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THE UNIVERSITY OF WESTERN ONTARIO MEDICAL JOURNAL

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Cover Art: Kevan Lu

Description: The syringe is labeled with years, representing the flow of time.

EDITORIAL

The future of medicine: A medical student's perspective

As medical students, we spend much of our education busily learning vast amounts of information in order to gain the knowledge we require to become competent clinicians. Much of the first two years of medical school is spent in didactic teaching. In the third and fourth years of our education we rush around the hospital during our clinical clerkship years attempting to apply that knowledge and to learn our craft from our mentors and supervisors. We are immersed in the here and the now and passing the next looming exam!

Even though we are the future leaders in healthcare, we are rarely asked what we think the future of medicine holds. This is a shame, since in my experience as a student at the Schulich School of Medicine and Dentistry I have found that my classmates have many ideas and great vision as to the future of the practice of medicine. We are also in a unique position of still maintaining our sense of idealism as we have not been working on the frontlines for very long. We can see where change can occur since our experiences in the wards and clinics are fresh and new. Having never come across resistance and barriers to change, we can imagine the possibilities that the future can hold. It is for this very reason that in this issue of the UWOMJ we have decided to explore what medical students believe the future holds for medicine. I hope that you enjoy reading these pages and take the opportunity to dream and to envision what you hope will be the future of medicine and embolden yourself to make change happen.

My own personal vision of the future of medicine is biased by my previous experience as a research scientist. I believe that the merging of the fields of molecular biology, biochemistry, materials science, engineering and nanotechnology will occur in the very near future and will lead to medical breakthroughs and treatments that are only now emerging from the realms of our imagination. We are entering an age that is full of promise and will reveal the mechanisms of numerous human diseases. These advances will lead to new treatment options for patients. The age of personalized medicine is just beginning and it is going to change the way we practice medicine.

The sequencing of the human genome and the development of bioinformatics tools to manage and analyze the sequence of our DNA have provided a glimpse into the complexity of our genetic makeup. The concomitant adaptation of mass spectrometry to the analysis of proteins now allows us to identify the protein makeup of a cell. These technological breakthroughs will be joined by the newly emerging field of metabolomics that will allow us to identify a large number of metabolites found in the human body. Armed with this new information detailing cellular processes during times of health and disease, the methods we use to manage patients and develop therapeutic drug targets will change at a rapid pace. Breakthroughs in the fields of materials science, engineering and nanotechnology will allow for the miniaturization of these applications so that they can be deployed for routine clinical use.

Imagine detecting life threatening genetic conditions and long term genetic susceptibilities at birth. A patient will have a lifestyle plan charted out to prevent the development of diseases detected in their genetic profile. Over the course of a person's lifetime the protein and metabolic profiles of their cells will be monitored to determine the onset of pathological changes. This testing will allow physicians to begin treating conditions before they have detectable clinical signs and symptoms, thus altering the course of a disease from the very beginning. A patient's genomic, proteomic and metabolomic information will also be used to select the most ideal, individualized pharmacotherapies.

We are approaching an exciting era full of enormous change. Today's physicians will need to develop public policy and lobby for the best delivery of future technologies. And both today's physician and tomorrow's physician will need to decide which technologies we adapt, always keeping humanity's best interests in mind as we progress towards an exciting tomorrow. Turn the page to see what other medical students at Schulich feel the future holds!

Melissa J MacPherson, PhD (Meds 2014)
Senior Associate Editor

FEATURE ARTICLE

Tides of change

The future of Canadian medical resident work hours

Jouseph Barkho (Meds 2015)
Faculty Reviewer: Dr. Catherine Yanchula, MD, CCFP, FCFP (Department of Family Medicine)

ABSTRACT

The paradigm of medical resident duty hours is currently undergoing vast changes, as research has demonstrated the negative effects of sleep deprivation on the wellbeing of both patients and residents alike. These changes began in the United States, where reduced work hour schedules for residents have been implemented within the past decade. However, the effectiveness of these changes has been debated in the literature. In Canada, this issue has only recently come into spotlight. Under the guidance of the Royal College of Physicians and Surgeons of Canada, a task force was assembled in 2012 with two main objectives: gather all evidence related to resident duty hours, fatigue, and patient safety, and to create a national Canadian consensus on resident duty hours.

In 1984, New York City was the setting of a new wave of thinking about residency training programs within the medical profession. That year, the death of Libby Zion, a lawyer's daughter, initiated the Zion vs. New York Hospital case, which would have an indirect impact on international rules for resident work hours.

Traditionally, it was not uncommon for residents to work up to 36 consecutive hours with minimal sleep, accumulating well over 100 hours of work in a week. Some considered this a rite of passage into the medical profession, while others saw it as a valuable learning tool. When the death of teenager Libby Zion was traced down to a medical error, more attention was drawn to the effect of sleep deprivation on residents' performance on the wards.

What effect does sleep deprivation have on residents? One review found that with acute sleep deprivation, residents showed decreased performance on tasks that required prolonged, vigilant concentration, but were resilient in performing brief, psychomotor tasks requiring manual dexterity and short-term recall.[1] Furthermore, resident mood was affected, with increased anger, hostility, and symptoms of depression being noted – all factors that hinder the physician-patient relationship. In addition, one study found that extended shifts put residents' safety at risk, by increasing the likelihood of reporting a motor vehicle accident after a call shift.[2]

A landmark study published in the New England Journal of Medicine compared two different work schedules head-to-head.[3] The first schedule, considered "traditional," had an average of 77-81 work hours per week with up to 34 hours of continuous work and 1 in 3 overnight call. The second, or "interventional" schedule, had 60-63 work hours per week maximum, 16 hours of continuous work maximum, and a day-call versus night-call designation, rather than a whole day of call. These schedules were randomized among internal medicine residents, and patient safety measures were prospectively followed. When researchers compared the traditional schedule and interventional schedule respectively, they found that residents made 35.9% more serious medical errors (136.0 vs. 100.1 per 1000 patient-days), 22.0% more total medical errors (193.2 vs. 158.4 per 1000 patient-days), 20.8% more serious medication errors (99.7 vs. 82.5 per 1000 patient-days), and 96.5% more serious diagnostic errors (21.6 vs. 11.0 per 1000 patient-days), while on the traditional schedule.[3]

In light of these findings, in 2003 the Accreditation Council for Graduate Medical Education (ACGME) in the United States instituted limits on resident work hours: 16 hours maximum for continuous shifts for PGY-1 (more hours allowed for seniors), 80 hours maximum per week, and 1 day off per week averaged over a 4-week period.[4] Any residency program's accreditation is endangered if their work protocols are not congruent with the ACGME. Unfortunately, data collected after these changes have shown mixed results as to the effectiveness of reduced hours. A systematic review of 7 studies (one of which was conducted after the 2003 ACGME changes) comparing reduced hour schedules with traditional schedules looked at mortality, adverse events, and medication errors as outcomes.[5] The results showed that some outcomes improved, others declined, and still others showed no change. For example, mortality was largely unaffected by reduced hours, but medication errors were reduced.[5] The authors emphasized a distinction between mortality outcomes, and task-based outcomes, the latter of which may be more susceptible to sleep deprivation. Although there were limitations within the studies in this review, such as the failure to measure baseline characteristics, the point is raised that reduced-hour schedules may not have the effects that were once anticipated.

There may be negative consequences with reduced hour work schedules. Proponents of the traditional, long hour work schedules raise the argument that by reducing hours and increasing patient hand-over, an element of discontinuity is introduced which in itself may increase medical errors. In addition, fewer predictable hours may not prepare residents for independent practice, where hours are not limited and may be unpredictable. This may be reflected by an increase in the length of residency programs to allow for adequate clinical exposure. A survey of surgical residents in the United States found that many are unsatisfied with the reduced work-hour changes: 55.1% believed their education declined, and 68.4% felt they were not being prepared for senior roles.[6] Although 61.9% of junior surgical residents had an increase in their quality of life, 54.4% of senior residents found a decline in their quality of life, likely due to seniors adopting the work that the juniors could not complete on their reduced hour schedules. Shockingly, 67.6% of surgical residents reported non-compliance with the work-hour limits, and 62.1% reported falsifying duty hours.[6]

In Canada, the resident association of each province has the daunting task of negotiating collective agreements for medical res-

idents. Presently, Quebec has been the only province to introduce drastic changes to their collective agreement regarding work hours. In 2007, the collective agreement of the Fédération des médecins résidents du Québec, which at the time permitted 24-hours of consecutive work, was challenged under the grounds that it violated both the Canadian Charter of Rights and Freedoms and the Quebec Charter of Human Rights and Freedoms.[7] Four years later, in 2011, a new collective agreement was signed, stating that residents will work no more than 16 consecutive hours. The total weekly hours will remain approximately the same—the hours will simply be re-distributed.[7]

Where is the rest of Canada heading in terms of resident work hours? In 2012, the Royal College of Physicians and Surgeons of Canada launched a project titled, "Towards a Pan-Canadian Consensus on Resident Duty Hours."[8] By creating a National Steering Committee on Resident Duty Hours (NSC) consisting of multiple stakeholders involved in resident training, and taking an evidence-based approach, the Royal College hopes to develop national Canadian recommendations on resident duty hours. The goals of the project are to (1) compile all current evidence on this topic, and (2) facilitate, "... educators, governments, policy makers, patient safety experts, and others, to come to a single, pan-Canadian statement on resident duty hours issues, directions, and best practices."[8]

In June of 2013, the NSC released the final results of their project. Firstly, the NSC does not support reducing the total number of work hours, but rather re-distributing the hours such that long stretches of consecutive hours are minimized.[8] Secondly, the original rationale behind reduced hours was the notion that resident fatigue impacts patient outcomes. However, evidence collected by the NSC has been inconclusive as to whether reduced duty hours improves patient outcomes. Why is this the case? The relationship between resident fatigue, medical errors, and patient safety is not as clear as once anticipated.[8] Fatigue does not affect each resident the same way, nor is sleep-deprivation the only factor that influences fatigue.[8] Although the NSC does acknowledge that current schedules pose risks to the, "physical, mental, and occupational health of residents," they emphasize that we must not place the spotlight entirely on duty hours, but rather take a comprehensive, holistic approach by addressing factors beyond duty hours alone.[8] Additional factors to be considered include resident education, health service delivery, and resident supervision.[8]

The NSC also acknowledges significant variation between residency programs, and that reduced consecutive hours may affect each specialty program differently.[8] Changes must be tailored specifically for each type of residency, rather than making uniform changes across all different residency programs.

The NSC has provided five key recommendations for Canadian residency programs, in accordance with their findings:[8]

1. We need a comprehensive approach to minimize fatigue-related risk, including "fatigue-risk management plans" in all residency programs across Canada.
2. Resident education needs to be re-modeled, along with resident duty hours, to ensure adequate medical training and exposure for residents.
3. Residency programs need to be held accountable for maintaining these changes through accreditation processes.
4. Multiple models of work schedules for after-hours care should be created and evaluated as to their impact on patient care.
5. An independent, pan-Canadian council, whose sole purpose is to evaluate resident duty hours, should be created.

These changes appear promising to both patients and residents in Canada, however the NSC was not specific as to the timeline for residency programs to adopt these changes. It may be some time before new schedules are formulated and adopted across Canadian residency programs.

Picture the following scenarios: a well-rested resident caring for patients mainly through reports, or a fatigued resident providing direct patient care through their own history and physical examination. Who provides the best patient care? Working long consecutive hours has disadvantages for both the patient and resident alike, however, reducing duty hours also has its own disadvantages. It is important to study the disadvantages of reduced consecutive-hour schedules, so that they may be minimized or eliminated during the policy-making process. Canada has taken the first step towards addressing this issue by compiling a task force whose aim was to create an evidence-based, pan-Canadian guideline regarding resident duty hours. With the NSC's final report, Canada is headed towards changes which will ultimately improve the health-care of Canadian citizens and simultaneously maximize the health and education of medical residents.

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FEATURE ARTICLE

Towards Healthier Doctors

Kevin J Dueck (Meds 2016)
Faculty Reviewer: Dr. Robert R Hammond, MD, FRCPC (Department of Pathology)

On June 17, 1963, Canadian Health Minister Judy LaMarch announced that cigarettes were linked to lung cancer. It was an important announcement for human health and one for which Canada displayed leadership. Unfortunately, after the news conference she promptly lit a cigarette. Sneering at the seeming hypocrisy of such an act would be easy, but we shouldn't throw stones. Do we not recommend lifestyle and behavioral changes targeting patient wellness while ignoring them in our own lives? This gap between physician recommendations and actions needs to be closed. Not only for the good of physicians, but that of our patients and the healthcare system.

WELLNESS CONCERNS

Wellness is multidimensional. It involves more than a lack of illness as traditionally thought. The definition of health according to the World Health Organization is, "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity." This definition encompasses a broader sense than mere biological function. Wellness includes the dimensions of spiritual, occupational, environmental, emotional and intellectual wellbeing along with personal awareness and proactivity in one's health.

