E-ducation. *New York Times*, Nov. 17, 1999: A29.
3. Nilssen A, Davis A. Unearthing the true value of web seminars and on-line events: applications & results from the customer's perspective. White paper by Wainhouse Research, September 2005. Available at www.wainhouse.com.
4. American Academy of Forensic Sciences website. 2005 member survey. Available to AAFS members at www.aafs.org.

Additional resources

1. Capper J. E-learning growth and promise for the developing world. World Links for Development, The World Bank. Available at www.techknowlogia.org/TKL_active_pages2/CurrentArticles/main.asp?IssueNumber=11&FileType=HTML&ArticleID=266. Accessed Jan. 27, 2006.
2. Danner RA. Strategic planning for distance learning in legal education: initial thoughts on a role for libraries. Duke University School of Law. Available at www.law.duke.edu/fac/danner/distanceLearning.html. Accessed Jan. 27, 2006.
3. Introduction to video technologies for distance education. The Commonwealth of Learning. Available at www.col.org/Knowledge/ks_videoconferencing.htm. Accessed Jan. 27, 2006.
4. On demand webcast: clinical diagnosis and management of anthrax - lessons learned. Thursday, November 29, 2001. University of North Carolina School of Public Health. Available at: www.sph.unc.edu/about/webcasts/2001-11-29_lessons/. Accessed Jan. 27, 2006.
5. Rapid knowledge transfer in changing times: how the pharmaceutical sector solves communication challenges with virtual classroom solutions. Larstan Business Reports 2005. Available at www.webex.com/overview/technology-white-papers.html.

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