Digital pathology: Attitudes and practices in the Canadian pathology community

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Received: 17 January 2012 Accepted: 27 June 2012 Published: 14 March 2013

Abstract

Digital pathology is a rapidly evolving niche in the world of pathology and is likely to increase in popularity as technology improves. We performed a questionnaire for pathologists and pathology residents across Canada, in order to determine their current experiences and attitudes towards digital pathology; which modalities digital pathology is best suited for; and to assess the need for training in digital pathology amongst pathology residents and staff. An online survey consisting of 24 yes/no, multiple choice and free text questions regarding digital pathology was sent out via E-mail to all members of the Canadian Association of Pathologists and pathology residents across Canada. Survey results showed that telepathology (TP) is used in approximately 43% of institutions, primarily for teaching purposes (65%), followed by operating room consults (46%). Seventy-one percent of respondents believe there is a need for TP in their practice; 85% use digital images in their practice. The top two favored applications for digital pathology are teaching and consultation services, with the main advantage being easier access to cases. The main limitations of using digital pathology are cost and image/diagnostic quality. Sixty-two percent of respondents would attend training courses in pathology informatics and 91% think informatics should be part of residency training. The results of the survey indicate that Pathologists and residents across Canada do see a need for TP and the use of digital images in their daily practice. Integration of an informatics component into resident training programs and courses for staff Pathologists would be welcomed.

Key words: Digital pathology, informatics, pathology, telepathology, virtual slides

INTRODUCTION

Over the past few years, the evolution of information technology has vastly changed the practice of pathology. Novel techniques have been implemented, primarily in the form of digital images and telepathology (TP).¹¹ Digital pathology can be defined as the electronic capture, management, analysis and distribution of gross or microscopic specimens. It encompasses the use of digital images as well as TP.

The spectrum of applications of digital pathology is wide and includes primary diagnosis, intraoperative diagnosis,
consultation, quality assurance, archiving, education, conferences, and research. Widespread adoption of digital pathology applications could expedite second opinion consultation; digital consultation can be performed within hours versus days to weeks for cases sent through the mail. It can also help improve service quality to under-serviced areas, facilitate immediate conferencing about a specimen by individuals in different locations, reduce costs of slide storage, limit slide loss, expedite slide retrieval and overcome the problem of slide fading.

There are, however, several challenges to the widespread implementation of digital pathology, including cost, and a lack of standardization. Added to this is the difficulty and expense of travel for specialist pathologists to these centers, especially in the harsh Canadian winter. This makes Canada a unique target for the widespread implementation of digital pathology.

Since pathologists represent the immediate “customers” of the technology, it is of prime importance to fully understand the reaction of pathologists towards this emerging technology. The objective of this study was to analyze the attitudes of pathologists and pathology residents throughout Canada towards the spectrum of digital pathology applications. This will be an essential step towards better implementation of digital pathology in our practice through a thorough understanding of the needs, concerns, and expectations of digital pathology.

MATERIALS AND METHODS

The study was conducted through an online survey consisting of 24 questions of different formats. The requested answers were in the form of yes/no, multiple choice and free text questions. The questionnaire was created in English and in French and addressed to all Canadian provinces. An E-mail was sent out through the databases of the Canadian Association of Pathologists-Association canadienne des pathologistes (CAP-ACP), which includes all anatomical pathologists across the country (practicing and retired) in addition to residents, fellows and non-degree trainees. E-mails with a link to the questionnaire were also sent to all anatomical pathology residency directors across Canada. A reminder was sent half-way through the study. The study was approved by the Research Ethics Board of St. Michael’s Hospital. A copy of the questionnaire is shown in Supplementary Table 1.

RESULTS

A total of 157 individuals answered the survey. The overall response rate was 17% of all CAP-registered pathologists (27% of practicing pathologists and residents). The breakdown of respondents according to level of practice is shown in Figure 1.

Telepathology

Survey participants gave a range of definitions for Telepathology (TP) as shown in Supplementary Table 2. Forty-three percent of respondents state that TP is used in their institutions. As shown in Table 1, the main applications were for teaching purposes, followed by frozen section (intraoperative) consultation, and routine diagnostic consultation services (30%). TP is not widely used for routine diagnosis or quality assurance activities. Interestingly, 71% of respondents see a need for TP in their practices.

