British Journal of Neurosurgery, June 2011; 25(3): 347–351

informa
healthcare

REVIEW

The Internet for neurosurgeons: current resources and future challenges

MARK A. HUGHES & PAUL M. BRENNAN

Department of Clinical Neurosciences, Western General Hospital, Crewe Road South, Edinburgh, United Kingdom

Abstract
Our professional and personal lives depend increasingly on access to information via the Internet. As an open access resource, the Internet is on the whole unbridled by censorship and can facilitate the rapid propagation of ideas and discoveries. At the same time, this liberty in sharing information, being unregulated and often free from external validation, can be oppressive; overloading the user and hindering effective decision-making. It can be difficult, if not impossible, to reliably ascertain the provenance of data and opinion. We must, therefore, discern what is useful, relevant, and above all reliable if we are to harness the Internet's potential to improve training, delivery of care, research, and provision of patient information. This article profiles the resources currently available to neurosurgeons, asks how we can sort the informational wheat from the chaff, and explores where future developments might further influence neurosurgical practice.

Key words: *Internet, neurosurgery, resources, learning, training.*

Introduction

The Internet as a tool to access and search for information has great potential to advance neurosurgical practice; just as previous technological milestones such as the operating microscope have done before. The extent of this impact will depend upon how effectively the quality and reliability of Internet-based information can be assessed and how this information is analysed. The ease with which information, data and opinion can be shared via the Internet can be burdensome, providing a seemingly endless number of sources to review, but with no guarantee as to quality or provenance. There are therefore risks if we cannot expertly sift the Internet 'wheat' from the 'chaff'. This applies not only to the clinician but also to patients whose understanding of a clinical condition, or expectations, might become misguided by an ill-written or poorly evidenced article. In contrast, the well-informed patient has the potential to positively change the dynamic of a consultation, and of the doctor–patient relationship. We will therefore explore how the Internet might be embraced to support neurosurgical training, professional development, and day to day service delivery in a safe and reliable way.

The Dawn of 'Online'

Before the widespread availability of the Internet, professional and academic learning came from a combination of human interaction and the pages of journals and textbooks. Changes in working patterns and hours have impacted on contact time between trainees and senior colleagues, but the value of the apprenticeship nature of surgical learning remains and cannot easily be replicated. Journals however have been liberated by the Internet. Access is available to most current and archived scientific journals in full. Some journals may in time end print runs altogether. For many, the allure of print on paper remains and is perhaps reflected in the evolution of online interfaces that mirror print layouts, and in a marketplace awash with ever slimmer electronic reading devices. Other journals though have only ever existed in the electronic ether. Many provide additional web-specific features such as multimedia material supporting published articles or providing forums for discussion; a *potentially* useful source of opinion and rebuke to influence your analysis of an article.

Where article selection is not limited by the economies of print, maintaining the quality of

Correspondence: Mark A. Hughes, Department of Clinical Neurosciences, Neurosurgery, Western General Hospital, Crewe Road South, Edinburgh EH4 2XU, UK. E-mail: hughes81@gmail.com

Received for publication 8 July 2010. Accepted 9 January 2011.

ISSN 0268-8697 print/ISSN 1360-046X online
DOI: 10.3109/02688697.2011.554582

peer-review is vital. The unregulated nature of the Internet, although liberating in many respects, is also a potential barrier to effective quality control. Peer-review has been the keystone of quality control for science and medicine for the last century, but assessing the quality of peer-review and subsequently determining the value of a paper remains difficult. Few reviewer characteristics, or experience, predict the quality of reviewers.[1] The number of citations may be no better a guide; 88% of medical papers published in 2002 were cited by 2007.[2] One potential mechanism of improving peer-review lies with the Internet. After all, peer-review professes to scrutinize work and ideas by experts in the field. The web opens this process to a larger and more diverse population of opinions and experience, although this pool of expertise will invariably include industry manderins and other potentially malign forces for whom it will be difficult if not impossible to identify. Discussion boards allow Internet readers of journals to post and attach feedback to articles. The comments of peer-reviewers might also be made available. Better still, draft papers might be deposited onto a central public site.[3] Editors could invite peer-reviews, and the reviews would remain 'attached' to the paper, regardless of whether they are accepted or not. This idea is already accepted in the physical sciences (ArXiv.org), but is it really better? Opponents of these ideas suggest that forums for feedback are open to abuse. Perhaps, the reader can make this judgement for themselves, but the benefit of the current system of peer-review, even if the process can seem shrouded in secrecy, is the authentication of reviewers that journals provide. Material in the form of scientific publications has been claimed to be more valuable when freely available, but authenticated quality peer preview and the editorial process has a cost. *Wikipedia,* the web-based encyclopaedia, appears to marry an openly editable resource with back-office support and a degree of paid editorial oversight funded by user donations. Although valuable for its role as an up-to-the-minute source of information, Wikipedia is also well known for its vulnerability to informational vandalism and this model cannot in its entirety be suitable for the scientific press. However, it does demonstrate that different peer-review mechanisms can work.