The training and practice of medicine are difficult. Maintaining the dimensions of wellness is not easy in these environments. One's personal wellbeing and ability to care for patients can suffer. A physician's wellness is important and an unmatched healthcare commodity.

Trainees are faced with many stresses, from their changing roles and increased workload to life events. Trainees are embedded in a high-stress environment and have high rates of depression.[1,2] Approximately a quarter of medial students experience depression, but are less likely to seek help – significant barriers such as stigma and confidentiality exist.[3,4] Studies suggest that mental health worsens through medical school and this distress can continue through postgraduate training.[5,6] According to a multi-institutional study in the United States, 11% of medical students seriously considered dropping out in the preceding year, with burnout, depression and quality of life being predictive factors.[7] Although the above studies focused on mental health, other aspects of wellness deserve similar concern.

Physician wellness also impacts the quality of care delivered. Burnout has been linked to reduced professionalism and empathy,[8] whereas wellbeing is associated with compassion for patients.[9] Physicians proactive about their health more often discuss health promotion with their patients,[10] and yet a third of physicians do not seek regular healthcare.[11] Interaction with other healthcare team members is likely negatively impacted when personal wellness is neglected, expanding the effect of this neglect. These concerns have led to a number of undertakings targeting physician and trainee wellness.

WELLNESS EFFORTS

There is reason to be optimistic. Efforts are underway to promote wellness throughout the medical profession. These include national, provincial and institutional initiatives: large-scale efforts to provide resources and revise training requirements, and smaller projects addressing student wellness. The essential nature of physician wellness is gaining traction.

Large-scale efforts target both trainees and physicians (links below). These provide resources specific to issues of the medical profession including crisis lines. At the national level the Canadian Medical Association (CMA) has established the Center for Physician Wellbeing and recently launched the Canadian Physician Health Institute (CPHI) in partnership with the Canadian Medical Foundation to support physicians and trainees. At the resident level the Canadian Association of Interns and Residents (CAIR) provides resident specific resources on their website and supports the recently launched ePhysicianHealth website. The latter resource provides online modules addressing specific wellness topics. Changes are also afoot in residency and clerkship call hours, limiting demands on trainee time. The Canadian Federation of Medical Students (CFMS) recently launched a medical student wellness website and is distributing wellness packages to all Canadian medical students. In Ontario the Ontario Medical Association's (OMA) Physician Health Program (PHP) and the recent inaugural Ontario Medical Student's Association Wellness retreat highlight further encouraging efforts. Thankfully, this is a time of increasing activity in this area with many complimentary efforts being launched.

Small-scale efforts involve multiple approaches. Curriculum changes have been introduced to reduce competition between students with broad pass-fail grading along with optimizing exam schedules as occurred at the University of Ottawa. In order to make personal connections with students both peer and faculty mentorship programs have not only become commonplace but standards for accreditation. Some schools have created separate support services for medical students and integrated wellness into their curriculum such as Queen's University. A number of student led initiatives have also been funded, giving the student perspective a larger role and allowing targeted activities addressing student needs.

Thus, wellness is being approached at both the large- and small-scale, within and across medical training and practice. While coordination of efforts is important, the wisdom of this approach whether intentional or otherwise is that wellness is clearly not 'one-size-fits-all'. Although the breadth of efforts demonstrates that the issue of wellness has earned wider attention, there is much work to be done. At the professional and resident level positive changes are underway, however, a key time to engage learners is during their undergraduate medical education. In the words of Dr. Chris Simpson, CMA President-elect 2013-2014, "Given that health

and wellness habits are learned early, it is this population of medical colleagues who, arguably, would benefit the most from a more activist wellness program."[12]

FORGING HEALTHIER DOCTORS

Focusing on the student level is an important way forward for wellness in the medical profession. By nurturing wellness at the early stages of training students can learn skills and be imparted values that can lead to changes in the larger healthcare culture as their careers progress. Coordination of the current efforts is needed to best address student wellness. A number of improvements are possible to current programs.

Firstly, initiatives should be carefully planned and monitored. Thus far evidence of effectiveness has been lacking. This concern must be addressed in the planning of new projects and implemented in existing ones; ensuring efforts are not futile or counterproductive. Though driven by positive intentions, one must have evidence to support the interventions proposed.[5,9] Programs for mentoring in the majority lack short and long-term evaluation criteria, making assessment of the effectiveness difficult.[13] Thus, existing programs need to clarify their goals and put in place clear outcome measures.

Secondly, implementation must be based on the best available evidence. Using stigma as an example, the importance of evidence-based interventions is apparent. Stigma is a major concern, especially towards mental health. This leads students to feel unable to seek help and ostracized due to their illness. Addressing stigma is a significant component of moving forward with wellness, but how does one approach this? National awareness campaigns do not appear to be effective alone,[14] while contact based workshops do impact the stigma of those attending.[14-16] However, the delivery of these workshops is key to their effect as they can also consolidate negative views.[17] Learning how to deliver programs in accordance with best evidence is a key aspect of moving forward.

Lastly, some efforts must be targeted to specific issues and utilize models of behavioral change. As noted above, large awareness campaigns are not globally effective. Specific issues need to be targeted and skills taught, whether these be life skills, personal coping skills or healthy behaviors. Furthermore, the delivery should be planned using a validated model of change. By example, the I-Change model involves 3 stages, those of awareness, motivation and action; all must be considered in bringing about positive change.[18,19]

Trying to introduce such changes will not happen without stressing the importance of wellness in the curriculum and the profession. It must be seen as part of professional responsibility; first to yourself, second to your peers and profession and finally to your patients. Making wellness central to medical education will not be without issue. A proportion of the student population is resistant to the idea of needing help or having future difficulties. The topic of wellness is thus difficult to broach with them. Furthermore, there still exists significant stigma especially towards mental health in our society. These need to be overcome for the good of all. Change is needed and must be evidence based, thoroughly planned and carefully implemented.

CONCLUSION

Wellness is a goal of medicine and needs to be applied to the training and practice of those involved as well. It is a part of aligning our practice with our principles. It is about the validity of our advice for our patients, but also the care we provide ourselves. While systemic and student barriers exist, there are efforts underway to address the shortcomings. Addressing wellness needs at the trainee level is an approach that will seed long term change within the culture of physicians, wellness becoming central to the curriculum and penetrating the healthcare system. If successful, these students become more resilient doctors, better teammates and better caregivers. The move towards physician wellness is needed to form a connected, caring network of peers working together for their own and their patients' wellbeing.

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FEATURE ARTICLE

Robotic Surgery

How are we training future operators?

Alex Jiang (Meds 2015)
Faculty Reviewer: Dr. Christopher Schlachta, MD, FRCSC (Department of Surgery)

BACKGROUND

Since 1921 when Czech playwright Karel Capek introduced the notion of and coined the term "robot" in his play Rossom's Universal Robots, robots have taken on increasing importance in society in sectors from industry to military and now, medicine.[1] First introduced in 2000 by Binder and Kramer, robotic surgery has revolutionized the field of minimally invasive surgery and has been rapidly adopted for various procedures.[2] Perhaps the most renowned surgical robot nowadays is the da Vinci Surgical System (dVSS) (Intuitive Surgical, Inc.).

Urologists, cardiac surgeons and general surgeons have swiftly adopted this technology and have been instrumental in its growth. Today, robotic-assisted laparoscopic radical prostatectomy (RALRP) is the most commonly performed robotic procedure worldwide. In 2002, only 766 RALRPs were performed in the United States. By 2007, this number had swelled to 48 000, and represented 68% of all radical prostatectomies.[3,4] Other urological procedures performed with robotic assistance include pyeloplasty, nephrectomy, radical cystectomy and urinary diversion.[4] Cardiac surgeons further refined this technology. Mohr et al used dVSS to perform CABG on 131 patients and mitral valve repair on 17 patients, and discovered that robotic systems could be used safely in select patients to perform endoscopic cardiac surgery.[5] Gynecology and general surgery have also adopted this system for certain procedures including hysterectomy, myomectomy, sacro-colpopexy, Roux-en-Y gastric bypass and Nissen fundoplication.[3]

Despite the growing popularity of this technology, education of residents and fellows has not kept pace with this new era of surgery. Duchene et al conducted a survey of urology residents training in laparoscopic and robotic surgery. They determined that robotic procedures were being performed at 54% of respondent hospitals and residents were involved in the majority of these cases, but only 38% of residents considered their expertise satisfactory.[6] A more recent survey of obstetrics and gynecology residents showed that 79% of them felt robotics training should be included in their residency program and 69% felt that their training was inadequate.[7] The Dutch Healthcare Inspectorate has also published a report stating that 50% of the hospital lacked a standardized method for assessing surgeons' competence before allowing them to operate with robotics.[8] In an attempt to address these shortcomings, this article highlights the challenges of establishing a robotics training program and the need for a standardized training curriculum.

ROBOTIC SURGICAL SYSTEM

The **Figure** depicts the four components of dVSS, which consists of surgeon console, patient-side cart, EndoWrist instruments, and vision system. The console allows the surgeon to manipulate the robotic arms. The patient-side cart is where the patient and robotic arms are positioned. EndoWrist instruments are a set of specialized tools that allows for clamping, suturing and tissue manipulation. The vision system provides the entire OR team with the live feed of the operating field.[9]

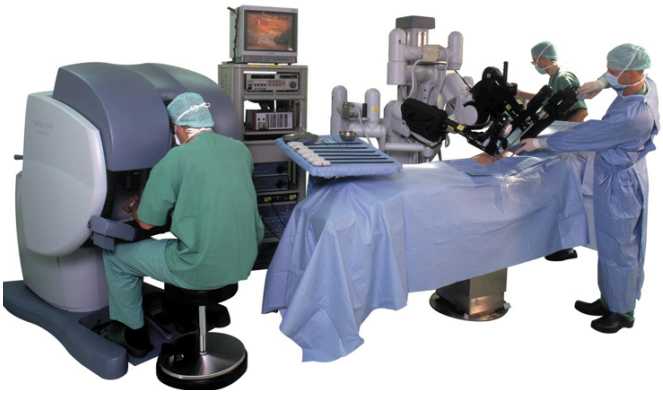

Figure. The da Vinci Surgical System. From left to right: surgeon console, vision system, patient-side cart and EndoWrist instruments.[9]
Image ©[2013] Intuitive Surgical, Inc.

The surgeons see a 3-D image of the surgical field through an integrated stereoscopic viewer attached to the console. The image shows the intraoperative area and the surgical instruments at the ends of the robotic arms. The surgeon controls the arms with a joystick and pedals. The movement of the surgeon's hands are transmitted electronically and reproduced by the robotic arms. These arms have joints that allow free movement comparable to that of human arms and hands. They also filter physiologic tremors, which allows for more stable arm motions. Since the robotic arms mimic the movements of the surgeon, the experience, proficiency and judgment of the surgeon influence the surgical results.[10] Nonetheless, when operated by a skilled user, it can yield tremendous benefits. The **Table** highlights its notable advantages and disadvantages.

ADVANTAGES	DISADVANTAGES
Minimally invasive	Long set-up time
Fewer complications	Limited console time for training
Better postoperative quality-of-life	No tactile feedback
Shorter recovery period	Expensive capital and running costs
3-D visualization	Long and steep learning curve
Tele-surgery	Trainer cannot teach trainees using the system
Improved dexterity and freedom of motion	
Better ergonomics	
Filtering of tremors	

Table. Advantages and disadvantages of robotic surgery.[1]

CHALLENGES

The cost of robotic surgery can be a huge impediment to establishing a robotics surgery program. This cost includes that of the robot, annual maintenance, disposable surgical instruments, operating room time, medication, hospitalization and health professionals. With a purchase price of $1.2 million and an annual maintenance fee of $100 000, the dVSS poses a significant financial challenge for many hospitals. Furthermore, Steinberg et al estimate that it would cost an additional $217 000 to train a single resident to proficiency.[12]

More problematic is the steep learning curve associated with the dVSS. Menon et al reported an initial operation time of 360 min for RALRP.[11] Similarly, it has been demonstrated that an average of 74 cases are required to achieve competency.[12] Heightened expectations from patients and medico-legal implications, as well as demands from hospital administrators to maximize results, mean that there is a limited opportunity for residents to train with the system.[13] Even more significant is the lack of any standardized competence-based training curriculum, which has been consistently underlined in successive literature.[14,15]

THE NEW TRAINING CURRICULUM

Guzzo et al and Shah et al proposed three essential phases in a structured robotics training program: preclinical phase, bedside assistant phase and operative console phase. During the preclinical phase, trainees receive information training delivered through didactics, videos and live surgeries. They also receive hands-on experience through inanimate teaching modules, cadaver dissection and animal laboratories. In the bedside assistant phase, the trainees function as co-surgeons, learning more advanced skills such as trochar and robot placement, instrumentation and troubleshooting. In the console phase, the trainees begin performing parts of the robotic procedures. They will be introduced to cases of increasing difficulty and evaluated objectively along the way. Live feedback will be provided to facilitate immediate skill enhancement.[16,17]

Simulation technology has been developed to address problems relating to cost and exposure time. Several virtual reality (VR) simulators for dVSS have been marketed. These include ProMIS (CAE Healthcare), SEP-Robot (SimSurgery AS) and dV-Trainer (Mimic Technologies).[18] Each of these simulators is comprised of a master console with finger cuff telemanipulators and a binocular 3-D visual output. Simulation exercises include EndoWrist manipulation, cameral control, object transfer, needle targeting, etc. The VR simulators allow for deliberate practice in a safe and controlled environment. Additionally, they allow for real-time assessment of trainee skill.[8] A systematic review demonstrated that VR simulators are effective training tools for junior trainees and can be used as adjuncts to traditional training methods.[4] Multiple studies have also demonstrated face, content and construct validity for this hardware.[18]

The concept of mastery learning has also garnered considerable attention in recent years for simulation-based training. Mastery learning is an extreme form of competency-based education and requires learners to acquire the clinical knowledge and skill to a degree measured against fixed proficiency standards.[19] In mastery learning, the educational results are uniform with varying educational time. This is in contrast to the current educational paradigm where students are given limited hours of lecture or practice time and assessed at the end, resulting in varying performance. The efficacy of this approach has been demonstrated for simulation-based central venous catheter insertion and advanced cardiac life support trainings.[20,21] Residents trained with a mastery learning approach improved their skills compared to those trained with more traditional methods. It is possible to integrate this training paradigm with da Vinci simulators to address shortfalls in robotic surgery training and establish a competency-based training curriculum.

