Anaesthesia and Health Informatics

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INTRODUCTION

A few years ago, financial institutions recorded all transactions on paper. Withdrawals from a bank that was not the home branch, would take many days to transact. Much has changed with online banking and automatic teller machines. The tangible and intangible savings, error reduction and efficiencies through computerisation have been enormous. It is almost impossible to imagine life without instant access to our savings, our bank account details and overnight settlement of bills. Most of us would never go back to the 'old way' of doing things, yet the 'old way' is exactly how we manage information about our health.

Electronic health information management has not been embraced because of its complexity, its cost, the social, cultural and ethical environments, developing data standards, security concerns, privacy and psychological considerations. Health informatics aims to understand the complexities of communication and logic in healthcare. Every day, we see new and novel informatics tools that will play a large role in the future[1].

Evidence is slowly accumulating that high degrees of informatics penetration into clinical care delivery are associated with reduced costs and more effective and efficient health outcomes. Intermountain Health Care, the largest healthcare provider in Utah has a high degree of informatics uptake. Utah now has one of the best outcome, lowest cost health services in the US[2]. Anaesthesia will be strongly influenced by health informatics development. The way we work will change and it is important that we understand what exists, how it works and why things are changing.

THE SCOPE OF HEALTH INFORMATICS

Health informatics embraces much more than the management of an individual's medical history. At the microscopic level, health informatics describes the association between genetic structure and phenotypic expression. From a larger perspective, aggregated data can provide public health information about populations, inform governmental resource allocation or give early warning about disease epidemics or terrorist attacks.

"Health informatics can be best understood as meaning the understanding, skills and tools that enable the sharing and use of information to deliver healthcare and promote health. 'Health informatics' is now tending to replace the previously commoner term 'medical informatics', reflecting a widespread concern to define an information agenda for health services which recognises the role of citizens as agents in their own care, as well as the major information-handling roles of the non-medical healthcare professions...." [3]

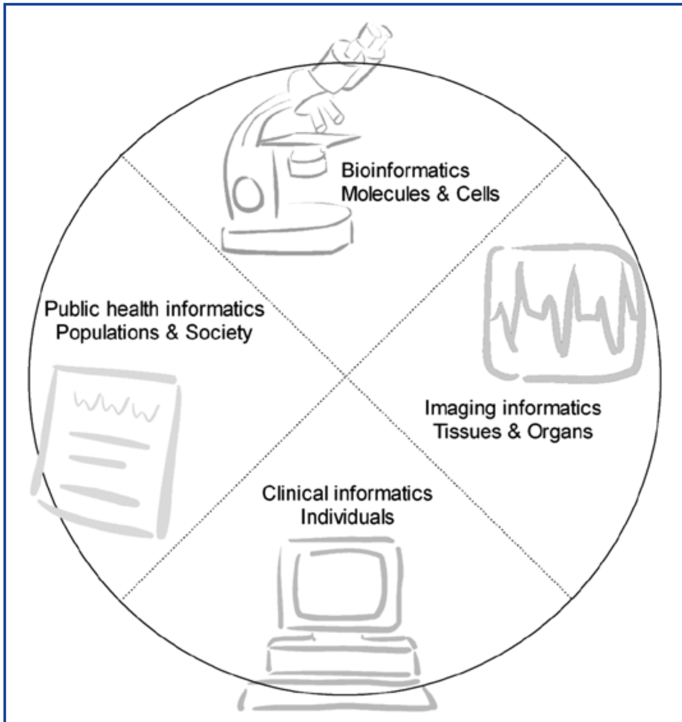
The study of health informatics can be more or less divided into four main levels; the molecular, the organ, the individual and the population.

At a molecular level, 'genomics' studies the association between genetic structure and phenotypic expression.

At the organ or physiologic level, diagnostic imaging technologies, standards and data transmission are explored.

Clinical informatics such as the Electronic Health Record sits at the level of the individual. Issues related to privacy, accessibility and interoperability come to the fore.

At a population level, the focus is on public health concerns, such as epidemiology and health governance.



Whilst it is tempting to divide health informatics research into spaces relative to the individual, the challenges are the same in each of these spaces. In 2000, Lorenzi described the cornerstones of medical informatics. They are:

- Producing structures to represent data and knowledge so that complex relationships may be visualised.
- Developing methods for acquisition and presentation of data so that overload can be avoided.
- Managing change among people, process and information technology so that the use of information is optimised.
- Integrating information from diverse sources to provide more than the sum of the parts, and integrating information into work processes so that it can be acted on when it can have the largest effect. [4]

Safety and quality of health care are the ultimate goals of health informatics. Anaesthetic safety and perioperative care can benefit tremendously from many of the current developments in health informatics. Already we collect a lot of data in the name of audit, record-keeping and quality activities, but it sits in individual patient histories or on separate databases. Many opportunities to improve our quality of care are missed because that information is not able to be collated, compared, analysed or presented meaningfully. In anaesthesia and intensive care, the AIMS and the ANZICS databases[5] are excellent examples of what can be achieved and would be further enhanced through automated data collection throughout the clinical environment.