In contrast to journals, textbooks form a more historical commentary on neurosurgical science and practice, summating knowledge from a number of resources. Journals may offer more up-to-date information, but a textbook ideally provides the value of knowledge that has been assimilated and rationalized in an effort to ensure accuracy, although not necessarily peer-reviewed. The breadth and depth of knowledge offered in textbooks is now becoming available online, not only as electronic versions of 'hard copy' textbooks (e.g. *online-neurosurgery.com* supplementing 'The Neurosurgeons Handbook,' OUP 2010) but also as novel web-based resources such as the UK and Republic of Ireland School of Neuroscience (UKRISON) (http://www.schoolofneuroscience.com). UKRISON has been developed to teach clinical neurosciences online to both trainees and established consultants. Learning resources are supplemented by a question bank for self-testing. Similarly, *Neurosurgic* (http://neurosurgic.com/) is an online forum launched by Swedish neurosurgeons to promote networking between neurosurgeons, as well as with those in allied medical specialties, to help them to stay up to date. Forums, blogs, an educational section with self-assessment questions and a specialized neurosurgical bookshop are available. These added features have the same limitations that we have already discussed but equally have the potential to improve the reliability of the information that textbooks provide.

The Internet certainly offers many opportunities for the humble journal and textbook, but the opportunities in many ways simply place more responsibility on the reader to assess the veracity and usefulness of the information. An innovation that might therefore further assist both patients and clinicians would be a system of kite marking of medical websites. The Health on the Net foundations HONCODE certification (http://www.hon.ch/HONcode/Conduct.html) is a step in the right direction. If this concept is to expand in scope and usefulness, however, the issue of cost and of who should decide what the kite marking means looms large.

Internet on the move

Notwithstanding the issues of accuracy and reliability, the usefulness of the Internet to simply access information has rocketed since mobile computers and other portable devices capable of reliably accessing the world-wide-web have become more available. With appropriate hardware, patient imaging and test results can be reviewed at the bedside or even remote to the hospital. The *Apple iPod* touch has found its way to the recent American Association of Neurosurgery 2010 conference to deliver content and scheduling information in place of traditional hard-copy material, and also enabled download of podcasts, videos and meeting information (http://www.aans.org/iPod_initiatives/). Electronic devices for reading uploaded literature (e-Readers, e.g. *Amazon Kindle*, *Apple iPad*) will increase the ease with which scientific resources come into the ward and clinic, both for doctor and patient. Firms such as *Apple* are engaging with the medical profession to better integrate technology in healthcare delivery (http://www.apple.com/science/medicine), and medically relevant applications (apps) for smart-phones are proliferating (Table I). If you identify a still unmet need that an app could fill, app design can be facilitated by the *iPhone* developer (http://developer.apple.com/iphone/index.action), with the help of

