



# A technological journey: specialty spotlights and beyond

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A year ago the editors at *CMAJ* joined the international community of general medical journals in deciding to devote a November issue to the impact of new technologies in medicine. We soon discovered that the greatest challenge lay in defining “technology.” After several MEDLINE searches and brainstorming sessions, I still felt unsure about how *CMAJ* ought to approach this subject. I decided to ask the 21 members of our editorial board and several of our peer reviewers with a stated interest in technology how they would interpret our theme.

In less than a week, all of the board members and reviewers had offered enthusiastic and thoughtful responses to my email query. In addition to musing on the ethical, political and economic issues related to new technologies in general, these physicians — representing a wide range of specialties and interests — described in some detail the emergence of new technologies in their fields. They opened before me an extraordinary and sometimes bizarre world of high-powered machines, biological tools, designer drugs and medical gadgetry. From this initial foray, I realized how powerful our email system and computerized reviewer database — both relatively simple technologies — could be as information-gathering tools. In moments I could travel across the country or the world to access the insights and experience of clinicians who work daily in today’s technologic environment.

Creating specialty listservs — that is, lists of email addresses for each of the clinical specialties — I tossed out a query, like a message in a bottle, to hundreds of physicians practising in 34 specialty areas: What did they believe to be the most important or exciting new technologies in their fields, and what Canadian authority would they recommend to describe that technology for us? Over the next few weeks 150 email responses washed up on our shore (some, interestingly, from physicians who had received the survey as messages forwarded from colleagues) and roughly 30 more came by telephone and post. Ultimately, more than 180 specialists listed almost 400 technologies and Canadian experts to describe them. As a final step, I contacted some of these experts, asking them to write about a new technology in their area of expertise and to provide additional material, such as Web site URLs, photographs and video clips. The end result is the Specialty Spotlights section that follows (p. 1131) and an enhanced online edition of this special technology issue ([www.cma.ca/cmaj](http://www.cma.ca/cmaj)).

The responses to my query, summarized in the accompanying list, reveal important trends in contemporary medical technology. Although a remarkable variety of technologies are available to today’s practitioner, certain key technologies were mentioned over and over again by our reviewers, suggesting that there is considerable agreement among specialists as to which innovations are the most promising. Although medical and surgical specialists tended to emphasize different technologies — medical specialists focusing on DNA diagnostics and gene therapy, and surgical specialists citing endoscopy and minimally invasive surgical procedures as key advances — some technologies transcended specialties. The overwhelming consensus was that advances in computer technology, imaging techniques and molecular biology are changing the face of clinical medicine.

Computer technology was described as important in a variety of areas, ranging from diagnosis and treatment to research and education. Respondents said that computers generally increased efficiency through automation in laboratory medicine, advanced informatics in emergency medicine and critical care, and improved monitoring and drug delivery in anesthesia. Computers were also cited as providing new ways of accomplishing old tasks, such as modelling for drug development and collecting survey information on sensitive topics in psychiatry. Another reported function of computer technology was, of course, communication, with large databases and links enabling, for example, worldwide tracking and coordination of infection control and easy retrieval of information for patients and physicians.

New imaging techniques have changed the way we see disease in virtually all specialties. Some, such as positron emission tomography scanning to determine myocardial perfusion, represent new applications of known technologies; others, such as magnetoencephalography for localization of epileptic foci, are relatively new on the scene. In the case of intraoperative MRI, a well-known technology has moved into a new environment.

It seems clear from the respondents that, along with new imaging techniques, no technology has had a greater impact on medical diagnostics than advances in molecular biology. These advances have fed progress in genetics and pharmacology — preclinical specialties whose wide-ranging contributions to clinical medicine warranted inclusion in the list. Not surprisingly, the development of new biological markers, genetic screening tests and tools for the treatment of cancer were cited as crucial advances in hematology and oncology. But nephrologists, neurologists, pharmacologists, respirologists and urologists alike credited the unprecedented explosion of knowledge in molecular biol-



ogy with improving accuracy and speed of diagnosis and providing new targets for therapy.