GENOMICS: A BETTER HEALTH SCREENING TEST?

Single nucleotide polymorphisms (SNPs), pronounced 'SNiPs', are small changes in genetic sequence that appear to be responsible for many diseases, either alone or in combination with other SNPs. There are probably 10 million possible SNPs, currently 500,000 have been identified[6]. The challenge is to accurately compare the genetic variations with phenotypic disease expression. Already SNPs have been used to identify patients with disease that is more likely to respond to certain therapies. In the near future, SNPs may be used to screen patients in the preadmission clinic before surgery to identify a predisposition to a variety of co-morbidities such as heart disease, allergy or infection.

IMAGING AND BIOMEDICAL TECHNOLOGIES

Many hospitals are using a Picture Archiving and Communication system (PACS) to display medical images on a computer screen. There are many advantages to a PACS system. The images will not be lost and can be viewed at any location. The ability to change contrast, accurately measure and magnify the images has been demonstrated to improve care, save time and save money. In anaesthesia, the development of new methods of monitoring wakefulness with BIS technology have gained widespread appeal[7].

Ultrasound is gaining popularity as a rapid assessment tool for cardiac function and for regional anaesthesia. As ultrasound technology becomes more accessible, many anaesthetists will use it to improve safety and quality of care[8].

TELEMEDICINE

Telemedicine is a term that describes the use of modern telecommunication and information technologies for the provision of clinical care to individuals located at a distance and to the transmission of information to provide that care. At its simplest level it could describe the use of a telephone to provide specialist advice in a difficult situation at a distance. More sophisticated communication technologies using videoconferencing combined with other technologies can provide better care in remote locations. Virtual intensive care units or 'outreach' high dependency units are examples of telemedicine within the hospital. Clinicians can also view patient information from outside the hospital.

In anaesthesia, telemedicine can be used to monitor or supervise many theatres at a distant location, contribute to ward rounds whilst in theatre and could be used for timely preoperative interviews. At Vanderbilt University Medical Centre a system called Vigilance® can be used to remotely supervise all the operating rooms in the hospital. A small TV screen set in a pair of glasses can display video of each operating theatre as well as the display from each of the monitors. A microphone and speakers enables instant verbal communication[9].

WHAT IS AN ELECTRONIC HEALTH RECORD?

An Electronic Health Record (EHR) is a medical record or any other information relating to the past, present or future physical and mental health, or condition of a patient which resides in computers which capture, transmit, receive, store, retrieve, link, and manipulate data for the primary purpose of providing health care and health-related services[10].

An Electronic Medical Record (EMR) is a smaller body of information used by a healthcare provider to deliver medical care.

A Patient Health Record (PHR) is created by and for the use of the patient who controls which aspects are transmitted to healthcare providers to become part of the electronic health record. The patient can also choose to share that information with others[11].

Potential benefits of a well designed and implemented organisation wide EMR with clinical decision support and a 'Computerised Provider Order Entry' system (CPOE) include: better patient safety, cost reduction, better communication inside and outside the hospital, standardisation of care, error reduction and more reliable administrative information.

Electronic health record software can be purchased from vendors or can be developed locally. On-site software development requires a team of software developers, project managers and systems analysts. Clinicians have the opportunity to be involved in software development and the systems can be designed to resemble familiar paper forms and follow local work

practices. The process is expensive and time consuming, but the result is a product that may be more suitable to a particular institution or group, well understood by the local developing team and can give more tailored support for clinical decisions and clinical pathways[12]. Existing products still require much work to install in any institution; however they remove some of the steps in software development and can be successful when introduced with the support of hospital staff at all levels. There are many examples of failed introduction of electronic health records, but successful implementations are characterised by institutions with common goals joining under strong leadership, engaging clinicians early, properly funding implementation, training and evaluation with an emphasis on patient safety[13].

Health records can exhibit a range of sophistication. Currently most products carry information that can be organised but not properly understood by computers. Machine-interpretable data is essential for developing systems to efficiently transfer clinical concepts, when designing smart clinical decision support or developing predictive safety systems.

Walker et al[14], define four levels for interoperability between health information systems:

- Level 1: Non-electronic data (e.g. mail, telephone)
- Level 2: Machine-transportable data (e.g. faxed or scanned documents)
- Level 3: Machine-organisable data (e.g. e-mail, proprietary file formats)
- Level 4: Machine-interpretable data (e.g. structured data within standardised messages).