CONCLUSION

With the rapid proliferation of robotic surgery in various specialties, there needs to be a standardized competence-based training curriculum for trainees. While there are foreseeable challenges, technologies and training paradigms are also evolving concurrently. With increasing quality of VR simulators and growing evidence supporting mastery learning, applications of robotic surgery will surely expand in the next decade and beyond.

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FEATURE ARTICLE

The use of ultrasound guidance in lumbar neuraxial blockade

Hao Li (Meds 2016)
Faculty Reviewer: Dr Sugantha Ganapathy, MBBS
(Department of Anesthesiology and Perioperative Medicine)

Neuraxial blockade of the lumbar spine is the standard of care for obstetric procedures (eg. Cesarean section) and orthopedic operations of the lower extremities when general anesthesia is contraindicated or unnecessary.[1] A local anaesthetic is injected epidurally (in epidural anaesthesia) or intrathecally (in spinal anaesthesia) at a level of the lumbar spine that is presumed to be below the conus medullaris, in order to minimize the risk of accidental trauma to the spinal cord.[2] Generally, this corresponds to the L3-4 vertebral interspace.

The current technique for locating the L3-4 interspace is by palpation of external anatomic landmarks. It is approximated by the height of Tuffier's line, an imaginary line connecting the highest points of the two iliac crests. This level is estimated to be either the L3-4 interspace or the L4 spinous process. The needle is inserted at this level at the center of the spine. Insertion into the epidural space is confirmed by loss of resistance to an injection of saline or air, and insertion into the intrathecal space is confirmed by the return of cerebrospinal fluid through the needle.

Unfortunately, evidence suggests that the technique of locating interspace levels by external palpation presents serious safety issues. As demonstrated by Broadbent et al.[2] in an observational study comparing external palpation to magnetic resonance imaging (MRI), identification of interspace using external palpation could be quite inaccurate. In fact, levels were identified correctly only 29% of the time, and this inaccuracy was especially pronounced in obese patients. In most of the errors, the physician underestimated the interspace level. This meant that the level they actually identified was higher than the level that they thought was identified (eg. believed that the level was L3, when it was actually L2), which can potentially lead to unintentional puncture of the spinal cord during injection.

This substantial risk of underestimating vertebral levels has indeed resulted in accidental spinal punctures in the clinical setting. Moen et al.[3] conducted a review of neurological complications associated with lumbar neuraxial blockade in Sweden from 1990 to 1999, and found that nine patients suffered from traumatic spinal cord lesions following the procedure. In eight of these cases, the physician thought that the puncture was performed at a safe interspace level, exemplifying an underestimation of level. The sequelae for five of these patients was severe pain, and for the remaining three, cauda equina syndrome. Hamandi et al.[4] reported five cases in the United Kingdom of irreversible neurological impairment resulting from puncture of the spinal cord during lumbar neuraxial blockade. In all of the cases, the physician underestimated the level of interspace punctured.

The incidence of spinal cord trauma associated with lumbar neuraxial blockade, most of which caused by underestimation of spinal level, is not high (1 in 190000, based on studies so far) as the majority of incorrect punctures are benign.[3] However, when it does occur, the consequences that follow such a complication can be devastating for both the patient and his/her family. Over the last decade, more and more physicians are beginning to perform their lumbar neuraxial blockade procedures under ultrasound guidance. Evidence suggests that ultrasound guidance, which is currently the only modality of guidance for these procedures other than palpation, makes lumbar neuraxial blockades more accurate and potentially safer. A detailed procedural description of ultrasound-guided lumbar neuraxial blockade can be found in a review by Chin et al.[5]

Current research shows that identification of vertebral levels using ultrasound guidance carries much more accuracy than through external palpation. In an observational study by Watson et al.[6] of patients undergoing spine MRI, ultrasound-guided identification of the L3-4 interspace was accurate 76% of the time. Furness et al.[7] compared palpation-guided to ultrasound-guided identification of lumbar interspaces in patients scheduled for spine X-ray, and found that the ultrasound-guided method carried an accuracy of 70%-90%, while the palpation-guided method was only 30%-40% accurate.

Clinically, performing lumbar neuraxial blockade under ultrasound guidance appears to generate more favourable patient outcomes than the conventional method. Grau et al.[1,8] conducted several randomized clinical trials comparing palpation-guided vs. ultrasound-guided lumbar neuraxial blockade with respect to both technical and patient outcomes. In one study performed on parturients undergoing conventional delivery or Cesarean section,[8] it was found that the ultrasound-guided method involved fewer puncture attempts than the palpation-guided method. A puncture attempt was defined as any puncture from outside the body, or any protraction and redirection of the needle within the body. Thus, this study showed that an ultrasound-guided procedure required less needle manipulations due to accidental misplacement, therefore holding the potential to minimize the risk of unintentional injury to the patient. Interestingly, patients in the ultrasound group also experienced better analgesia compared to those in the control group. This may be attributed to a greater accuracy in injection, such that the drug distributes itself equally on both sides of the injection site. Pa-

tients in the ultrasound group suffered from fewer side effects and overall, were significantly more satisfied than the control. Another study by Grau et al.[1] concerned combined spinal-epidural anaesthesia performed on parturients scheduled for Cesarean section. Again, the ultrasound-guided method involved fewer puncture attempts than the palpation-guided method, and patients in the ultrasound group reported greater satisfaction. While these data pertain solely to obstetrical patients, it does not seem unreasonable to extend the results to orthopedic patients as well.

In light of the severe and irreversible neurological complications that can occur with spinal cord trauma due to the inaccuracy of needle placement in conventional palpation-guided lumbar neuraxial blockade, and the findings that ultrasound-guided lumbar neuraxial blockade is more accurate and leads to greater patient satisfaction, it is likely that the ultrasound-guided method will replace the current protocol as the standard of care in the future.

With regards to challenges, an obvious concern with ultrasound-guided lumbar neuraxial blockade is potential cost. Another obstacle is patient safety. While ultrasound scanning itself is generally regarded as safe, it is possible for the transmission gel to leak into the puncture site.[5] The safety implications of this are currently unclear and require careful observation. Finally, it is recognized that the real-time ultrasound-guided procedure is fairly difficult, requiring stabilization of the ultrasound probe on the patient's back and dexterity with needle angle changes. Furthermore, the population in whom the conventional technique poses difficulties, such as the morbidly obese, may also have poorly visible structures on ultrasound. Thus, students practising on patients may inflict serious harm. Fortunately, these challenges can potentially be surpassed by having students initially train on spine phantoms,[9] low-cost simulations where a spinal model is immersed in a solid gel medium. Spine phantoms have been shown to possess similar echogenic properties as human bodies, and can be constructed to mimic a wide variety of patient characteristics (eg. obesity, kyphosis, scoliosis, etc.).

Currently, there is a lack of research to assess the safety and cost-effectiveness of ultrasound-guided lumbar neuraxial blockade, and few studies to directly compare it against the conventional method in terms of patient outcomes. One major reason is that utilization of ultrasound for lumbar neuraxial blockade is adopted by only a few practitioners around the world.[5] More large-scale randomized clinical trials are required to generate a greater amount of rigorous evidence supporting the higher safety of the technique. Thus, there are still several hurdles that must be leaped before ultrasound-guided lumbar neuraxial blockade can be established as the standard of care, and one must be patient. However, the already existing demonstration of its higher accuracy combined with the relatively low cost of ultrasound scanning makes the situation very encouraging.

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FEATURE ARTICLE

International surgery interest in Canadian medical training programs

David Mainprize (Meds 2015), Jimmy Yan (Meds 2015), Mike Livingston (Gen Surg PGY 3)

Globalization is the zeitgeist of our current world. With technological innovation and commercial liberalization, interactions across borders are being propelled forward at a meteoric pace. Health care systems have also been increasingly engaged in international endeavours through advances in medical education, biomedical research, and information dissemination. A part of this health care globalization process has been the promotion of public awareness and prioritization of international public health. Global health continues to be a growing interest among both medical professionals and trainees, and international programs have been established or supported in undergraduate and post-graduate medical education in each of Canada's 17 medical schools.[1]

Despite the increasing awareness of international health actions, not all areas of the global health sphere are equally represented in this effort. Major global health advances and infrastructure have been invested in fields such as infectious disease, epidemiology, community health, and occupational health while the field of surgery has been relatively underemphasized and referred to as the "neglected stepchild of global health."[2] While it has been estimated that approximately 11% of the total global burden of disease can be attributed to surgically amenable conditions,[3] only 3.5% of surgical procedures worldwide are carried out in the poorest third of countries where surgical need is the greatest.[4] Even more distressing, an estimated 2 to 3 billion people in the world are without access to basic surgical care.[5,6] While the awareness of global infectious disease issues has pioneered incredible international efforts resulting in substantial global impact on diseases such as polio, smallpox, tuberculosis, and AIDS,[2] an analogous movement championing international surgery as a public health initiative to address the immense gap between surgical need and provision in impoverished nations has been slow to gather momentum.

Traditionally, the languid push for monetary and political support towards surgery and perioperative care as a global health priority has been attributed negative perceptions. Common misconceptions towards international surgical care include thoughts that these efforts are not cost-effective, require too large an initial capital investment, require highly specialized training programs, and have a disproportionately small impact on the population.[7] However, more recent research by physicians with interests in global health and groups such as the Disease Control Priorities Project have revealed that surgical interventions are cost-effective and can provide essential care to the most vulnerable in impoverished populations.[8,9] One issue delaying the correction of these misguided perceptions results from the minimal exposure to international surgery that medical professionals receive in their early training stages.[10] As Canadian training programs have begun to incorporate focused objectives on global health in their curriculum,[1] inclusion of international surgical health education may reframe its current misconceptions and inspire a greater interest on global surgical health.

One of the main founders and promoters of international surgery was Canadian surgeon Dr. Norman Bethune who described the field as 'a humanitarian branch of medicine concerned with the treatment of bodily injuries or disorders [...] including cooperation and understanding between nations involving education, research, development and advocacy.'[11] Spearheading the pursuit of Dr. Bethune's vision in Canada is the Committee of International Surgery, a branch of the Canadian Association of General Surgeons, whose main directive is promoting international surgical awareness and service among Canadian surgeons and residents.[13] Several studies have been performed to assess the level of awareness and interest toward international work in the surgical community.

A study in 2003 has shown that interest in international medical efforts increased from 6%-20% between 1984 and 2003 in US medical schools and is thought to be similar in Canadian programs.[12] One method of promoting interest and awareness while also providing a valuable learning opportunity for residents interested in international surgery is elective experiences. The Royal College currently allows 3 months of overseas electives during Canadian residency training but funding for these electives is variable depending on the affiliated program.[11] A recent survey shows that 63% of residents would be interested in doing an international surgical elective and of those whom had already been on one elective, 98% responded with a desire to perform another.[11] The same questionnaire evaluating long-term interest in international work found that 25% of all Canadian general surgical residents and 80% of those who had done a previous international elective were interested in incorporating international surgery into their careers.[11] Similar surveys have been performed with surgical staff to assess their interest and support for international work. One such survey run by the University of Toronto in 2002-2003 indicated that 46% of staff were interested in being involved in international work, and of those who had previous international experience an overwhelming majority found it personally and professionally beneficial.[11] Approximately ¾ of the respondents in this study believed that medical students and residents should be encouraged to pursue international electives and that more funding should be made available to facilitate this goal.[11]

These surveys illustrate the strong interest among Canadian surgical residents and staff towards participating in international surgery. Efforts to explore the discrepancy between the apparent interest and current initiatives have identified specific barriers preventing students from committing to international work. In one survey Canadian general surgical residents identified multiple bar-

riers including family or other commitments, insufficient elective time, a lack of sufficient information or opportunity, and financial burden, the last of which was the most commonly cited.[11] There currently appears to be a strong interest toward pursuing international surgery in Canadian training programs but there remains a gap between this interest and concrete action, which may be due to certain personal and institutional barriers. One of the next steps is to improve financial and personal supports for students interested in international surgery experiences and introduce the fundamental concepts of international surgery to the medical undergraduate curriculum to motivate and inspire student interest early in their careers. Through improved organizational infrastructure and administrative support, residents and medical students will gain greater access to international surgical opportunities.