Digital Images

The majority of the respondents are familiar with the term “virtual slide” (97%). Static or virtual digital images are routinely used by 85% of pathologists and residents as part of their practice or training and 90% of respondents feel there is a need for digital pathology in their institutions. Twenty eight percent of practicing pathologists have requested a second opinion/consult using a digital image. The suggested applications of digital pathology are depicted in Figure 2. Of note is that only 35% indicated the potential use of digital images for routine diagnosis. Interestingly, 63% of our cohort felt that it would be an advantage to have “routine” digital images for gross pathology specimens. Only about one third of the participants (37.4%) had experience of image analysis programs. This was mainly used for research purposes (83%), estrogen and progesterone receptor quantification (22.6%) and ki-67 proliferation index calculation (30%). As shown in Figure 3, digital pathology became a significant component of pathology education in Canada. 40-70% of participants indicated the use of digital pathology as a tool for learning and continuing medical education (CME). Moreover, the vast majority (98%) were in favor of an on-line digital image library (static or virtual) to review the features of challenging and rare cases.

The potential advantages of using digital images are depicted in Figure 4. The ‘other’ category responses given for advantages of digital pathology included the ability to perform automated images analysis, that images could be projected at conferences versus sitting at crowded multi-headers and the fact that it enables remote pathology.

As shown in Table 2, there are a number of limitations that were raised for using digital imaging in practice. Within the “other” category for disadvantages of digital
pathology, responses included the possibility of image manipulation, technologic limitations of institutions, poor inter-observer variability, time to scan/digitize slides and issues regarding billing/payment for consultation services. Interestingly, most pathologists did not recognize the difficulty of training as a major disadvantage.

Digital Pathology Infrastructure and Training

In terms of equipment, 51% of respondents state that their institutions have a virtual slide scanner and 45% of respondents have used a slide scanner before. The majority of respondents (64%) would prefer cases to be stored as both glass slides and digital images.

Eighty-four percent of respondents stated that they are interested in following the literature on digital pathology. A favorable response is observed towards pursuing digital pathology training; 57% of pathologists and 77%
Supplementary Table 1: Survey

Level of practice
- Resident
  - Pathologist with 0-5 years of practice
  - Pathologist with 6-10 years of practice
  - Pathologist with 1-20 years of practice
  - Pathologist with >20 years of practice

How do you define telepathology?

Is telepathology used in your practice?
- Yes
- No
- I’m not sure

If yes to Q3, In what capacity is the technology used (choose all that apply):
- Teaching
- OR/frozen consult
- Routine diagnosis
- Consult service
- QA

Do you see a need for telepathology in your practice?
- Yes
- No

Are you familiar with these terms?
- Digital image
  - Yes
  - No
- Virtual slide
  - Yes
  - No

Do you use digital images (static or virtual) in your practice/training?
- Yes
- No

In what teaching environments is digital pathology used?
- CAP PIP or ASCA check path or CME activities
- Web
- Conferences
- Resident education
- Other (please specify)

Do you see a need for digital pathology in your practice/training?
- Yes
- No

What do you think should be the application(s) of digital pathology? (choose all that apply)
- Teaching
- OR/frozen consult
- Routine diagnosis
- Consult service
- QA

Have you ever requested a second opinion/consult using a digital image?
- Yes
- No
- N/A

What are your observed advantages in using digital images? (please select all that apply)
- Faster
- Conservation of space
- Cheaper
- Easier access

(Contd...)
Supplementary Table 1: Contd...

| N/A
| Other (please specify):
| In your opinion what are the disadvantages in using digital images (choose all that apply)?
| Cost
| Compromise diagnostic quality
| Security
| Not representative
| Time to make diagnosis
| I am not comfortable with the technology
| I am concerned about image quality
| it would take too long to learn how to use the technology
| there is not a perceived need for the service
| other (please specify):
| Are you aware of/read about digital pathology in the literature?
| Yes
| No
| Would you attend an informatics workshop/training course if available?
| Yes
| No
| Do you see a need for routine digital imaging of gross surgical specimens?
| Yes
| No
| How would you feel if the Royal College exam in Pathology was totally digitized instead of using glass slides?
| In favour
| Not in favour
| Undecided
| N/A
| Do you think resident’s training should include a pathology informatics component (that focuses on the creation and use of imaging modalities)?
| Yes
| No
| Would you favour an on-line digital (static or virtual) library to review features of challenging or rare cases?
| Yes
| No
| Have you ever used image analysis programs?
| Yes
| No
| If yes to above, what was the main application?
| ki-67 proliferation index percentage
| ER, PR percentages
| Research
| Other (please specify):
| Does your institution have a virtual slide scanner?
| Yes
| No
| Not sure
| Have you ever used a virtual slide scanner
| Yes
| No
| What would be the better option for slide storage in your institution?
| Digital images
| Glass slides
| Both
**Supplementary Table 2: Responses to survey question 2**