These new diagnostic technologies promise to reveal the

body's hidden truths; at the same time, they force us to see more from farther away. With the expanded sensory capacity provided by these innovations, medical practice has be-

### Current technologies in medicine

#### Anesthesia

Cerebral monitoring to detect awareness under anesthesia  
Monitoring during cardiopulmonary bypass  
Depth-of-anesthesia devices: bispectral index, auditory-evoked responses  
Transesophageal echocardiography  
Transcranial Doppler

#### Cardiology and cardiac surgery

PET scanning for myocardial perfusion and metabolism  
Contrast echocardiography and harmonic imaging  
SPECT and 3-D imaging  
Digitalization of full-motion images in echocardiography, angiography  
Intravascular ultrasonography and intravascular pressure/flow measurements  
MRI of heart  
Molecular cardiology  
Gene identification in familial atrial fibrillation  
Implantable cardiac monitoring devices and cardioverter defibrillator  
New potent antiplatelet drugs (glycoprotein IIb/IIIa inhibitors)  
Gene therapy for angiogenesis and coronary artery disease  
Immunologic manipulation  
Mechanical heart  
New arterial conduits (e.g., radial artery) for bypass surgery  
Intracoronary radiation  
Ablation treatment for atrial fibrillation  
Port access minimally invasive cardiac surgery  
Ventricular assist devices for treatment of heart failure  
Xenotransplantation  
Bridging strategies, cardiomyoplasty  
Robotic surgery  
Angioplasty and stenting for carotid stenosis  
Left ventricular remodelling surgery  
Telemedicine  
Database and patient chat line on congenital heart disease

#### Critical care

Recognition of new mediators of acute inflammation in adult respiratory distress syndrome (ARDS) and sepsis  
New treatments for ARDS  
Monoclonal antibody therapy directed against IgE antibodies and cytokines in sepsis  
Inhaled nitric oxide for hypoxemic respiratory failure  
Noninvasive ventilation, including liquid ventilation  
Brain protective drugs  
New drug delivery systems  
Home telemetry with ST-segment monitoring and alarm to signal unstable angina or myocardial infarction to critical care team  
Blood substitutes and transfusion therapy in ICU  
Continuous renal replacement therapy in ICU

#### Dermatology

Photodynamic therapy (laser light and porphyrins) for treatment of skin cancer and retinal degeneration  
Laser surgery  
Telemedicine

#### Emergency medicine

Bedside ultrasonography  
Mini-CT and MRI  
Point-of-care laboratory testing  
Ultrasound examination of fractures  
Rapid-sequence intubation  
Home treatment of deep vein thrombosis with low-molecular-weight heparin  
Home treatment of cellulitis and pneumonia  
New observation units  
Procedural sedation

#### Endocrinology

Bone densitometry  
New blood glucose monitoring devices  
Noninvasive detection of diabetes complications  
New insulins, including inhaled insulins  
Computer analysis of blood glucose levels with insulin adjustments

#### Forensic medicine

DNA evidence  
Toxicology  
CT and MRI imaging for dating of child abuse injuries  
Gunshot wound technologies  
Portable x-ray machines to identify position of bullets at crime scene  
Laser fingerprinting  
DNA typing for confirmation of sexual assault

#### Gastroenterology and general and colorectal surgery

Endoscopy and endoscopic ultrasonography  
"Virtual" colonoscopy  
Population screening for colorectal cancer  
Molecular genetics of colonic neoplasia, hemochromatosis, cystic fibrosis  
Urea breath test and new treatments for *Helicobacter pylori*  
Probiotic treatment for GI disease  
Designer drugs for inflammatory bowel disease  
Computer modelling for drug development  
Antitumour necrosis factor treatment for Crohn's disease  
Photodynamic therapy  
Small-bowel transplantation  
Minimally invasive surgery, including laparoscopy  
Cryosurgery  
Robotic surgery  
Harmonic scalpel  
New uses of ultrasonic energy in surgery  
Biliary stenting  
Transjugular intrahepatic portal-systemic shunts  
Angiographic control of GI bleeding  
Pancreas and islet cell transplantation in brittle type 1 diabetes  
Radiofrequency ablation of liver tumours  
Living-related liver transplants  
Xenotransplantation

#### Genetics

Human Genome Project and molecular diagnosis and screening  
DNA chip technology and high-speed DNA sequencing for mutation analysis  
Fluorescence in-situ hybridization (FISH) and spectral karyotype analysis for rapid diagnosis of syndromes, prenatal diagnosis and use in cancer genetics  
Tandem mass spectrometry for newborn screening and diagnosis of metabolic diseases  
Positional cloning  
Expressed sequence tags searchable using information technology  
Analysis of fetal cells in maternal blood and preimplantation diagnosis  
Bioinformatics and computational biology  
Integrative studies of gene-gene and protein-protein interactions  
New ways to apply information from model organisms to humans  
Gene therapy for muscular dystrophy  
Cloning for tissue and organ replacement