Scanned clinical records have a role as a transition measure and many systems allow use of scanned forms as direct data entry devices.

At the highest level, the Electronic Health Record is designed to support the functions of automation, data storage, decision support and data analysis.

Computers are very good at automating functions. Tracking the location of patients, scanning equipment and medication and importing data from monitors are generally well handled by computer systems.

Data storage requires considerations of data security and data capacity as well as the design of systems to make data entry and presentation easy for users.

Decision support and data analysis are sometimes done well in locally developed systems [15], however there is much work to be done to develop generic decision support systems that are widely accepted.

Computerised provider order entry (CPOE) is a term used to describe the portion of a clinical information system that enables a clinician to enter an order for a medication, test or procedure directly into the computer. The system then transmits the order to the appropriate department or individuals. Some systems also provide clinical decision support such as dosage and alternative medication suggestions, duplicate therapy warnings, and checking drug-drug and drug-allergy interaction [16]. One of the pitfalls of clinical decision support alerts is that they are not always appropriate for the clinical situation and alert fatigue [17] can be a consequence of clinically unaware systems.

DATA COMMUNICATION STANDARDS

NEHTA (National e-Health Transition Authority) is an organisation supported by the Australian national and state governments to develop standards to ensure health data compatibility as well as data privacy and security [18]. Developing a system to uniquely identify every patient and provider has been one of their early tasks. Many standards exist for the transfer and organisation of health information. NEHTA has adopted a number of internationally recognised standards that sit well together and will encourage national or even international compatibility of health care data. HL7 version 3 and SNOMED CT are just of couple of the standards that have been selected for use in Australia.

HL7 is a globally recognised standard to allow functional (e.g. file exchange) and semantic (language) compatibility between and within healthcare organisations.

SNOMED CT (Systematized Nomenclature of Medicine - Clinical Terms) is the clinical standard supported by NEHTA. It is a multilingual healthcare terminology designed for the Electronic health record. Jointly developed between the NHS in England and the College of American Pathologists (CAP), it contains more than 357,000 concepts with unique meanings and

formal logic-based definitions organized into hierarchies allowing consistent machine interpretability.

ARCHETYPES are agreed information content frames that ensure a specific piece of information is interpreted by a receiving computer in the same way the sending computer intended. This is known as semantic interoperability. A number of archetypes have now been adopted by the NHS and more are under development both in Australia and overseas. Multiple archetypes can be organised together to create a template for specific clinical workflows such as obstetrics or intensive care[19].

SECURITY AND PRIVACY

Information security ensures, protects and supports confidentiality, integrity and accessibility[20].

- *Confidentiality* requires that only people authorised to manage information can do so. Confidentiality is achieved through access control and encryption.
- Information *integrity* requires that information is not changed or deleted by error, accident or malicious intent. Information integrity requires user identification, data authentication, physical protection of information repositories, electronic defence against unauthorised intrusion and virus protection. The ability to create an audit trail for interactions with the electronic record means that unauthorised or inappropriate use is relatively easy to identify.
- Information *accessibility* requires transparency of access control, system reliability, backup, system and data redundancy[21].

PERIOPERATIVE INFORMATION MANAGEMENT

As more patients arrive on the day of surgery for elective surgery, a growing anaesthetic challenge is to gather clinically relevant information preoperatively when time is limited. Many public hospitals now run preadmission clinics; however it is rare that the anaesthetist giving the anaesthetic on the day consults with the patient in the preadmission clinic. There is a need for a structured centralised document with clinical decision support assisting with medication advice, testing guidelines and referral standards. Using a systematic approach with clinical support and good communication mechanisms, quality of care would be enhanced whether consultations are performed by anaesthetist colleagues or other clinical staff [22].

Often, the clinical information has relevance to the decisions made by other clinical staff, case managers and waiting list managers. For example, a patient with diabetes should be done early on the list; patients who need tests on the day of surgery can be booked for surgery later in the list. Patients who are waiting for tests or medical consultation should not be booked for surgery.

Automated patient information sheets could be generated that are specific to the individual patient. The use of mobile computing technologies was demonstrated to significantly improve the workflow and information availability in a Canadian operating room environment for pain management[23].

THE ANAESTHETIC RECORD

Automated anaesthetic record systems collect data automatically from the anaesthetic machine and monitors. Drugs and events need to be entered manually, although a system does exist that uses bar coded syringes to add greater safety[24]. An automated system is legible, complete and accurate. It has high legal value when used in cases of alleged anaesthetic misadventure.