The long term goal of improving international surgery exposure during medical education is to eventually address the surgical care deficit, as there are many impoverished communities without access to basic surgical care. One avenue of addressing the underserviced international burden of surgical disease is by targeting undergraduate medical learners. Early exposure to the field through formalized teaching and oversea elective experiences will hopefully recruit a larger number of students to the field of international surgery who may become strong advocates and providers of international surgical care in the future. Additionally, as student interest grows and institutional supports expand, current staff surgeons may be encouraged to become involved more heavily in international surgical work creating more teaching and surgical care partnerships in areas of the world currently underserviced.

As much of the world's most vulnerable populations still lack access to safe surgical care, a new generation of surgeons interested in and passionate about international surgery is needed to bridge this gap. Expanding student interest and improvement of institutional supports to advance the ease of access to elective opportunities for residents and medical students in international surgical programs may eventually help address the current unmet burden of surgical disease in underdeveloped areas.

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FEATURE ARTICLE

The med in social media

Considerations on integrating social media into medical educations

Jimmy Yan (Meds 2015)
Faculty Reviewer: Dr. George Kim, MD (Department of Family Medicine)

Social media is a broad term describing a collection of online and mobile technologies that allow people to create interactive communication channels.[1] These mediums can be used to create, monitor, manipulate, and share a variety of content including text, audio, video, or digital images. Its use can be done actively in real-time or passively through different platforms such as individual blogs, websites, YouTube, podcasts, social networking sites, or even an online discussion forum.[2] The user base of these sites has formed an evolving digital community known as Web 2.0, or the Social Web, the internet's second version. The crux of Web 2.0 is interactivity, content is no longer simply 'pushed' to viewers, but a dynamic exchange of 'push, pull, and create' by all users.[3] Social media serves as the defining element of Web 2.0.

Regardless of how it's defined, social media has become a prominent discussion point in the medical profession. Survey findings report that over half of Canadian physicians use at least one form of social media, and over 80% of Canadian physicians expressed concerns that social media "poses professional and legal risks to physicians."[4] Indeed, in a field where confidentiality and trust are paramount, it is easy to see why physicians are hesitant to embrace social media and it's insouciance towards personal privacy in their professional lives. Medical students are also wary about their actions on social media: opting to hide themselves away, limiting their privacy settings or even deleting their accounts when CaRMS selection rolls around.

Yet, consider the following bits of information. The current global active user base for Facebook is over 1.1 billion users;[5] the registered user base of Twitter is over 500 million, with over 340 million tweets generated daily.[6] In comparison to the 38 and 13 years it took the radio and TV, respectively, to be adopted by 50 million users, the times that Facebook (1 year) and Twitter (9 months) reported are eye-opening.[7] Furthermore, these users are everyday individuals, and they are everyday patients. To disregard social media would be to overlook significant aspects of how patients are getting and communicating information.

Additionally, due to the pervasiveness of Web 2.0 and its ability for information to be created and stored by any user, simply detaching oneself from social platforms or changing privacy settings does not guarantee one's personal activities and online presence will remain anonymous or publicly un-cited. Photos or videos of medical students or physicians can still be posted by peers or colleagues identifying them. Comments, tweets, and mentions that include one's name can also be made by any friend, co-worker, patient, or even strangers, and once those words are put online, there will always be a way for it to be found.[2] Patients googling a physician, hospital, or medical school can, and will find, information made by other people. If one rejects participation entirely in these social platforms, the ability to mold the online content around them is lost. Medical professionals need not become envoys in all aspects of social media, but at the very least become knowledgeable of their own digital footprints.

The debate on whether physicians should be engaged on social media professionally will continue on, and illustrates why this topic needs to be brought into current medical education. Consider the following summary of the possible benefits and uses for social media in medical care:

BENEFITS OF SOCIAL MEDIA USE

1. Opening Physician-Patient communication channels

Social media is the gateway for online communication. The interactive exchange along these platforms can strengthen the physician patient relationship by giving a new means for patients to reach medical professionals. It places the patient truly at the centre of care as they can communicate their research and ask questions on their own schedule, even from the comfort of their own homes. Used strategically, social media allows for greater patient participation and autonomy in their health care.

2. Improved access to knowledge and resources

One great feature of social media is its ease of customization. Professionally designed Facebook pages, YouTube channels, blogs, Twitter accounts, and web forums allow users to subscribe to information on their own topics of interest. These include some of the most established medical organizations, including the New England Journal of Medicine (@NEJM), and the Lancet (@TheLancet). These platforms can all be great tools for self-directed adult learners, giving users the freedom to learn within their own schedules and often a variety of modules to accommodate individual learning styles.[8]

3. Public Campaigns

Social media can bring public awareness of healthcare initiatives. In spring 2012, Facebook launched a feature that allowed US and UK users to share their organ donor status with their network, the addition of this tool prompted a huge, albeit transient spike in local organ donation registry sign-ups.[9,10] This effect was also seen in Canada. For example, Ontario's Trillium Gift of Life registry also reported an increased number of individuals signing up following the move by Facebook.[11] There could be a potential future avenue for social media in garnering support to organ donations, blood drives, or other public health campaigns.

4. Physician to physician networking

Indubitably social networking can be a great asset for physicians to reach each other. Social media platforms allow easy sharing of links, articles, research interests, and can generate discussion among those with common interests.[1,2] For example, The Skeptics Guide to Emergency Medicine (theSGEM.com) is a physician created and operated website that utilizes Facebook, Twitter, Google+, and weekly podcasts to share Emergency Medicine clinical scenarios. Since its inception in 2012, it has already been linked with other podcast groups with similar goals, and is included in a global community of physicians committed to providing free open-Cited resources for medical education.[12,13,14] Another avenue that social media has become useful for physician networking is within conferences. Many medical conferences have adopted official Twitter hashtags – labels which allow users to find content related to that tag easily. Through Twitter and these hashtags, physicians at conferences can find out, in real time, information from workshops they could not attend from those present, engage in side discussion about a talk with other listeners without interrupting the speaker, and make acquaintances with other physicians there. The ability to connect and communicate from any part of the world, as long as one knows which hashtag channel to follow, is a powerful advantage which allows physicians to form online global networks.

5. Monitoring of disease trends

With greater participation of patients in the access of health information, the data in what is being searched or asked about can become value to survey and monitor as well. The 21st century saw the beginnings of a new field of data analysis: infoveillance.[15] This is the field where health informatics are used to track user queries and recognize patterns that are associated with specific disease parameters. Closely related to this is the new field of infodemiology: using information from an electronic medium, specifically the Internet, within a population to shape and inform public health and policy.[15] One of the more well-known examples is Google Flu Trends, which keeps tracks of online search queries from a particular population region to provide real-time estimations of flu outbreaks within that area.[16] Information sent over Twitter has also been tracked in order to see how it can be used to monitor disease.[17] Other research has been conducted to see if social media can be used to predict the incidence of depression and other mental illness in a population.[18]

6. Positive professional image

There is a great deal of concern about the content of a physician's online life not only damaging their professional image but also compromising the reputation and general confidence in the medical profession.[1,2] While these concerns are fundamentally reasonable, physicians and medical trainees can work proactively to create a positive online presence. This is achieved through purposeful and curated activity over social media. Adding a stronger physician presence can help provide patients with better access to doctors, more credible sources for information, and a stronger voice to balance the other sorts of opinionated claims online.[2,3]

CONCLUSIONS

Social media has clear potential to greatly enhance the field of medicine. However, without early exposure and guidance on proper use, it will remain a hesitant and nebulous subject to approach. As current and future patients are becoming more adept at utilising social media, likewise medical education needs address this area and train students appropriately. It is time to be proactive in the handling of social media and train the next generation of physicians into the Net generation of physicians.

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CLINICAL PROCEDURES

Nanotechnology in cancer therapeutics

New insights on an old disease

Denise Darmawikarta (Meds 2016), Alexander Pazionis (Meds 2015)
Faculty Reviewers: Dr. Paul Charpentier, PhD, Sahar Samimi (PhD Candidate)

ABSTRACT

The field of cancer therapeutics is rapidly evolving. Of particular interest is the potential for nanotechnology to overcome one of chemotherapy's biggest barriers: targeted drug delivery. Owing to the sheer small size of nanoparticles, the opportunity arises for chemotherapy to be administered much more accurately to cancer cells while sparing healthy adjacent tissues. In this article, we review the various tools in nanotechnology that have emerged as candidate delivery systems for chemotherapeutic agents. We discuss the ways in which nanotechnology has been demonstrated to eradicate cancer cells and comment on both successes and current limitations.

INTRODUCTION

Cancer dates back to the time of Hippocrates, who described it using words like carcinos, Greek for crab or crayfish. The oldest known description of a surgical procedure for cancer was developed in Egypt and thought to originate from approximately 1600 BC; the papyrus made note of 8 ulcerations of the breast treated via cauterization and concluded that "there is no treatment" for the disease.[1]

At the turn of the 20th century, William Stewart Halsted, professor of surgery at Johns Hopkins University, developed the technique of radical mastectomy,[1] which became the mainstay of breast cancer treatment until the mid-1970s, when less disfiguring procedures were found to be equally effective and carry less complications.

The evolution of cancer surgery mimics that of both radiation therapy and chemotherapy. Radiation therapy began with the discovery of primitive X-rays but today, we have at our fingertips the services of computed tomography (CT) and magnetic resonance imaging (MRI) to more accurately locate tumours and determine the required dose of radiation. Chemotherapy can be traced back to the use of mustard gas in chemical warfare during World War II and presently, oncologists are equipped with a wide array of chemotherapeutic drugs including alkylating agents, antimetabolites, and vinca alkaloids, to name a few.

With further development of combinational chemotherapy and radiotherapy, the field of cancer therapeutics began to flourish at an exponential rate. Nonetheless, the lack of target specificity of anticancer agents (ie their relative inability to accurately distinguish between normal and cancerous cells) remains a nagging problem in the field of cancer medicine.[2] The birth of nanotechnology, which involves the synthesis of materials and devices to manipulate matter at an impressively small scale, presents the opportunity for chemotherapy to be more accurately delivered to target tissues, thereby minimizing collateral damage to the surrounding tissues.[2] Here, we discuss the principles, successes, and limitations of nanotechnology as it relates to cancer medicine.

NANOTECHNOLOGY IN DRUG DELIVERY

Various tools in nanotechnology have been explored with respect to their potential roles in cancer medicine; these include liposomes, nanotubes, dendrimers, and many others, each with their own unique characteristics. For example, nanotubes, which are carbon cylinders composed of benzene rings, can enter the cell via different methods, including passive diffusion and endocytosis.[3] Further, their dynamic chemical properties are conducive to the manipulation of their solubility so that drugs contained within the tubes can be released at a specified rate. Alternatively, liposomes, which can form lipid bilayers, are able to carry both hydrophilic and hydrophobic molecules simultaneously, and are therefore attractive vehicles for combinational drug therapy.[4] Furthermore, the newest classes of dendrimers, characterized by their tree-like branches around an inner core[3] that provide vast amounts of surface area for drug attachment,[5] have been modeled to carry a therapeutic drug, a diagnostic agent, and an active targeting molecule all in a single dendrimer.[4] Evidently, nanotechnology, involving the synthesis of various nanoparticles of different shapes and behaviours, can open a wide avenue of possibilities in terms of achieving targeted drug delivery.

There are several ways in which the use of nanotechnology has been demonstrated within the realm of cancer medicine. They include (but are not limited to): (1) intracellular chemotherapeutic delivery, (2) photothermal ablation of tumour cells, and (3) gene therapy.[6-8]

Intracellular chemotherapeutic delivery takes advantage of angiogenesis. Angiogenesis is one of the hallmarks of cancer that involves the formation of new blood vessels through which tumour cells cultivate themselves by taking nutrients and oxygen from surrounding cells. As a consequence of their rapid, uncontrolled growth, angiogenic blood vessels form irregularly and are leakier than normal healthy vasculature.[5,9] Pores in these vessels range from a few hundred nanometers to several microns in diameter, while their size reaches only 2 to 6 nm in normal vessels. Since nanoparticles are within 10 to 300 nm in diameter, they are the perfect size for penetrating tumour cells through their blood vessels without considerably entering healthy tissues.[9] This Trojan horse method presents an attractive means of minimizing damage to surrounding cells.

