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Short communication

Solving certain dental records problems with technology—The Canadian solution in the Thailand tsunami response

David Sweet *

Bureau of Legal Dentistry Laboratory, The University of British Columbia, 6190 Agronomy Road, Suite 202, Vancouver, BC, Canada V6T 1Z3

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Abstract

Each natural or man-made disaster presents a different set of circumstances and, as a consequence, each event results in new challenges for response teams. The very large number of deceased victims in recent tragic events is certainly one of the enormous challenges that can tax many different resources for identification specialists. But there are other significant challenges. And during the response, some of these seem insurmountable. They can be solved if we embrace technologies outside the customary disciplines.

The Canadian identification effort following the December 2004 tsunami involved responders from several disciplines. Each discipline faced challenges in many different and special areas that were difficult and in some cases previously unseen. This paper presents examples of the ways the Canadian identification team used Internet technology to solve problems that were encountered when it became necessary to duplicate victims' dental, medical and personal records, and transport these records halfway around the world. Digital images of the records were saved at high resolution in multi-page PDF files. These images were made available to on-site personnel using an encrypted, password-secured website.

Keywords: Forensic identification: Disaster victim identification; Dental records; Internet

1. Introduction

A devastating tsunami was spawned in the early morning of December 26, 2004 by a magnitude 9.15 earthquake off the coast of Sumatra, Indonesia in the Indian Ocean. The waves traveled many thousands of kilometers and resulted in the deaths of approximately 275,000 people originating from 60 countries from Indonesia and Myanmar to Kenya and Tanzania. A large international team responded in an unprecedented relief effort. This team comprised first responders to save lives and treat and evacuate the injured; clean-up crews to remove dangerous debris and mobilize personnel and equipment; and disaster victim identification (DVI) specialists to recover and identify the dead and missing and repatriate or dispose of the remains.

Thousands of tourists were vacationing at the beach resorts of southern Thailand at the time of the tsunami. As a consequence of the coastal topography, the three waves approaching the Thailand shore varied in height from 4 to 12 m at different points of contact. Estimates of casualties included 5300 confirmed dead from 44 countries [1] with 3350 persons missing, 8400 injured and over 53,200 affected and displaced in six provinces.

The number of Canadians that were missing and presumed dead in Thailand was initially overestimated at several hundred souls. As more reliable information became available and the early chaos began to subside, it was determined that some of the missing had made it to first aid posts for treatment and had survived. Some were able to leave the country and seek refuge elsewhere. Dealing with inaccurate early data in this situation is something that was repeated for the governments of all countries attempting to locate their citizens. Such inaccuracies are not uncommon in a disaster response, but in this case the enormous number of corpses, amount of physical destruction to the land and buildings, tropical climate, and lack of infrastructure increased the complexity of the response effort to previously unseen levels.

As part of the international response, Royal Canadian Mounted Police (RCMP) specialists were deployed to Thailand within days of the event to evaluate the impact on Canadians, assist the international efforts, and assess the on-site needs and requirements. Team members included forensic evidence

* Tel.: +1 604 822 8822; fax: +1 604 822 8884.
E-mail address: dsweet@interchange.ubc.ca.

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technologists and fingerprint, anthropology, and other identification specialists. With respect to the DVI issues, in cooperation with this on-site team, a Task Force was established at home to recover, collate and transport the necessary ante mortem records that would be needed for identification. Considering the condition of the bodies from advanced decomposition in the tropical conditions, it was clear that a large variety and amount of ante mortem data would be needed. As a minimum, efforts were made to collect the following from the next of kin: physical descriptions, medical and dental records, indirect DNA reference samples and, if possible, descriptions of clothing, jewellery and other personal effects thought to be in the victims' possession at the time of the earthquake.