#### Hematology/oncology and surgical oncology

Genetic identification of people at risk for cancers  
Identification of genetic abnormalities and translocations in pediatric cancers  
DNA diagnostics for thalassemia and subcategorization of lymphomas  
PCR for more sensitive detection of viruses  
Molecular markers for diagnosis of solid tumours  
Identification of new risk factors for venous thrombosis (e.g., Factor V Leiden mutation) using molecular methods  
Advances in hematopoietic transplantation, including mini-transplants and nonmyeloablative allogeneic peripheral blood stem-cell transplants for older patients and mismatched donors  
New drugs for graft-versus-host disease  
Manipulated hematopoietic grafts for diseases in which tumour cells contaminate grafts  
Immunomodulatory therapy for leukemia  
Conformal radiotherapy with 3-D computerized treatment planning  
Precision radiotherapy using sensor technology  
Gene therapy and manipulation of viruses for treatment of hematologic and other cancers  
Application of methylene blue and solvent detergent to virally inactivate plasma  
Storage of cord blood from newborns in the event leukemia develops later  
Leukoreduction filters to decrease virus transmission and transfusion reactions  
Anti-angiogenesis-based treatments (e.g., thalidomide)  
Tumour vaccines  
Antibody therapy (e.g., Herceptin, B-cell monoclonal antibodies conjugated to radiolabelled iodine and CD20 [Rituximab] for low-grade lymphomas)  
Brachytherapy  
New treatments for pediatric thromboembolism  
Dedicated CT simulation



come less tactile and immediate. In the 19th century, when Laënnec invented the stethoscope, he called his method “mediate auscultation” to emphasize the interposition of a

device between the physician and the patient.<sup>1</sup> The gap between physician and patient may widen as our vision becomes increasingly mediated by machines, as surgery be-

### Current technologies in medicine (continued)

#### Infectious disease, microbiology and virology

Automated and molecular diagnosis of infections (e.g., chlamydia, gonorrhea, HIV, HCV, HBV)  
HIV viral load assays  
Anti-sense nucleic acid sequences and bacteriophages  
Nucleic amplification to detect changes in cellular cytokines in chronic inflammatory diseases  
Prokaryotic PCR for detection of new pathogens (e.g., agents responsible for cat-scratch and Whipple's disease)  
Representational differential analysis of virulence factors  
New antivirals and antiretrovirals  
HIV vaccines  
Recognition of virus-coded proteins that interact with receptors  
New antibiotics for infections due to multidrug-resistant bacteria

#### Laboratory medicine and pathology

Point-of-care testing  
Molecular diagnosis of infectious diseases and cancer, including molecular hybridization for human papillomavirus testing  
Molecular screening  
Laboratory automation  
Liquid-based cytology  
Automated cytology using artificial intelligence for cervical cancer screening  
PCR for determining diagnosis and prognosis in anatomic pathology and to detect B- or T-cell clones in lymphoma and microbial antigens in infections  
FISH for determining diagnosis and prognosis in anatomic pathology

#### Neonatology

Dual-photon x-ray absorptiometry in evaluation of whole body and regional fat, muscle and bone mass  
Technological advances in assessment of fetal well-being  
Somatic gene therapy for inherited disorders  
Genetic engineering  
Surfactant and steroid therapy for respiratory distress syndrome  
Developmental homeostasis in the treatment of thromboembolic disease  
Laparoscopic surgery

#### Nephrology

Online monitoring using biosensors during hemodialysis  
New transplantation methods, including pig kidney transplantation  
New drugs to prevent transplant rejection  
Nocturnal hemodialysis  
Molecular biology and cloning

#### Neurology, neurosurgery and vascular surgery

Functional MRI  
Intraoperative MRI  
Magnetic resonance spectroscopy  
SPECT scans for vascular disease  
Magnetoencephalography for localization of epileptic foci

Genetic analysis  
Pharmacogenetics in treatment of Alzheimer's disease  
New drugs for epilepsy, Parkinson's disease and multiple sclerosis  
New intravenous and intra-arterial thrombolytic therapies for stroke  
Implanted infusion pumps for severe spasticity due to spinal cord trauma or multiple sclerosis  
Deep brain stimulation for Parkinson's disease and dystonia  
Vagus nerve stimulation by implanted pacemaker for epilepsy  
Surgery and transplantation for Parkinson's disease  
Surgery for epilepsy and stroke  
Stereotactic surgery for arterial venous malformations, epilepsy, vestibular schwannoma, movement disorders, pain  
Endovascular coiling/stenting of aneurysms  
Ventriculocopy, neuroendoscopy

#### Nutrition

MRI to measure fat deposition  
Identification of risk gene profiles to allow targeted diet modification  
Food irradiation  
Genetic alteration of food