Photothermal ablation exploits the fact that normal cells undergo apoptosis at approximately 46°C while cancer cells typically do so at about 42°C.[10] Several studies have used gold nanoparticles that are tuned to be excited only at certain ranges of light, thereby eliminating targeted tumour cells while sparing the neighbouring healthy cells.[11]

The use of nanotechnology in gene therapy has the potential to overcome limitations of current methods, such as reducing the health risks associated with efforts relying on viruses. In a recent

study,[12] nanoparticles consisting of a synthetic delivery system (described in detail elsewhere) along with small interfering ribonucleic acid (siRNA) were successfully designed to reduce the expression of RRM2, an established anticancer target.

SUCCESSES TO DATE

Currently, there are two notable nanotech reformulations of existing chemotherapeutics that have been approved by the US Food and Drug Administration: (1) Abraxane, an albumin-bound reformulation of paclitaxel, a mitotic inhibitor, and (2) Doxil, a nano-sized liposome encapsulating doxorubicin, an anthracycline antibiotic.

Since 2005, Abraxane has been used for the treatment of metastatic breast cancer for women who failed to respond to first-line treatment for metastatic disease and for whom standard, anthracycline-containing therapy was contraindicated.[13] It is an antimicrotubule agent that prevents depolymerisation of microtubules, thereby inhibiting their normal dynamic reorganization as required for cellular function.[13] Abraxane has been shown to confer fewer toxic side effects and greater antitumour activity than its non-nanotech counterpart.[13] Furthermore, this reformulation eliminates the requirement for premedication in anticipation of hypersensitivity reactions, reduces infusion time, and allows for the use of standard infusion equipment for its delivery.

Doxil was originally approved for its use in HIV-related Kaposi's sarcoma.[14] Its application has now extended to the treatment of ovarian cancer and multiple myeloma. Compared to previous standard therapy involving doxorubicin or bleomycin and vincristine, Doxil was found to be more effective in the treatment of advanced Kaposi's sarcoma.[14] In fact, Doxil confers other significant benefits over standard therapy, including better overall quality of life, reduced disfiguring quality of indicator lesions, and improved pain control and energy.[14]

CURRENT LIMITATIONS

While nanotechnology has opened up a window of endless and exciting possibilities into cancer therapeutics, it has its limitations. Perhaps the most significant obstacle yet to be entirely overcome is the biosafety issue of nanoparticles. This is primarily due to a host's complex immune response to invading nanoparticles. Further investigations with respect to the distribution, metabolism, excretion, pharmacokinetics, and pharmacodynamics of nanomedicines need to be carried out if nanotechnology is to become the mainstay of chemotherapy.[15]

Issues with regards to costs and environmental safety are also important to consider. For instance, both Abraxane and Doxil are priced at more than ten times the cost of their non-nanotech counterparts, and while they have been demonstrated to markedly improve quality of life as they are less toxic to healthy tissues, neither has been proven to significantly increase survival.[9] Additionally, although nanoparticles appear to impose no immediate threats to human or environmental health, long-term investigations assessing risks due to chronic exposures have yet to be undertaken. Of particular concern is the early observation that some nanoparticles seem to persist in the environment for longer than others, which underlines the importance of thorough risk assessment and management.[16] The field of cancer therapeutics will only continue to expand and evolve, and while nanotechnology could be the long-awaited promising breakthrough, we are simply grazing the tip of the iceberg of its true therapeutic potential.

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DIAGNOSTIC REVIEW

New techniques in the detection of juvenile open-angle glaucoma

Hammood Ahmed (Meds 2015), Angela Zhang (Meds 2015), Thomas Fear (Meds 2015)
Reviewer: Dr. Tony Lin

INTRODUCTION

Recent advances in molecular biology techniques and imaging instruments have opened up the possibility that genetic-based screening and imaging might become faster, less expensive, and more available.[1] One condition where these new technologies could have an application is juvenile-onset open-angle glaucoma (JOAG). Current practices for detecting cases of juvenile- onset glaucoma involve measurements of intraocular pressure (IOP) and optic nerve assessment by cup-to-disc ratio (CDR). These practices are far from perfect, and results vary from one ophthalmologist to the next. Furthermore, because the levels of IOP and the CDR at which pathology is likely to be seen have not been well defined there is a degree of uncertainty in determining whether or not a diagnosis of glaucoma can be made.[2] There are problems in the guidelines for current screening for JOAG and the solution to these problems could lie in new technologies such as genetic screening and imaging that could potentially complement each other in helping to better screen for this disorder in the future.

BACKGROUND

Glaucoma is a disease of the eye characterized by increased IOP and progressive degeneration of the optic nerve leading to permanent visual loss. JOAG has a prevalence of 1% in the population and presents in affected individuals between the ages of 3 and 40. Its pathophysiology can be traced to defects in genes, like myocilin, that code for structural components of the eye.[3] JOAG is inherited as an autosomal dominant trait and could be detected early in development using imaging of the retina and optic disc at high resolution. The disease is currently detected by measures of IOP. When the increased pressure is noted it can be reduced with medications or laser surgical procedures,[4] though these techniques prevent progression but do not reverse damage. While screening for glaucoma is done in adults in order to detect increases in pressure and allow initiation of treatment prior to optic nerve damage, it is uncommon to employ such practices in children. Still, while it is uncommon for the disorder to present at such a young age, in cases of JOAG optic nerve damage can develop at a very early age and is irreversible.[5] As such, genetic screening and imaging in this younger group of individuals could be useful tools for identifying JOAG early before damage occurs.

CURRENT PRACTICE

Currently there are no screening programs for JOAG. The diagnosis is made on an individual basis by combining information from IOP testing and fundoscopic evaluation of the CDR with additional supporting signs such as visual field loss, presence of myopia, and blurry vision due to corneal edema or thickening.[5] The diagnosis can be made earlier in children who have a parent, sibling, or more elderly family member affected by the disease. This diagnosis requires clinician judgement, and the interpretation of what is significant is subjective and may differ from one ophthalmologist to the next. However, an earlier diagnosis results in a more favorable outcome because measures to prevent further optic nerve damage are taken earlier.[6] Criteria for diagnosis were developed from just one demographics study of congenital, infantile, and juvenile glaucoma. Given the lack of research currently being used to establish existing diagnostic criteria, and that intraocular pressure gives us no indication of the extent of optic nerve damage, there needs to be a more reliable method that can be used to both diagnose JOAG and assess optic nerve pathology.

The present treatment for JOAG is trabeculectomy, which usually results in considerable benefit. However, the treatment may result in harm if it is done before the onset of symptoms. Some complications that can arise with premature surgery include hyphema, subconjunctival hemorrhage, vitreous loss, and tearing of the sclera.[7] If the disease is detected early and IOP is monitored closely and kept in the normal range, optic nerve damage can be prevented. Early treatment is important because a great deal of optic nerve damage has occurred by the time the disorder can be clinically identified.[8] This risk gives incentive for identifying individuals with potential pathology and following them clinically.

NEW TECHNIQUES IN SCREENING

An emerging tool that may aid in diagnosis of this disorder is genetic testing because JOAG exhibits genetic inheritance. Some genetic variants exhibit more expressivity than others, and genetic testing will allow difficult cases to be more easily recognized and treated. Three main gene variants are implicated, all encoding proteins of the trabecular meshwork of the eye. Mutation of the myocilin (MYOC) gene is the most important of the 3 because it is implicated in cases where subjects have an earlier onset of disease, high intraocular pressure, and a strong family history.[9] Between 6 and 83% of JOAG cases are associated with MYOC mutations.[10] A strong family history provides an important clue about whether or not screening for the disorder is appropriate. Genetic testing in such families would result in a better prognosis because affected individuals could be identified prior to disease onset.

Another test to aid in screening for JOAG is confocal scanning laser ophthalmoscopy (CLSO). CLSO is a method of examining the

eye that uses microscopy to image the retina with a high degree of spatial sensitivity. It is helpful for screening for glaucoma and macular degeneration. It is currently being combined with adaptive optics technology to provide images of the retina with a higher resolution. Imaging modalities such as CSLO show promise for improving the detection of the optic disc and retinal nerve fiber layer changes that can be used as clinical indicators of developing glaucoma. Using this technology in combination with clinical judgement and other methods in high-risk individuals could aid in the screening and diagnosis of glaucoma.[6]

LIMITATIONS

Genetic testing may have an application in JOAG though currently there are limitations to its utility. Genetic testing for JOAG is done by gene sequencing for mutations on chromosome 1. It takes approximately 12 weeks to receive results and costs $200 per test.[8] The cost of screening can be high, but there is considerable benefit for doing so in individuals with a previous family history. Some possible goals for the future could include reduction in the cost of genetic screening and characterization of the genetic determinants of this illness.

Further research into developing CLSO is also required before it can be widely applied. CLSO is currently limited because measurements may be affected by blood vessels seen in the image of the eye, along with anatomic variation or other pathologic processes. The resolution of the images this technology produces also prevents useful quantitative measurements of changes that are occurring in the retina and optic disc.[6] Finally, an improved understanding of how levels of IOP and CDR are associated with pathology needs to be better studied.

CONCLUSIONS

Optimal management of JOAG is still hindered by our inability to make an early diagnosis in many individuals that present with the disease before irreversible damage has been done. Genetic screening and CLSO are two methods that show a great deal of promise in advancing the management of this condition; however, neither is currently useful. Goals for the future should include further research and development of these techniques, along with better-defined clinical values of IOP and CDR that are significant. Genetic-based testing and CLSO may hold significant promise in the future for an improved management of JOAG. Specifically, genetic testing may allow for the identification of individuals at a high risk for JOAG, who could then be monitored with CLSO to avoid irreversible vision loss.

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Personalized Genomics

Saad Ahmed (Meds 2016)
Faculty Reviewer: Dr. Rob Hegele, MD, FRCPC, FACP, FAHA, FCAHS

A growing number of doctors have reported patients arriving at their offices with genotyping results or even readouts of their partially sequenced genome.[1]

The advent of commercial direct-to-consumer (DTC) genetic testing has made such scenarios not uncommon. For only $100, companies such 23andMe will send customers a kit to collect their saliva from which the company will sequence certain segments of the customer's genetic code (also known as non-targeted genetic profiling genotyping). This genotype will be uploaded to the customers' private account on the company's website, with which they will able to see their results and their risks for developing certain diseases. It is important to distinguish these types of DTC tests from what are known as whole-genome sequencing (WGS) tests. WGS tests sequence the entire genome, a feat that can now be accomplished in under a week and for under $10 000.[2] WGS tests can also be DTC; however they are not as common-place due to the high cost and the limited knowledge about interpreting whole genome sequences. Non-targeted genetic profiling (NGP) tests genotype consumers' genetic information – that is, that they look for single nucleotide polymorphisms (SNPs) in certain segments of the genome that estimate the risk of a certain disease, usually by comparing it to other genetic profiles which are linked to case-control studies in which the patient's disease status was determined at the time of the study. However, most of these SNPs only predict slight increases in disease susceptibility. These SNP-based genotypes are known as non-targeted genetic profiling and their clinical utility is questionable at best.[3]

Many health professionals, including family doctors, do not feel comfortable dealing with such scenarios. Reasons include a lack of exposure to genomics in medical education as well as the tremendous difficulties in objectively predicting disease from any genomic sequence or genotype.[4,5] One report recently referred to NGP genetic tests as 'fortune telling reports.'[3,6] Indeed, in the United States a study found that only just over half of specialists in clinical genetics who had seen patients as a result of NGP tests judged the test to be clinically useful.[1] Part of the problem is the manner in which NGP tests are analyzed. For instance, a recent review of two prominent NGP tests noted that they did not focus on diseases for which high-risk marker predictions were available, and instead chose to report on diseases for which genetic markers only added a modest increase in risk.[7] The clinical importance of such reporting is unclear, partly because the genetic markers themselves do not account for 100% of the genetic heritability of a disease.[7] There is also a lack of consensus amongst companies about the markers to use for diseases, and two tests from different companies could thus give two very different risk estimates for a disease.[7] Commissions on NGP testing in the UK and US have also found that there were no follow-up systems in place to ensure proper interpretation of test results by patients and physicians.[8]

ETHICS

The ethical issues converge for both forms of DTC testing – WGS and NGP. Both forms of testing suffer from an overload of information and an impossibility of deciphering the actual risk of disease, which in turn cause problems with informed consent. As explained above, this means that the clinical validity and utility of NGP and commercial WGS tests are questionable at best, and thus the use of NGP testing as a screening tool is problematic. All screening programmes need to undergo a risk-benefit analysis to minimize the potential of unnecessary testing and treatment.[9] The World Health Organization has an entire list of criteria for effective screening programmes, one of which is that the screening test be able to detect a clinically relevant disease for which effective treatment is available.[10] Furthermore, the ethical principles of nonmaleficence and beneficence require that health professionals strive to minimize harm and promote the well-being of their patients. Insofar as NGP and WGS testing lead to unnecessary testing and treatment, health professionals should strive to educate patients about the truth of the tests, including both the benefits and pitfalls. Education is especially pertinent, since many NGP testing companies claim to offer the tests solely for interests' sake, and yet will report on the genetic predisposition to diseases as serious as breast cancer or Alzheimer's Disease.[11]