| Response                                                                 |
|--------------------------------------------------------------------------|
| Gross or microscopic pathology images on monitor for the purpose of diagnosis and consultation |
| Usually, it is the review of anatomic pathology microscopic slides through an electronic connection |
| Visual capture of pathology images for transmission electronically |
| Digital pathology which may be used for remote consultation |
| A fad that will soon pass |
| Computers to transmit images |
| Use of digitalized slides for remote diagnosis |
| Using digitally recorded pathology materials to make a diagnosis |
| Primary diagnosis by digital pathology from a distance |
| Viewing slides remotely |
| Internet imaging |
| Consult and review at a distance by academics. |
| Sending visual images of slides for discussion/consultation |
| Use of digital medium in pathology |
| The practice of pathology using technology to review and sign out cases at a distant site |
| Imaging transmission and reporting |
| By definition, telepathology is the practice of pathology at a distance |
| Communicating with digital photos of pathology histology |
| Remote, real-time diagnosis |
| Pathology at a distance |
| Use of digital imaging to practice pathology from a remote location |
| Using electronic means to transmit surgical pathology information to a remote site for consultative or sign out purposes |
| Very useful |
| The use of informatics devices to process pathologic specimens in order to pose a diagnosis |
| Sending images via telephone |
| Remote review of microscopy using computers/internet. Also, consultation with consultants via emails/telephone while reviewing online microscopy |
| Use of IT to allow remote viewing of pathology specimens/slides for diagnostic or educational purposes |
| Review of slides from remote location (clinical and edu) |
| Really? Technology used to aid in pathology services challenged by distance and time |
| Pathological interpretation of slides via digital technology |
| Digitalization of images that are evaluated remotely |
| Digitized slides and online conferencing |
| Using virtual slides to consult experts at a distance |
| Remote diagnosis using telecommunication tools |
| Real time pathology diagnosis/teaching at a distance |
| Getting rid of the “physical distance” in pathology |
| Transmission of gross and/or microscopic images, usually digitized, via the web to facilitate diagnosis, teaching or research in pathology |
| Digital slides |
| Use of tee tolls to do any task related to the practice of pathology, from grossing and FS to editing and finalizing reports. Also includes consultation, teaching and some research activity |
| Electronic visualization of images via a microscope elsewhere over which you have control in real time |
| Pathology services (Clinical Educational and research) performed by remote transmission/reception |
| Interpretation of cases at a distance via digital media for mainly consult, teaching, frozen sections from an off-site hospital |
| Using digital images in real-time to diagnose |
| Remote examination of digitalized pathology slides broadcasted from one place to another |
| Just encountered briefly during residency |
| Electronically viewing and reporting cases |
| Remote computerized images |
| Reading slides that have been prepared elsewhere, with no direct physical contact with glass slide/clinician/technologist. Electronic transmission of pathology images for remote review |
| Viewing images at a distance |
| Diagnosing via viewing histopathology from a distance (over a screen of some type) |

(Contd...)
Supplementary Table 2: Contd...

| Pathologic assessment performed remotely through the use of digital images or scanned slides |
| Any technology or mechanism that makes use of a virtual slide or image and a computer |
| Histological diagnosis from virtual images, can be from a distant site |
| Digitalized scanned slides based evaluation |
| The use of digital and virtual imaging for histopathological diagnosis on national and international consults designs |
| Electronic transmission of digital slides |
| Digital images based on scanning of slides. Often, but not necessarily remote from source of slides |
| Viewing histologic slides remotely |
| The practice of using imaging technology to allow pathologic assessment of specimens at a different location than the source materials |
| Performing diagnosis on digital images from a distance |
| Pathology frozen section, gross pathology or microscopic pathology done at a remote site by the use of electronic devices including but not limited to digitized slides, distant viewing stations and robotics remotely controlled |
| Practicing pathology at a distance from the biological material via technological aids |
| Pathology diagnosis based on digitized images from remote source |
| Use of telecommunications to aid with pathological diagnoses |
| Diagnosing pathology specimens using computerized technology, at a site remote from where the procedure occurred. |
| Providing any pathology services over a distance using digital imaging and internet-based links |
| It is the practice of pathology from distance. With technology advances we receive courses and information from different places. |
| Assessment of digital images of tissue specimens |
| Pathological consultation provided remotely via electronically transferred images |
| Digital recordings of slides and pictures for remote consultation or diagnosis |
| Ability to educate, diagnose and participate in patient management decision-making via transmission of verbal communication and visual images of pathology cases |
| The sharing of microscopic slides via the internet |
| Telecom-pathology mash-up |
| Making a pathological diagnosis (gross, microscopic) from a distance using visual telecommunications technology |
| Scanning of a slide to make an electronic version virtual slide to send to a consultant. There is a possibility to do this in real time. |
| Virtual remote viewing of pathology images, gross or micro |
| Digital pathology |
| Ability to see the abnormal pathologic changes while not on site |
| Use of digital images for diagnosis |
| Practice of Pathology at/from a distance |
| Internet based pathology service |
| Electronic transfer of digital images |
| Histopathology done electronically |
| Pathology viewed in an institution where the received material is solely a digitized copy of the slide |
| Need more experience |
| Remote consultation with knowledgeable colleague |
| Slide view online |
| Cases on my microscope could be seen by a distant consultant |
| Digitized slides viewed at a remote location |
| Useful |
| Accessing and reporting specimen preparations remotely |
| Remotely accessing images to make a diagnosis “at a distance” |
| Glass slides replaced by digital image of glass slides that can be manipulated on screen |
| Review of cases on line using Aperio or similar software |
| Using telecommunication technology for examining pathology slides/images/specimens |
| Transfer images and related information for diagnostic purposes in pathology |
| Use of digital images of pathology specimens for consultation or presentation |