Sometimes the automated anaesthetic record is printed out and stored in the history, however, more often the data is centrally stored and can be used for audit, research, reference and practice review.

Common concerns with the automated anaesthetic record are artefact, increased time of drug and event data entry and compatibility. Artefact does not appear to be a big issue as it can be marked as such on the electronic record. Drug and event entry can take more time in some systems, however careful selection and the creation of commonly used templates or individual templates can overcome this issue. Compatibility and interfacing with other hospital systems can be a significant issue at technical, user interface and workflow levels. Resources need to be

allocated at a sustainable level to ensure initial and continuing compatibility with existing hospital systems so that realisation of all of the advantages of an automated anaesthetic record is achieved.

THE PATIENT

The internet has opened the way to an enormous amount of information and new possibilities for communicating with patients. Many sites exist to provide patients with general information about disease, treatments, diagnosis and interventions. The doctor's role as intermediary between the patient and knowledge has diminished as patients learn about health from the internet. With so much information available, the challenge now is to provide credible pointers to high quality sources of information, or information that is comprehensible and timely[25].

Many hospitals and health care companies are providing 'web portals' where patients can view their test results, make or change appointments, view their medication lists, review health plans, communicate with their doctor using secure email or join support groups with other patients with similar problems. Patients can also complete a preliminary health record online, prior to a medical visit or surgery.

It is possible that actively involving patients in their health care, by sharing information about medications and health care plans and by fostering greater ownership of health problems, we will deliver significant improvement in safety and quality of care[26].

THE SOCIAL DIMENSION

Often the greatest problem when introducing informatics technologies is the failure to recognise the complexity of the underlying social and psychological aspects of an organization. Processes can be more complex than anticipated and may need re-engineering. Informatics systems do not solve clinical problems when the issues are process based. Understanding hospital processes is often a very complex task and is best done by examining the process from many points of view[27].

Whilst region wide implementation of information systems can deliver compatibility and some economies, they can be problematic when there has not been involvement and ownership at all levels[28, 29]. Information systems have not been adopted when the time taken to input data is large and the value of the analysis of data is not realised. Staff with low psychological investment in a new technology are unlikely to embrace it and have the capacity to precipitate its failure[30].

Implementing new systems is about the management of change and addressing non-technical issues. It is more likely to be successful when there is ownership of the new system, trust that the new process will realise true benefits and a sharing of the potential gains[31].

Healthcare informatics systems are difficult to design because they change the socio-technical aspects of our work. Technical systems have social consequences, for example the decreased eye contact with a patient, when a GP is looking at a computer screen. Social systems have technical consequences and may determine how we use technology, for example, email may be a good system for communication, however we won't use it if our manager doesn't use it. Healthcare is a collaborative activity that requires a technical system to allow communication between healthcare workers as much as recording the interaction between clinician and patient. It is an exciting challenge to understand how people and technologies interact[32].

Cognitive research examining aspects of the 'Human-Computer Interface' does much to enhance the experience of inputting data or comprehending processed information. Timely, concise decision support and continuing medical education is more easily comprehended than large amounts of unfiltered data[33]. Poor design may also create new errors. Some medication systems allow inadvertent mouse rolls to select the wrong drug. It is also difficult to prove the advantage of current medication order entry systems[34]. Recent work in Tokyo [35] demonstrated that point of care closed loop medication management system not only generated significant financial savings from improved inventory control and reduced waste but also trapped numerous administration errors particularly when staff were tired towards end of shift.

AGGREGATING DATA FOR QUALITY AND SAFETY

Combining data from many institutions can inform public health practitioners about epidemiologic trends and the burden of disease. Individual clinicians can also benefit from

ongoing practice and outcome audit. Being aware of our post-operative nausea and vomiting rate compared to other clinicians with a similar practice profile could, for example, allow us to make better choices about our anaesthetic techniques.

Some uses of aggregated data may draw administrators and clinicians into conflict. Using the automated anaesthetic record, practice administrators can monitor, punish or reward certain practice characteristics such as start times or change over times [36].

The AIMS database is an excellent repository of critical incidents, however collation and analysis is very time consuming and many incidents are not reported. Automatic or easy reporting of critical incidents, high risk environments or near-misses would greatly inform and direct better patient safety.

SUMMARY

The human mind is flexible and performs well in complex or un-familiar situations. Computers are excellent at calculation and repetition. Computers make fewer errors when working quickly with large amounts of information, but cannot cope beyond defined parameters.

The complexities of healthcare grow everyday and the need for a systematic, evidence-based approach to most problems is becoming clear. Clinical pathways, order entry, automated data collection, automated patient tracking, automated medication delivery, accessible clinical data, clinical decision support and clinical data analysis are all important tools that will help us achieve better safety and quality of care.

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