The advent of DTC testing also raises questions about social justice. Although doctors consciously minimize requests for unnecessary tests, individuals getting DTC tests could feasibly pressure their doctors into getting the extra tests done to allay those concerns, and thus drain health care resources. Furthermore, the fact that the patients can pay for the DTC tests in the first place means that they certainly are not poor, which means that affluent people who are ordering such tests will use the health care system disproportionately in comparison to those who are less affluent.[12]

In WGS tests, issues of privacy, obligations and future uses of data pose significant questions. For example, there can be unintended research results, such as an association found between race and IQ, which the test subjects might have not consented to. This calls for regulation and oversight of the obligations that researchers owe to the original test subjects.[13,14] This specifically and recently became an issue when the NGP testing company 23andMe utilized consumer genotypic data and surveys to develop and patent a method to detect Parkinson's Disease. The company mentions in fine print that they would own all customer genetic data; still, the

consumers whose data were used for the study obviously felt the need for reimbursement.[15,16] Private ownership of genetic information also raises the question of whether such data can be bought or sold.[11]

POLICIES/LAW

Various societies have formulated responses to DTC testing. The American Society for Human Genetics says that there should be government oversight and regulation of DTC tests, including testing the clinical validity of the claims of the tests. The companies offering them should be totally transparent and offer all the possible information in an accessible manner.[17] An editorial in the BMJ called for an international industry certification of DTC tests,[1] with the understanding that an Internet-based industry needs global regulation. Similarly, other pieces have argued for more oversight, regulation and certification of genetic testing labs to ensure the quality of commercial genetic testing,[11] and to work towards common standards amongst DTC testing companies.[7]

Many European countries, such as France, Belgium, Germany, the Netherlands and Switzerland have adopted legislation curtailing DTC tests and allowing predictive genetic tests only on the request of a health professional.[18] Each country still has its own approach to DTC tests. For instance, the Netherlands has a framework protecting individuals against screening tools that are clinically useless and that may pose a threat to health. Future regulation of DTC testing in the Netherlands specifically could be built upon such provisions.[18] In the United Kingdom, the Human Tissue Act criminalizes the analysis of genetic information without consent,[18] which means the policies with which 23andMe was able to utilize consumer genotypes would have to be carefully explained to all of their customers so as to ensure that the customers were fully consenting to their genetic information being collected and analyzed.

Currently, the United States has the Genetic Information Nondiscrimination Act, which prohibits employers and insurance companies from using genetic information. However, Canada has no such laws regarding the use of genetic information by insurance companies for underwriting. The Privacy Commissioner of Canada thus requested two papers on the subject, both of which advocated for a ban on using any genetic information in health and life insurance policies. This also included monogenic disorders, as the papers argued that they were very rare and would have a limited financial impact on insurance companies.[19]

REALITY CHECK

It is important to ask at this point – are health and specifically health information a "consumption good"?[11] And what sort of future does this predict for the patient-physician relationship? On the surface of it, noted philosopher Ivan Illich's critique of modern society becoming increasingly "medicalized" certainly rings true, where people increasingly see their life problems as medical problems. It is also important to add a dose of reality here – genetics is not destiny.[20]

A recent series of articles in the CMAJ deal with the hyperbole surrounding personalized genomics. Simply put, just as the original Human Genome Project was unable to find exact genetic bases for diseases, sequencing individual genomes is unlikely to reveal answers easily. The phenomenon of incomplete penetrance, in which a genetically inherited condition may not manifest itself phenotypically due to environmental factors, highlights how non-genetic factors play a significant role in the development of any disease process. The environment and the genome also intersect in the epigenome, heritable changes to DNA that do not involve base pair sequences and can occur due to environmental stresses. This of course further complicates the correlation of a genetic mutation with a disease.[21-25]

The crux of the matter is that while sometimes genetic sequencing can reveal genetic mutations that are associated with a high risk of disease – as in the case of Huntington's Disease and other monogenic, heritable diseases, or even the BRCA1/2 susceptibility genes for breast cancer – at other times they do not. In other contexts still, as in the case of pharmacogenetics, it can provide useful information about a patient's response to drugs that would prevent allergic reactions or aid in drug dosing. Unfortunately, as with most things it will take time and experience to fully flesh out the ethical and legal ramifications of DTC testing.[26] As health professionals we will have to keep in mind our duties to our patients' well-being and question the clinical value of advances in genetic testing that emerge in the future.

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HEALTH PROMOTION

Sick planet, sick patients

The health impacts of climate change

Charlotte Hunter (Meds 2015)
Faculty Reviewer: Dr. John Howard, MD, FRCPC (Departments of Medicine and Paediatrics)

In 2007, Dr. Margaret Chan, the Director General of the World Health Organization (WHO), referred to climate change as "the defining issue for public health during this century."[1] In spite of this pronouncement, many members of the public, and of the medical community, do not fully appreciate the link between anthropogenic greenhouse gas emissions, rising average global surface temperatures, and human health. In a series of in-depth interviews with 22 residents of Southern Ontario, researchers found that 77% of interviewees believed that climate change would have health impacts.[2] However, the study participants were generally unable to provide details about the specific health effects of climate change or to put these effects in the context of their own community and their own health.

Although the developing world is much more vulnerable to the expected health impacts of climate change,[3] this article will examine the health effects anticipated in Canada and other industrialized nations. It will also demonstrate that the responsibility for addressing these health impacts lies with primary care providers, emergency department physicians, and other medical specialists – not just with public health officials. Finally, it will describe these impacts in the context of how they will affect the most vulnerable members of Canadian society.

Perhaps the most obvious health impact of climate change relates to the increased frequency and intensity of heat waves. We have already begun to experience this effect of climate change: in Toronto, the number of days above 30°C each year nearly doubled during the period of 1995-2005 compared to the period of 1961-1990.[4] Due to the urban heat island effect, which is when the abundance of concrete and asphalt in cities traps more heat compared to rural areas, heat-related mortality is expected to be greatest in urban areas.[5,6] Climate change models have projected a fourfold increase in the number of extreme heat warnings in Toronto by the 2080s, which could lead to a tripling of heat-related deaths.[4] Risk factors for heat-related mortality include: extremes of age; living alone and being socially isolated; pre-existing medical conditions like cardiovascular, cerebrovascular, or pulmonary disease; psychiatric illnesses; not having air conditioning; being homeless; and working long hours outdoors.[5-7]

Climate change is also expected to lead to an increase of air pollution-related morbidity and mortality. Higher temperatures lead to increased concentrations of ground-level ozone, which can lead to exacerbations of COPD, asthma, and cardiac disease.[6,7] There is also concern that climate change will increase pollen production and the duration of the pollen season. These changes are expected to cause increased morbidity associated with allergic rhinitis and asthma, especially among children.[5,7,8]

The prevalence of extreme weather events, including storms and floods, is expected to increase with climate change. In fact, it has been estimated that there was a 24% increase in the frequency of extreme precipitation events in the United States between 1948 and 2008.[9] Health effects of extreme weather events can include: drownings; injuries; infectious disease outbreaks from contaminated water supplies; and mental illnesses like anxiety and depression.[5-8,10] A longitudinal study of individuals affected by Hurricane Andrew, which occurred in the Southern United States in 1992, found that 20–30% of adults in the area met criteria for PTSD at 6 months and at 2 years after the event.[6,10]

Another major health impact of climate change will be the morbidity and mortality associated with changing infectious disease patterns. There has been an increase in the incidence of West Nile Virus infections in humans, from 62 cases in the United States when the virus was introduced to North America in 1999, to 1,338 cases in 2008.[6] This trend is expected to continue as climate change leads to an earlier onset of spring and an extended amplification cycle for the virus. In general, warmer temperatures, increased precipitation, and elevated humidity are associated with an increased incidence of West Nile Virus.[8] Similarly, climate change is expected to alter the geographic range of Lyme disease and other tick-borne diseases, with warmer temperatures allowing for a northward migration of the tick vector.[7,8] Finally, climate change may lead to increased transmission of water- and food-borne illnesses (such as Cryptosporidium and Salmonella, respectively), as warmer temperatures allow for pathogen survival and increased precipitation facilitates contamination of drinking water supplies.[7,8,11]

As demonstrated above, the health impacts of climate change are not merely theoretical, nor are they restricted to the developing world. They include tangible health problems that fall within the scope of practice of Canadian physicians. Medical students, residents, and physicians should familiarize themselves with the changing epidemiology of diseases associated with climate change and be prepared to address these health issues in a clinical setting. In a recent commentary for Canadian Family Physician, Dr. Alan Abelsohn and others outlined the clinical treatment and prevention of several health problems associated with climate change.[7] Some examples include: preventively counseling individuals at high risk of heat exhaustion; treating injuries and PTSD after extreme weather events; counseling patients with COPD, asthma, or cardiac disease to reduce their exposure to air pollutants; diagnosing and treating Lyme disease with doxycycline; and participating in the surveillance of water- and food-borne diseases.

Another important reason to be concerned about the health impacts of climate change relates to the equity dimension of the problem: climate change will disproportionately affect the most vulnerable members of society. Children will be at an increased risk for morbidity associated with heat waves, air pollution, and gastroenteri-

tis due to water- and food-borne pathogens.[8] Elderly individuals will be highly susceptible to heat-related mortality and many of the other health impacts mentioned above due to their existing burden of chronic disease.[7] Homeless individuals will be highly susceptible to heat exhaustion, the effects of extreme weather events, air pollution, and mosquito-borne diseases like West Nile Virus, due to their lack of shelter and increased amount of time spent outdoors.[6]

Canada's Aboriginal population will perhaps face the greatest burden of illness associated with climate change. The traditional diet of some Aboriginal communities could be compromised as the changing climate alters the populations of animals depended upon for subsistence hunting.[11] The increased survival of water-borne pathogens could contaminate water supplies in more marginal locations, while food-borne pathogens could threaten traditional diets that include raw meat.[11,12] In more remote communities, coastal erosion due to rising sea levels, extreme weather events, and changing ice distribution could lead to community displacement and psychological harm.[11,12] In addition, all of the health problems discussed previously with respect to the general population are likely to be exacerbated by the poverty, lack of access to health services, food insecurity, overcrowded housing, and other social inequalities already disproportionally affecting Aboriginal communities.[11]

It is evident that anthropogenic climate change will have adverse health impacts on our patients and communities. It will also worsen existing health inequalities in our society. As members of the medical profession, we have a duty to address these health problems when they arise in our clinical practices, while supporting public health programs that aim to prevent climate-related illness from occurring in the first place.

Scientists and policymakers addressing climate change have often called for a two-pronged strategy that includes both mitigation and adaptation. Much of what has been discussed previously would be considered adaptation, as it involves reducing our vulnerability to the effects of climate change. While this may seem like the natural sphere of action for health care professionals, I would dare to argue that we have just as much of a duty to participate in climate change mitigation. This would involve being vocal advocates for carbon dioxide emission reductions, calling for investment in renewable energy infrastructure, and reducing the energy consumption of our clinics and hospitals. Given the profound health impacts of climate change, these actions should be considered primary prevention – and that's just good medical practice.

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INTERDISCIPLINARY

Robots in Medicine

A future member of the healthcare team?

Kyle Pangka (Meds 2016), Yin Hui (Meds 2015), Alexander Yan (MD/PhD 2018)
Faculty Reviewer: Dr. Amit Bagga MD, FRCPC (Department of Medicine, Division of Nephrology)

Optimus Prime, R2D2, and Wall-E, are examples of how we envision future robots. Though it is difficult to distinguish robots from other machines, robots can be defined as machines that are capable of performing a variety of tasks with a degree of autonomy from humans. In this article we will focus primarily on service robots: robots which perform services for human well-being and are found outside of manufacturing operations.[1] The innate qualities of robots—their tirelessness, physical robustness, and immunity to emotional stress—may make them a promising addition to healthcare teams. We will explore contemporary examples of how service robots are being used in healthcare and the potential role of these robots as members of the interdisciplinary healthcare team.