#### Obstetrics and gynecology

New ultrasound techniques for imaging uterine contents  
Prenatal diagnosis in first trimester by ultrasound and maternal serum screening  
In vitro fertilization and other new infertility treatments  
Multifetal pregnancy reduction  
New treatments for abnormal menstrual bleeding  
Specific estrogen receptor modulators  
Human papillomavirus vaccines  
Tension-free vaginal tape for urinary incontinence  
Laparoscopic Burch procedure  
Microwave endometrial ablation

#### Orthopedic surgery

Alternative bearing surfaces (e.g., ceramic components) in total joint arthroplasty  
Bone graft substitutes  
Use of growth factors  
New cartilage replacement strategies  
Minimally invasive spinal surgery  
Thermal capsular shrinkage for treatment of unstable shoulder  
Minimal access fracture fixation

#### Palliative care

Subcutaneous infusion pumps to administer pain drugs  
New drugs for pain control  
New palliative radiotherapy methods

#### Pharmacology

Magnetic resonance spectroscopy  
Sodium-hydrogen exchange inhibitors to limit damage from cardiac reperfusion  
New drugs for male sexual dysfunction  
Biosensors and continuous immunoassays with digital read-outs  
Designer drugs interacting with newly discovered

receptors (e.g., glycoprotein IIb/IIIa receptor blockers)

Transfection of endothelial cells with virus-carrying genes for vascular endothelial growth factor in treatment of atherosclerosis  
Prediction of drug interactions and effects through knowledge of drug enzyme systems  
Combinational chemistry

#### Psychiatry

PET, SPECT and MRI to determine drug occupancy at receptor sites  
New computerized neurocognitive assessment batteries  
Genetic mapping of childhood disorders  
Tryptophan deprivation to determine appropriate timing of discontinuation of SSRIs  
Computerized, structured diagnostic interviews  
Transmagnetic stimulation for resistant depression  
Designer drugs for psychosis and depression  
Eye movement desensitization and reprocessing  
Computerized analysis of patient characteristics, treatment regimens and course of care  
Telepsychiatry

#### Respirology, thoracic surgery and otolaryngology

PCR-based diagnostics  
DNA fingerprinting in study of TB transmission  
Rapid diagnosis of TB  
Sputum induction and differential cell counts for asthma and other lung disorders  
Spiral computerized tomography  
Virtual bronchoscopy  
New sleep study equipment, including methods to detect increased upper airway resistance  
Oximetry and rapid blood gas analysis  
Gene therapy for cystic fibrosis  
Autotitration of continuous positive airway pressure (CPAP) for sleep apnea  
CPAP for congestive heart failure  
Noninvasive ventilation for chronic obstructive pulmonary disease  
Nonfluorocarbonated inhalers for drug delivery  
Thorascopic surgery and peritonoscopy  
Lung-volume-reduction surgery for emphysema  
Mandibular advancement devices for sleep apnea  
Aerosol delivery of nonpulmonary therapeutic agents  
Bone-anchored hearing aids  
Laser-assisted surgery of upper airway  
Endoscopic sinus surgery

#### Rheumatology

Bone densitometry and other new methods for measuring bone mass  
Biologic treatment for rheumatoid arthritis and systemic lupus erythematosus  
Anti-tumour-necrosis-factor-alpha antibodies for rheumatoid arthritis  
Autologous cartilage cells for treatment of local cartilaginous defects in osteoarthritis

#### Urology

New treatments for prostate cancer, renal calculus disease and impotence  
Sacral neuromodulation for voiding dysfunction  
Holmium laser



comes less invasive, and as investigations become virtual rather than real. Moreover, technology is increasingly defining the illness experience itself: renal failure, for example, once a hopeless condition defined by the symptoms of “dropsy,” has been redefined by dialysis and the new set of difficulties that this technology brings.<sup>2</sup>

It is easy to imagine that the social and ethical issues surrounding contemporary technology represent uncharted territory in the history of medicine. But just as pathology, radiology and microbiology grew out of the recognition that autopsies, x-rays and the microscope could render the body transparent, today’s specialties continue to be defined by their technologies and to challenge our notion of what we ought to see and do. As CT scans and genetic testing allow us to see ever more deeply into the core of what makes each of us human, the question remains: How should our vision be used, and how can we, as physicians and as a society, integrate new technologies humanely into patient care?

Evidence-based methods and technology assessment are examples of medicine’s efforts to answer this fundamental

question. So, in a small way, are the Specialty Spotlights in this issue. These brief and lively reports attempt to shed light, for both the specialist and the general practitioner, on the history, problems and promise of established and emerging technologies. As a group, together with the other articles in this issue, they illuminate the larger landscape of scientific, political, social, ethical and economic issues that medical technologies necessarily create.

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## References

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