TABLE I. Some smart-phone/mobile applications for the neurosurgeon

Application	Platform	Description
NeuroMind	iPhone, iPOD touch, iPad	For clinical neuroscience trainees; contains information including basic neuro-anatomy, the WHO Safe Surgery checklist and relevant scoring systems.
OsiriX	iPhone, iPOD touch, iPad	Portable image processing application dedicated to DICOM (Digital Imaging and Communications in Medicine). The iPhone app can download images from the OsiriX desktop application over a wireless network and can interface directly with an institution's PACS server.
SLIC	iPhone, iPOD touch, iPad	Evidence-based decision supporting system for surgical treatment of sub-axial cervical spine injury.
Xprompt	iPhone, iPOD touch, iPad	Innovative translation platform to aid communication between patients and medical care staff who speak different languages. Translates into the text of the target language, together with a voice output for spoken languages or a video sequence if sign language is selected.
Procedures-hospital collection	iPhone, iPOD touch, iPad	Detailed step-by-step instructions of 15 medical procedures accompanied by high-resolution video and images. Includes lumbar puncture, central venous cannulation and others.
iRadiology	iPhone, iPOD touch, iPad	Aimed at students and juniors, catalogues >500 radiology cases designed to help improve plain film, CT and MRI reading skills.
Neuro Toolkit	iPhone, iPOD touch, iPad	Enables calculation of relevant scores and grading scales in neurosurgery and neurology
Epocrates	Blackberry, Palm, Android, iPhone, iPOD touch, iPad	Information regarding drug dosing and interactions, including a section on complimentary medicines.
MedCalc	Palm OS, Windows Mobile, iPhone, iPod Touch	Free medical calculator; gives easy access to complicated medical formulas, scores, scales and classifications.
Eyechart Pro	iPhone, iPOD touch, iPad	A handheld randomly generated Snellen chart that enables a rough screening of visual acuity.
Medical Radio	iPhone, iPOD touch, iPad	Streams medical content from ReachMD, providing generalist and specialist content and access to 5000 searchable podcasts.

a free *iPhone* Application Programming course from Stanford University (*I Tunes-U*), or else commercial companies such as the *MEDL incubator* (www.medlmobile.com/) can help, where the development costs are offset by future revenue.

At the same time as looking to exploit these myriad opportunities, we must ensure the security and confidentiality of patient identifiable information. Data protection and privacy in the UK is enshrined in the legal framework laid out by a European Union directive. Health service data protection in the UK is the legal responsibility of the local Caldicott guardian (named for Dame Fiona Caldicott's 1997 report), but ultimate responsibility lies with the person handling the data. Dame Caldicott's report outlined a number of principles for good practice, including only using patient-identifiable data if strictly necessary and only then using the minimum amount. This is the only real safeguard against theft, although encryption of a hospital's wireless local area network, and data storage equipment (e.g. USB devices) is also helpful. Importantly, information governance guidelines must evolve *in parallel* with new information technologies to avoid stifling the opportunities they offer. Simply banning the transfer or remote access of patient-related data is draconian and unlikely to improve patient care.

Resources for the trainee and trainer

Rapid access to and sharing of patient data has impacted on assessment of trainees' performance. In the UK, the Intercollegiate Surgical Curriculum Specialty (ISCP) website (https://www.iscp.ac.uk/) provides access to the neurosurgical training curriculum, a record of portfolio competencies, and an operative logbook. Similarly, the pan-surgical electronic logbook (www.elogbook.org) is a web-based surgical logbook for both trainees and trainers, where CPD-related activities can also be recorded. Trainee operative logs can be validated in real time by their trainers, hopefully providing a more accurate history of a trainee's skill and progression. Since data is stored centrally, it is available for analysis. We can ask questions about how surgical training may be changing, for example, in response to working hour limitations or the emergence of interventional vascular services, and then better identify how to offset the negative consequences of these changes. Trainees can also compare their experience objectively with their peers. For all these benefits, we need to ensure that the ease of access and input of information does not become a surrogate for good interactive human–human supervision. Assessment tools should be used if they are validated as discriminators of skill and knowledge, not simply because they are easy to create as online resources.

Web-based surgical simulators

Alteration in the structure and duration of training has impacted on the time available for trainees to acquire and develop skills in the operating theatre. Whilst there remains a strong voice calling for more

hours to train in, the recent report from Sir John Temple, (www.mee.nhs.uk/our_work/work_priorities/review_of_ewtd__impact_on_tra.aspx), instead puts the emphasis on training better. This has in part motivated changes in the methods used for surgical skills acquisition, whereby knowledge and skills learnt and rehearsed outside the operating suite can optimize the time spent in theatre. These novel methods are certainly not a panacea for decreased training hours, but both trainees and consultants may nevertheless benefit from web-based surgical simulation tools, enabling them to train or practice in an environment imitating the real surgical world but without risk to the patient. Indeed, evidence is emerging that simulation might have a real effect on trainee competence and patient safety. For example, in ENT surgery, a blinded study using a surgical simulator found that the simulator reduced operative times and errors.[4] If quality simulators can be developed, it is plausible that this might also apply to neurosurgical trainees. For the Consultant, simulators might allow new procedures to be rehearsed or existing ones improved and there is also the emerging concept of surgical 'warm-up.' Akin to other professionals such as dancers who warm up to optimize psychomotor skills, surgeons of differing specialties were shown in one study to have reduced operative time and surgical errors with a pre-operative warm-up consisting of a generic test of dexterity.[5] The Internet offers a portal to these tools.