The push towards having robots assist future healthcare workers is arguably driven in part by the projected demographics of industrialized countries. A handful of countries such as Germany and Japan are facing aging populations: It is expected that by the year 2060, 40% of Japan's population and 34% of Germany's population will be over 65.[2,3] Furthermore by the year 2060 it is estimated that the ratio of nurses to patients in Germany will change from 1:9 to 1:17.4 The need to ease the workload faced by future nurses has fuelled the development of robots to principally assist nurses in physically and emotionally demanding tasks.[4]

The robotic nurse assistant (RoNA) prototype designed by Hstar technologies was created to eliminate the repeated strain nurses experience in lifting and transporting patients.[5] Although RoNa moves on a set of wheels, the upper portion of the robot appears humanoid, with large bent padded arms that can be used to lift and transfer individuals from a bed to a stretcher.[5] Boasting the ability to carry and transport patients weighing up to three hundred pounds, RoNa shows promise to decrease the injuries suffered by nursing staff and patients resulting from lifting accidents.[5]

Service robots may also be assigned repetitive tasks, such as dispensing and distributing medication. In a case study by Beard and Smith, the installation of a medication dispensing machine was found to reduce the time hospital staff needed to spend in the dispensary and significantly reduce dispensing error.[6] If robots were able to autonomously dispense and distribute medication to patients, it would reduce the workload of nursing staff and pharmacists. Having an entirely automated medication handling system would potentially allow pharmacists to focus purely on their roles as consultants and patient educators.

Even more intriguing than the use of service robots as nursing aids or medication dispensaries, is their use as patient companions. Paro is a companionship robot designed by Intelligent Systems Research Institute that mimics the appearance of a baby harp seal and is primarily used in patients with dementia.[7] Despite the robot's lighthearted appearance, Paro uses sophisticated machinery which allows it to sense sight, sound, balance, and touch.[7] Paro responds to the touch and actions of patients by blinking, moving its tail, and making affectionate noises.[8] Though further studies are needed to explore the possible long term effects of using Paro on the disease process in patients with dementia, studies have found that Paro can improve the mood of patients and facilitate social interaction.[8] Unlike most caretakers, Paro has infinite patience, unlimited time to give, and is non-judgmental. In addition, companion robots like Paro may prevent caretakers from developing compassion fatigue by bringing about positive responses in patients that might otherwise seem unreachable.

It should be emphasized that although Paro can elicit genuine human emotions from patients—it is by no means a substitute for human interaction. Psychologist Sherry Tuckle points out that Paro may fulfil a patient's desire to tell stories and have conversations with it, however it cannot reciprocate the care it receives.[9] She also notes that if a person constantly interacts with robots rather than humans, they will become accustomed to the limited range of responses to emotions that robots have to offer.[9] Ethicist Christopher Calo puts Paro's true designed function quite eloquently writing, "Paro's purpose is to grease the gears of social interaction."[9]

If the capacity of robots increases, they may one day have a future role in diagnosis and screening. In the book Complications, Atul Gawande described a study by Edenbrandt et al. involving an EKG "competition" between a computer and an experienced cardiologist.[10] The computer made 20% more accurate diagnoses of myocardial infarction since the machine was less likely to be biased by previous diagnoses, or past experiences. With increasing technological advancements, it is not unrealistic to presume that the robot will eventually become a valuable diagnostic tool. At the same time, the clinical experiences, and the gestalt, that every seasoned physician rely on to see the patient beyond numbers and statistics, will be invaluable to make the final treatment decisions and work together with patients to achieve their treatment goals.

We have already discussed some contemporary examples of healthcare service robots and their potential future role as members of the interdisciplinary healthcare team. However, if these robots eventually become fully-fledged members of the healthcare team, the issue of their appearance is certainly significant. Japanese roboticist Masahiro Mari proposed a much cited theory, the "uncanny hypothesis," proposing that our affection for our robots increases the more human-like they are. However, our affection soon turns to disgust as soon as the robot becomes almost realistic, such as in the case of a corpse-like or prosthetic-like robot. Then, as the appearance of the robot becomes more human-like, there is a sharp rise in our affection, approaching human-to-human empathy levels (Figure 1).[11] In short, the ideal health care robot in the future would either look like robots, or completely life-like to the point that we may mistake them for a person on first glance.

Despite the many potential benefits of incorporating robots into the healthcare team, there are also several notable limitations and

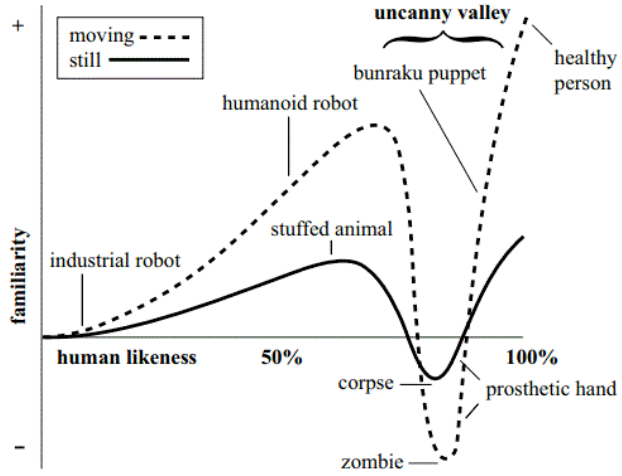

Figure. A depiction of the 'Uncanny Valley'

barriers. In the realm of companionship robots, current research challenges include programming personality, empathy, interpretation of patient's physiological signals, and behaviour adaptation into the robot's social functions. Research into these areas is currently in its infancy.[12] Moreover, while many studies report positive effects of companionship robots in elderly care, the scientific value of the evidence is limited due to low methodological quality.[13] It is also important to note that even if companionship robots are eventually programmed to display empathy, the depth of the bond between humans may be impossible to reach. Additionally, while many people believe that technology such as robotics will improve health care quality, safety, and efficiency, fewer people stop to consider that they can also introduce errors and adverse events. In Patient Safety and Quality: An Evidence-Based Handbook for Nurses, the authors recognize four common reasons why the benefits of new technology may not be realized: "(1) poor technology design that does not adhere to human factors and ergonomic principles, (2) poor technology interface with the patient or environment, (3) inadequate plan for implementing a new technology into practice, and (4) inadequate maintenance plan."[14] Certainly, there may be many unforeseen circumstances where robots may cause harm to patients. More studies need to be conducted with every new application of robotics in medicine. Another issue is the potential for robots to cause lost jobs. It is unknown whether robots will eventually replace healthcare workers in order to lower personnel costs or only function in an assistive capacity.

The strengths of many contemporary healthcare robots, such as Paro and RoNa, are geared towards aiding patients with limited mobility or declining mental function. This seems highly appropriate in the face of the aging populations in many developed countries. However, we have yet to tap into the capacity for logic that robots can be programmed to have. In the future, robots may be more actively involved in the distribution and dispensing of medication, patient screening, and diagnoses. At the same time, advancements in the function and appearance of robots should be done in a way that mitigates any initial uneasiness that patients may feel while interacting with a robot. From the examples cited thus far, robots have proven useful when it comes to lessening demands on healthcare staff and increasing the quality of life of patients. Robots will likely continue to modify the roles of various healthcare professionals within the interdisciplinary healthcare team, especially as our interactions with robots become increasingly sophisticated. Eventually, they may become fully-fledged members of the healthcare team. Nevertheless, in spite of the enthusiasm surrounding robotics in medicine, caution should always be exercised. The benefits and potential pitfalls of robotics usage need to be further explored.

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Electronic Medical Records

Current status of implementation across Ontario

Laura Callan (Meds 2015), Nancy Chen (Meds 2016)
Faculty Reviewer: Amanda Terry, PhD (Department of Family Medicine)

An electronic medical record (EMR) is a digital version of a paper chart that contains a patient's medical information from one practice, used by health care providers for patient care. EMRs have been widely implemented across the Province of Ontario, with more than 9,000 physicians and specialists employing such systems in both primary and secondary care settings;[1] however, problems with intercompatibility of various EMR systems as well as legal and funding issues have limited the uptake of EMRs.[2] Understanding how to further improve implementation and efficacy of EMRs across Ontario requires an understanding of barriers to implementation and the current solutions to these barriers, how EMRs are currently implemented and used in both in Ontario and across the country, and the current ongoing programs to improve implementation and uptake.

EMRs have some benefits to physician practice.[3] It has also recently been estimated that EMR systems in primary care centres throughout the country have saved the Canadian health care system approximately $1.3 billion over the past 3 years.[2] EMRs have been shown to reduce the number of duplicate tests ordered, benefiting not only the patient but the health care system.[2] EMRs also reduce the number of adverse drug events, thereby improving patient safety.[2] Further, EMRs reduce time spent on administrative tasks, improving efficiency within the physician's office or hospital,[2,3] and have also been shown to decrease wait times for patients with urgent concerns to see their family physician.[4] EMRs also improve both disease management and preventative care.[3] In addition to these benefits, EMRs can be used to identify patients who are due for a screening or preventative visit, or patients who have been flagged with abnormal test results and cue to schedule an appointment.[5] Further, EMRs can be used to track blood pressure, weight or other health indicators over time, displaying them graphically for both the physician and the patient.[5]

Despite the many benefits of EMR systems, enabling province-wide implementation has proven challenging. Barriers such as the time involved for a practice to convert to EMRs from paper records, the training of health care professionals on the new systems, and computer literacy have slowed the implementation of EMR systems in many practices.[6,7] Other barriers also include the financial cost associated with purchasing the new EMR system and availability of technical support.[7] To encourage physicians across the province to use EMRs, the provincial government has introduced programs such as the New EMR Adopter Funding Program which provides funding to physicians in the transition from paper-based records to EMRs.[8] While this program reduces the financial burden of switching from paper to electronic records, training and computer literacy continue to be a challenge.

In addition to the above barriers, legal concerns have also come to light. These issues include who owns the records, who has access to the records and how the records can be secured to ensure privacy. Before electronic records, the physician was responsible for accurately documenting every patient encounter, storing the records securely and retaining these records for 10 years after the last entry.[9] With the advent of EMR this has not changed; however, it does become more complicated. If one patient sees multiple physicians, each will be altering the patient's EMR. Who, then, is responsible for ensuring the record's accuracy? The College of Physicians and Surgeons of Ontario (CPSO) has clarified this point by stating that physicians are accountable for all of their own entries into a shared record.[9] The CPSO has also set out requirements for ensuring security of EMR. These include keeping track of all medical and non-medical staff who have access to the EMR system, ensuring user identification be used to keep track of who has accessed which records, controls to restrict access based on user's role, encrypting any data stored on a mobile or external device, and ensuring that all wired and wireless connections are secure.[9] Requirements for retention of records are not stated to be any different with EMR as opposed to paper records, except that a physician is required to regularly backup their records and store them securely.[9]

Progress has been made in Canada towards more physicians and health care practices using EMRs instead of paper records. The Health Council of Canada reports that 57% of primary care physicians now use EMR, compared to only 37% in 2009.10 This progress, however, is not evenly distributed across the country. British Colombia has the highest adoption rate, with over 70% of physicians using EMR; New Brunswick, on the other hand, has only a 26% adoption rate.[10] It was found that an important factor in increasing adoption in a province is the provision of technical support.[10] Support staff allow novice users to move forward and overcome the time and computer literacy barriers, thus making the implementation process smoother.[6,10] Canada Health Infoway is an organization created by the Government of Canada to plan a strategic approach to a Canada-wide electronic health system.[2] This organization has a number of projects underway to create this nation-wide system, including programs to guide and assist provinces and territories in implementing technologically based health care systems, programs which improve the intercompatibility of various EMR systems and programs which set guidelines and standards for emerging technological solutions, all designed to improve EMR adoption rates across the country.[2]

To improve not only implementation of EMRs, but also the effect of EMRs on patient care and the health care system, the Prov-

ince of Ontario created the eHealth Ontario program.[1] Past spending and oversight scandals within this program and its predecessor, Smart Systems for Health Agency, have slowed the progress of the implementation of EMRs within Ontario[11] and resulted in some public wariness of a province wide Electronic Health Record system linking all of the EMRs and other patient health information.[12] eHealth Ontario, however, does currently have a number of initiatives designed to improve the uptake of EMRs as well as to improve interconnectivity of these records, further increasing efficiency within the health care system.[1] These include the New Adopter program mentioned above, as well as the Regional Integration program, designed to increase interconnectivity within South West Ontario, Greater Toronto and North East Ontario regions, and the Ontario Laboratories Information System, designed to allow physicians to access laboratory test results online.[1] These programs, along with a number of other initiatives, have the potential to improve EMR adoption, use and health information connectivity in Ontario.

Research evidence has shown EMR systems have the potential not only to decrease health care spending, but also to improve patient outcomes and workplace efficiency. While the shown benefits are impressive, progress towards a fully electronic province-wide system has been slow as a result of a number of identified implementation challenges including technological, legal and funding issues. eHealth Ontario is working on a provincial level while Canada Health Infoway works on a national level to overcome these barriers and produce an efficient and effective electronic health care system. To achieve this, programs which focus on improving computer literacy, EMR intercompatibility and financial burdens must be a priority.