2. Dental response

The Task Force designated the Bureau of Legal Dentistry (BOLD) Laboratory at The University of British Columbia in Vancouver as the repository and clearinghouse for Canadian ante mortem dental records. Efforts were made by members of the Task Force and BOLD personnel to acquire all available records and data through interviews with the victims' family members who reported the names and contact information of dentists and physicians, and submitted DNA samples, photographs and other personal data. These records were recovered by local police officers that forwarded them to Vancouver from various locations across the country. Custody of the dental records was released to BOLD in preparation for these data to be sent to Thailand while the Task Force analyzed the DNA, medical, fingerprint, and personal records. Subsequently, all of the original records were to be taken by hand to the site by forensic specialists being deployed there. Depending on the time available, delivery by response personnel might not be possible so it was decided to send the records via commercial courier if required.

When the original dental records were received at BOLD, each record was examined in its entirety for content, legibility and orientation. The main problem encountered was intraoral radiographs were either incorrectly mounted (e.g. one or more films mounted back-to-front) or mislabeled (e.g. label mounted on back of film). In some cases, dentists refused to release original records and faxed copies were sent to the Task Force. Considerable time was lost to make demands on the dentist and seize the original records. Once these issues were corrected, best practices dictated that the records should be duplicated in the highest quality manner as insurance against potential loss since the irreplaceable original records were to be sent halfway around the world.

The highest quality duplication method was determined to be digitization, so the complete records were scanned into a computer at high resolution. This produced an electronic resource that provided the best possible information if the records were misplaced in the complexity of the disaster response efforts on site.

Generally speaking, in all forensic cases, one of the primary responsibilities of the odontologist is to ensure continuity of the evidence. Significantly, this includes not only physical exhibits, such as teeth and jaws, but also the ante mortem records from the putative victim. Ensuring the accuracy of labels showing the person's name and demographic data and accurately recording the chain of custodial ownership are established norms with respect to correct handling of forensic exhibits. When original records are duplicated, this responsibility for authenticity and accuracy also extends to the orientation of the records and quality of the duplication. The duplicate record must be able to stand alone as an exact analog of the original. Unfortunately, without extreme care at the time of duplication, this is not always possible and many cases have been unsuccessful because of poor quality duplicate records.

The same fastidious examination and handling of the records during duplication was required in this case to maintain orientation and accuracy. The BOLD odontologist verified in each case that the records were: (a) as complete as possible, (b) correctly oriented with respect to the patient's right and left, (c) color entries were recorded in color, and (d) digital resolution was sufficient to produce high-quality output.

3. Technological methods

Desktop computer equipment in typical use at BOLD is not substantially different than the equipment available to other odontologists. A 867 MHz CPU with 640 MB RAM using Adobe Photoshop CS v8.0 (Adobe Systems Inc., San Jose, CA) and a Umax PowerLook 1000 transparency scanner (Umax Technologies Inc., Dallas, TX) were used to input the dental records to the computer. The images were saved in TIFF format at 400 dpi.

Digital images of the records were uploaded to a server for viewing from remote locations. The images were saved in Portable Document Format (PDF) using Acrobat Professional v6.0.2 (Adobe Systems Inc., San Jose, CA). The PDF format is a standardized specification for more secure and reliable electronic document distribution and exchange. PDF files can be saved, viewed and printed by anyone, on any system, using free Adobe Acrobat Reader® software regardless of either the operating system or the original application used to produce the files or file contents.

To view the files on the Web, the end user requires an Internet browser and the Acrobat Reader® plug-in, which can be downloaded from the Adobe website to any remote location with Internet access. Most web users are already familiar with the use of PDF files since they are widely accepted as an easy-to-use file exchange protocol.

By design, the PDF file uses a page structure that makes it an ideal format to contain a series of related images. For example, one file can be set up to include the contents of one case, with each page containing separate images. This structure is easy to set up since the images (pages) can be reordered as needed and each image can be compressed individually to make it more suitable for web transmission.

The server was configured using a 3 GHz CPU, 512 MB RAM and 40 GB hard drive. The software recommended to

handle these data included: any popular computer operating system, such as Windows, Linux and Unix; the popular web servers, such as HS or Apache–SSL; and any of the popular scripting languages, such as ASP, PHP or JSP. The database component can be satisfied with applications such as Microsoft-Access, SQL Server, Oracle or MySQL.