of residents stated that they would attend informatics workshops these if made available to them. In addition, over 90% of respondents feel that resident training programs across the country should include an informatics component that focuses on the creation of digital images and the uses of various imaging modalities. Only about a quarter of respondents, pathologists and residents alike, were in favor of digitizing the Royal College certification
examination in pathology.

**DISCUSSION**

The main limitation of this study was the low survey response rate. This most likely introduced automatic bias to the study and probably included respondents who were more familiar with and interested in the topic of digital pathology. Another limitation was the lack of a sharp demarcation between the definition of digital pathology and TP in the survey itself; this might have affected the responses of the study population. The phrasing of some of the questions was a little vague and broad, for example asking questions beginning with the wording “have you ever heard of ….” It should also be noted that our results might have been affected by the type of practice the individual respondents belonged to; e.g., academic versus community versus remote underserved areas.

There are many factors that make Canada ripe for early adoption of “digital pathology” including large geographic size with a relatively small population, extreme disparities in population density, and available technically advanced health-care with a shortage of anatomical pathologists. There are only 1195 practicing pathologists in Canada, of which approximately 615 are anatomical pathologists. Although, this survey involved only Canadian pathologists, we feel that the findings apply to the pathology community at large as several other countries share similar geographic and demographic characteristics.

Our results highlight three applications of digital pathology to be of practical interest to pathologists; namely frozen section diagnosis, consultation services, and teaching. Only a small proportion of pathologists support the use of digital pathology for routine diagnoses. Many of the Canadian concerns regarding digital pathology were similar to those previously listed in the literature, including cost and image quality. They also shared similar views of the benefits of digital pathology, including easier access to cases and faster turnaround time. Interestingly, the need for learning to use the technology was essentially a non-issue amongst respondents and very few were “not comfortable with the technology” [Table 2].

An important concern that was highlighted in our survey was the potential compromise of diagnostic accuracy due to lower image quality or under representation of the lesion in digitized images. More recently, accumulating literature has shown good to superior agreement between glass slides and digital slide diagnoses in a variety of specimen types. In a study by Evans, et al., the authors reported average accuracy rates of 98% for TP frozen section diagnoses with rapid turnaround times. Worries concerning image quality would be overcome with standardization procedures of the steps involved in the digital imaging process, which are yet to happen. An important issue in the process of creating a digital image, more specifically a virtual slide, is the consistent focus which can affect image quality. This is being addressed, and there are now commercially available scanners that have continuous focusing mechanisms, which prevent unfocused areas in whole slide imaging.

In terms of cost, setting up the infrastructure to support digital imaging and TP using whole slide scanners can be costly. It is likely that with time, the technology will become more affordable and greater numbers of institutions will be able to avail of its benefits; most especially remote institutions that are not affiliated with universities. Over time the technology will likely pay for itself by no longer having to employ full-time pathologists in remote locales and/or saving on pathologists’ travel to these areas for part-time service. In addition, the cost of shipping consult slides across the country would be eliminated.

According to our results and previous reports, digital pathology is highly favored for educational purposes. Whole slides as well as static images have replaced the microscope in several university histology and pathology courses with good student satisfaction and performance on exams. Up to 35% of US medical schools have integrated digital microscopy into their pathology courses. Many educational courses at national and international pathology meetings have adopted the digital pathology approach; this way the number of participants does not need to be capped due to insufficient room at a multi-header microscope or because of a limited number of glass slides that can be distributed to participants.

Overall, the attitudes toward digital pathology in Canada are positive. We have found strong support for obtaining more training in the field of digital pathology by residents and staff pathologists alike. Based on our findings, we recommend the integration of digital pathology into current resident training programs. Education in digital pathology from an undergraduate level through resident training will yield generations of pathologists who are more familiar with the technology and will be better equipped to use and apply it in daily practice.

Lastly, our survey shows that as the field evolves, pathologists are more welcoming for digital pathology to be gradually incorporated for specific applications that are integrated into our current practice rather than a sudden revolutionary change.

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