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Interview with Dean Michael Strong

Visionary, driver, and leader in excellence

Sissi Cao (Meds 2016), Joyce Zhang (Meds 2015)
Faculty Reviewer: Dr. Michael J Strong, MD, FRCPC, FAAN, FCAHS

As students sitting in the Office of the Dean, we had every reason to be nervous because in a few minutes, we would have the distinct privilege of speaking with Dr Michael Strong. We had taken a break from our daily routine and stepped into Dean Strong's brightly lit office in the Rix Clinical Skills Building. Dr Strong was kind enough to sit down with us and share stories about his illustrious career, as well as delve into the future of medical education, the role of physicians and the Schulich School of Medicine & Dentistry.

Dr Michael Strong was born in Windsor and raised in Leamington. He completed 2 years of undergraduate studies in biochemistry at Queen's University before entering medicine. His relationship with Western University began in 1982 when he began an internship in internal medicine and subsequently completed his training in neurology in 1987. From there, his career took an interesting turn when he joined the National Institutes of Health for 3 years doing post-graduate studies. During his time at Fort Detrick in Frederick, Maryland he developed the first-ever rabbit model for amyotrophic lateral sclerosis (ALS), also know as Lou Gehrig's disease, a degenerative disease of upper and lower motor neurons. Dr Strong rejoined Western in 1990 as a clinician-scientist and began his scientific, clinical and teaching career. He stayed on and eventually became chief/co-chair of neurology from 2000 to 2010, then dean of Schulich School of Medicine & Dentistry in 2010.

UWOMJ: What was your path to becoming dean?

Dr Michael Strong: You never start your life off saying you're going to become a dean. It just sort of happens. I started off my research career doing experimental neuropathology. The reason I went to the lab that I chose was because of the work they had been doing on Lou Gehrig's disease in Guam in the Western Pacific, where the incidence was 3000- to 4000-fold higher than what you would see anywhere else in the world. To this day, we developed the only animal model of reversible ALS. We developed the first technique that would allow me to isolate the motor neurons, grow them in culture and get them to survive. So I became an experimental neurobiologist. Ten years later, I was doing a lot of work in protein chemistry. We'd isolate the proteins and look at their modifications. Ten years after that, we now have found ALS to be an RNA-mediated disorder and are viewed as being the leaders. But if you had asked me 20 years ago if I'd be doing RNA biology – [laughs]. Just like I would have never believed I would become chief of neurology, co-chair of the department or the dean of the medical school. But these are just things that happen over your lifetime.

What is your life like outside of being dean?

I still have my lab – I'm there every Monday morning, Tuesdays for grand rounds in clinical neurological sciences and Thursdays for journal club. I have three graduate students that I meet with every week. And I do a half-day of clinic every Tuesday morning. Those pieces of my life continue on. As for hobbies, my wife and I love to garden. We love to camp and spend a lot of time camping with our kids. And then as we got older we started golfing. We love to ski and we do love to travel because there are so many neat places to go to in the world. So we try to lead a quasi-normal life.

Where is medical education heading?

There is a difference in what people are looking for in lifestyles now. The day of people like myself and some of my predecessors working 100 hours per week and trying to drive a lab forward are few and far between. I think one of the things we're going to have to be more cautious about is ensuring that people understand what balance really means. If you're going to be a physician you're going to have to look after yourself as much as anybody else. As we move forward, we're going to have to cautiously think about true balance: between being an individual, being a physician, having a family and our roles in society.

Second, the rate of change in science is phenomenal. Patients have the capacity to send off their blood and get their entire genome back in weeks. And then they come into your office and say, 'I've got a Bcl-1 mutation – what does that mean?' Physicians need to understand how to get into new literature to better answer those questions, but there also needs to be better systems in place in order for physicians and practices to become integrated with emerging science.

Third, we have decided at this school to do simulations. You already get tons of it: patient simulations, anatomy simulations – just name it we're doing it. But there's a difference between doing simulation because you need to be educated in that realm versus doing simulation because you want to be leading in their development. I'm never interested in doing something just because you have to. If you're going to do it, do it well enough that you are actually creating new knowledge that goes along with that. My medical educators are thinking about what is next in the simulation curriculum and what resources are required if we're going to be a leader in it.

What is changing for physicians in the future?

Physicians are the ones that everyone trusts. We get to see the impact of a lot of things that are happening in society, so I think we have a role and responsibility. At this school, I see everything that students do in terms of social responsibility, which is something I'm

really proud of. It's got nothing to do with me, nothing to do with Carol Herbert, the previous dean, or anybody before us. It seems to be intrinsic to the students. You folks have said 'this is our responsibility' – don't lose it.

What do you think are the future roles of Schulich?

There are several roles for Schulich locally, nationally and internationally. Locally, the school must take responsibility in order to best serve a population as diverse as that of Southwestern Ontario. As a tertiary care center, we serve a population of 6.2 million that has everything from absolute rural and underserviced populations and First Nations right through to urban populations. Everyone has different health care requirements. So why is health policy established somewhere else? It shouldn't be. I think the school has to take a major lead role in being the determinant of health in this region. The Interfaculty Program in Public Health will be up and running starting in September. It took 18 months from inception; that's how quickly we're moving and building. It will be the only case-based Masters of Public Health program in North America, so we'll be cutting new pathways there. We're focusing on leadership and social responsibility and teaching using cases with an international flavour.

Nationally, there 17 medical schools in Canada and I want to have our school clearly identified and recognized as a leader in health implementation and social responsibility. On the international level, no school can exist in isolation anymore. There is so much for us to learn from other areas of the world. It doesn't matter if we're talking about Africa, China, Saudi Arabia, Budapest or Detroit. These are areas we're developing very strong linkages with: student exchanges, professor exchanges and curriculum development. Over the rest of my term I see our school really developing in a meaningful way those types of bidirectional relationships. There's a great amount happening at this school that most people don't see. I'm really changing the focus and direction of this school.

Do you have one take-home message for those reading this article?

It's a great school. There is so much to be proud of. From the students through to faculty, the achievements of this school are astounding. It's hard to see when you're in the middle, but when you're standing outside of it and you get a chance to look, you know. I travel the world doing things for this school and people are getting to know us. They know our curriculum and what we do in terms of research. So for students, you can be proud. There are many things that are happening here that have got nothing to do with me. This is just the history and the nature of our school.

Introspection and vision are the characteristics that make Dean Strong a great leader, evident through the plans he has already set in motion but also in the passion he brings to his position. His dedication to excellence also permeates through his clinical, scientific and academic careers. There is no doubt the work Dr Strong is championing will drive the Schulich School of Medicine & Dentistry forward as a national and international leader in medical education, patient care and research.

THINKING ON YOUR FEET

Inspiration for the future of emergency medicine

Elaine Tang (Meds 2015), Anthony Chow (Meds 2016)

Faculty Reviewer: Dr. Dave Ouellette MD FRCPC ABEM (Department of Medicine, Division of Emergency Medicine & Trauma, Critical Care Medicine)

Emergency medicine (EM) was born from a public demand for a high-quality emergency service that would always be available and was meant to serve as a link between out-of-hospital services and in-hospital critical care.[1] Since the 1950s, hospitals have been the preferred locations for around-the-clock diagnostic testing and medical care. Originally, patients went to the emergency department (ED) after hours, when they could not access health care anywhere else.[1]

Today, EDs are notoriously known as places of overcrowding, long wait-times and frustrated patients.[2] This will continue to be a national problem. ED crowding leads to delays in care, increased mortality, decreased patient satisfaction and physician burn-out. This problem is an every-day reality for many EM physicians, reflects a system-wide performance issue and can be an indicator of health care quality.[3]

The causes of ED overcrowding are multifactorial. Multiple strategies have been implemented and evaluated in an effort to improve this situation: new technologies, triage systems and care-accelerating interventions. In the following section, we have outlined and evaluated four strategies to reduce ED overcrowding.

CASE 1: Hospital & Emergency Ambulance Link (HEAL)[4]

A 75 year old man with a history of chronic obstructive pulmonary disease (COPD) lives at home and is on home oxygen. Over the past week, his wife has noticed changes in his behavior. After breakfast, he complained of nausea, sweating and some shortness of breath. An ambulance was called. On arrival and initial assessment, paramedics suspected CO2 narcosis secondary to the high O2 setting on his home oxygen machine.[5] En route to the hospital, the complete ambulance record was transmitted to the ED using a linked computer system.[4] The system is comprised of a front-end mobile computer to input vitals and interventions, a database server to send the information and a workstation in the ED to receive the information. As the ambulance transported the man through the city, the nursing staff was already preparing a room and the necessary equipment for his treatment.[4]

BENEFITS: The advanced data transmission received by the hospital will accelerate patient triage and expedite the delivery of patient care. In addition, continuous coverage and advanced warning of medical cases will improve bed coordination, overall ED flow and may warn of any unforeseen mass casualty.[4]

DISADVANTAGES: Implementation of the system can be costly, particularly in larger centers. Equipment will be required for the ambulances and emergency departments and the staff will need to be trained in all system operations. In addition, it will take time to ensure a coordinated system response by the staff.[4]

CASE 2: Fast-track non-acute patient[6]

A 7-year-old boy is playing outside when he trips, falls and skins his right knee. His mother, concerned about infection and unsure of his tetanus status, takes him to the ED. Once in the ED, he is triaged appropriately to a non-acute setting and does not require an ED bed or any urgent interventions. He is taken to a desk-type consulting room where he is quickly seen by a physician dedicated to looking after the "fast-track" for that day. He is given a tetanus booster and swiftly discharged from the ED.

BENEFITS: Many emergency departments utilize separate streams for conditions such as myocardial infarction, fractured femoral neck, or critically ill/trauma patients. However, research has shown that a separate stream for minor injuries is useful in decreasing waiting times and patient complaints.[6] Having a nurse practitioner or physician assistant is often sufficient to deal with minor injuries. More efficient evaluation and discharge of ED patients improves ED flow and throughput. In addition, this increases bed availability for more critically ill patients.[6]

DISADVANTAGES: A fast track area with chairs and cubicles requires a separate physical space and can be logistically difficult to set up.[6]

CASE 3: Rapid Entry and Accelerated Care at Triage (REACT)[7]

A 27-year-old female who recently moved into the city has been encouraged to go to the ED for a flu-like illness. It has progressively worsened over the past 2 weeks, but she believes it will improve shortly. Her co-worker believes otherwise. She didn't want to go to Hospital A because she's heard about their very long wait times, so she decides to go to Hospital B.

Hospital B has recently started the REACT program.[7] The REACT program helps to streamline registration of the patient into the hospital system with a computerized integrated sign-in, patient tracking on arrival and the option for physicians to initiate a range of ancillary tests and interventions at triage. During this time ED space and beds can be arranged and readied, even prior to complete patient registration.[7]

BENEFITS: The REACT system helps to remove duplicate steps in the registration process and allows physicians to start ancillary tests prior to assigning patients a bed.[7] This will reduce the waiting time of patients after they get to a bed, as more results from labs or imaging will be available already by the time they are admitted to the ED. Physicians will also be able to interview, diagnose and treat

a patient faster without having to wait for investigations to return in between patient care. Overall, this strategy has been shown to decrease the number of people who leave the ED without being seen.[7]

DISADVANTAGES: This process may require additional staff available at triage and in the ED, and may require significant changes to the staff culture and processes. Early laboratory investigations and imaging tests may increase resource utilization.[7]

CASE 4: Frequent attender intervention[8]

A disheveled man smelling of alcohol wanders into the ED late at night. It is his fifth visit to the ED in the past month. He was concerned because he started feeling "woozy" after a couple of drinks tonight. The hospital staff is all familiar with him, and no one has very much patience for his antics. The ED has recently started a new volunteering program, providing compassionate care to selected homeless adults, and one of the volunteers goes over and begins talking with this man.[8]

Over the course of the next hour in the waiting room area, he is given a light meal while he talks to the volunteer about his family and his life. He leaves, and doesn't come back again for the rest of the year.

BENEFITS: Research shows that compassionate care for the homeless helps to decrease the subsequent use of emergency services and helps decrease repeat visitors.[8] While the exact mechanism is uncertain, it is speculated that increasing satisfaction can help to reinforce confidence in the medical care received and allow patients to wait longer for self-limited symptoms to resolve before seeking medical attention. It can also increase trust and lessen patient concerns. Reduction in ED visits can decrease the healthcare costs to society.[8]

DISADVANTAGES: Implementation of compassionate care to homeless individuals can be difficult as this population is often unkempt, may have threatening or aggressive behaviours, and requires much more time to evaluate and treat. It can be hard to train and staff volunteers in the ED to be able to provide these services and even more difficult to find room in the ED to properly interview and counsel these patients.[8]

CONCLUSIONS

Many strategies shown to be effective for improving efficiency and throughput in the ED are far from universally applicable and not widely adopted. Hospitals need to establish performance indicators for prospective ongoing monitoring of ED overcrowding and invest in technology to help track these indicators.[3] Addressing these issues will help benefit both the physician's and the public's health – limiting burnout amongst ER doctors while improving the quality and timeliness of care delivered to patients.[9] Given that emergency room visits are increasing faster than population growth, continued research into and implementation of coping mechanisms is vital to providing quality care.[10]

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