Confidentiality of the data and security of the website are obviously important issues that must be considered. In this case, security involved limiting access to the web page that contained links to the PDF documents by protecting it with a specific user name and password. These credentials were saved in a Microsoft-SQL Server database and only made available to the odontologists and RCMP liaison officers on site in Thailand.

Another level of security was afforded by the use of Secure Sockets Layer technology for encrypting the client-server communications over the Internet. SSL is the same technology that is used to protect confidential credit card transactions. Additionally, the case files were stored on the server in a location that was completely separate from any other data or websites that were housed on the server. This made it impossible to link directly to the case files from any unauthorized HTTP address, including through any Internet search tools (e.g. Google). The case files could not be found except through use of the designated credentials. The case files could not be bookmarked within the browser, even after the correct credentials were entered, which removed the possibility of unauthorized persons gaining access by searching through favorites or reloading the site after an authorized user had logged out.

Finally, the PDF case files were served dynamically from the secure folder on the server whenever an authorized user requested the files. The script on the web page allowed retrieval of the specific file but at other times and from other routes, the secure folder was inaccessible.

4. Discussion

Safe transportation of the ante mortem records became a problem in the initial response because many airports in the disaster region were not able to accept commercial air cargo. Courier companies had reduced access so shipments by courier were unreliable. The team was able to use the security detail that accompanied several top Canadian government officials that visited the site to transport certain ante mortem records. But this was inefficient since these flights were not routine. Plus demand for access to ante mortem dental data within the DVI response was increasing. A decision was made to use the Internet to allow on-site personnel to view and work with the digital copies of the original records using the technology described. This resulted in an efficient and secure method to expedite the transfer of these data.

Soon it was realized that this method could be used to transfer other important data. Custody of urgently needed patient records was released to BOLD; they were digitized and uploaded to the secure server. Medical radiographs (400 dpi), fingerprints (1600–2400 dpi) and photographs of teeth, clothing and jewellery (400 dpi) were added to the multi-page PDF files for certain victims and relayed to Thailand.

The importance of careful and systematic review by the odontologist of the dental records before duplication and transportation cannot be overemphasized. A double-check system at this stage, so that this important step is independently verified by a second examiner, emphasizes the critical nature of this review step. It is especially important for the dental radiographs to be correctly oriented. When they are viewed on the computer screen, the images should appear as if the person is standing in front of you. A right–left laterality marker must be added to the image, especially if the standard practice of mounting the images (as if looking at the patient in front of you) is not used.

Encryption of the website, the need for credentials to access the files and the extensive security around the handling of these data may seem unnecessary to some. After all, the aim is to provide quality data to all that are involved in the identification effort to maximize the positive outcomes. However, it must be remembered that personal and family information and other unique physical data from the patient is being widely distributed. From both an ethical and legal point of view, the confidentiality of the patient record must be maintained.

Set up and administration of a secure website is not difficult; any network administrator or Internet consultant should be able to accomplish this once the hardware and software requirements are available. The administrator as part of the initial set up can establish Website access protection methods. A computer programmer is needed to complete the necessary scripting and software programming.

The use of PDF files is seen as a distinct advantage for distribution of high-resolution digital images. Acrobat Reader® is universally available and is free of charge, so the utility of the program is well known. Even more important is the potential to use the magnification tool in Reader® to enlarge the image on the monitor to see minute detail. This was important when viewing the radiographic images, and it was crucial when working with the fingerprints.

The records in this response were first digitized to produce high quality copies of the records in case the original files were lost in transit. This is recommended as a standard operating procedure at any time the custody of such records and data must be released to others. Using the computer technology mentioned in this paper to produce high-resolution images will provide good insurance against losses of this type.

An additional use for these digital images was determined, in this case, after challenges arose with respect to transporting the actual records in an expeditious manner. Using the web server and Internet technology to transmit the PDF files of dental, medical, fingerprint and personal records remotely to the DVI on-site effort proved efficient, reliable and expeditious. Once agreement was reached to use BOLD's website for this purpose, the technology team uploaded and encrypted the data within 26 h. The digital records were used to confirm a tentative identification within 6 h of images being made available to identification personnel in Thailand.

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