A number of computer-based simulators are being developed in neurosurgery (http://neurosurgery.medicine.dal.ca/Innovation.htm). These can assist in acquisition of visual spatial skills useful for microscopy, assist in planning of surgery or simulate specific steps of surgical procedures.[6] Simulators can record efforts and might allow an aspect of competency to be assessed. A UK group (http://www.hpv.cs.bangor.ac.uk/Sim/) specializing in augmented reality have established several online surgical task simulations utilizing Virtual Reality Modelling Language to create virtual training environments. Trainees manipulate a virtual surgical tool in a 3D scene using a 2D device (mouse). Other neurosurgical simulations include ventricular catheterization, needle insertion during percutaneous rhizotomy, pedicle screw insertion and lumbar puncture. As well as assisting skills acquisition for trainees, online operative representations may also help patients gain a better understanding of their procedure. Evidence for efficacy of surgical simulation, and of web-based simulation specifically, is encouraging but limited. A 2009 Cochrane review of the subject assessed 23 studies dealing specifically with virtual reality laparoscopy.[7] Trainees without prior experience completed tasks quicker, were more accurate, and made fewer mistakes. Whether simulation can or should be allowed to take the place of the hours of operative exposure that working hour regulations have cast out remains a topic for debate. Moreover, more patient-relevant outcomes of the benefits of simulation are certainly needed, as are studies focused on the feasibility and benefits specifically for neurosurgeons.

Global potential

Where inequalities exist amongst the international community in access to and provision of healthcare, the Internet offers a possible democratization; promising *universal* access to the same knowledge and resources we have outlined above, and a route to spreading their own expertise worldwide. Realizing this opportunity will require some bridging of the 'digital divide'; in 2009 just 6.7% of Africans had Internet access, compared with 27.7% in the rest of the world. The rewards could be great, allowing medical teams in the most geographically remote areas not only to seek expert medical advice, but also to utilize the best available resources for learning and training. When thinking how we can best harness the Internet for our own use, we should consider how we can connect with surgeons around the globe.

Conclusions

The Internet offers a vast array of opportunities for neurosurgeons to access information, to learn, and to interact with colleagues and patients. In future, proliferation of wireless technology and shrinking of portals to access the Internet will increase its role in clinical practice. The sheer volume and lack of regulation of the information available has the potential to overwhelm unless, both individually and as a profession, we can ascertain and ensure its quality, veracity and usefulness. Enhanced access to information via the web must not compensate for a decline in accurate knowledge and understanding, or else we risk becoming subservient to it. Confidentiality is also crucial. There are no quick fixes to these problems, as we have discussed. Variations on existing systems (such as traditional peer-review) may prove valuable in the end, but we must also be willing to explore alternative solutions in order to maximise the true potential of the Internet for both clinicians and patients.

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

References

1. Callaham ML, Tercier J. The relationship of previous training and experience of journal peer reviewers to subsequent review quality. *PLoS Med* 2007;4(1):e40.
2. Lariviere V, Gingras Y, Archambault E. The decline in the concentration of citations, 1990–2007. *J Am Soc Inf Sci Technol* 2009;60:858–62.
3. Ioannidis JP, Tatsioni A, Karassa FB. Who is afraid of reviewers' comments? Or, why anything can be published and anything can be cited. *Eur J Clin Invest* 2010;40(4):285–7.

4. Fried MP, Fried MP, Sadoughi B, *et al*. From virtual reality to the operating room: the endoscopic sinus surgery simulator experiment. *Otolaryngol Head Neck Surg* 2010;142(2):202–7.
5. Kahol K, Satava RM, Ferrara J, Smith ML. Effect of short-term pretrial practice on surgical proficiency in simulated environments: a randomized trial of the ''preoperative warm-up'' effect. *J Am Coll Surg* 2009;208(2):255–68.
6. Malone HR, Sved ON, Downes MS, D'Ambrosio AL, Quest DO, Kaiser MG. Simulation in neurosurgery: a review of computer-based simulation environments and their surgical applications. *Neurosurgery* 2010;67(4):1105–16.
7. Gurusamy KS, Aggarwal R, Palanivelu L, Davidson BR. Virtual reality training for surgical trainees in laparoscopic surgery. *Cochrane Database Syst Rev* 2009;1:CD006575.