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Genomics and general practice: the next 10 years

Should general practitioners care about genomics? Perhaps not right now, but definitely within the next decade.

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Genomics is the study of the genetic information of organisms from their basic nucleic acid structure (so-called base pairing) to their polymorphisms and their variability over time and space. If we go further downstream, genomics leads to transcriptomics (study of transcription of genes into ribonucleic acids [RNAs]), proteomics (study of translation of RNA into peptide sand proteins) and finally, metabolomics (study of interaction of various proteins for normal metabolism). In the last 2 decades, these fields have significantly impacted practically every branch of biological and medical sciences, and equally sociology,[1] anthropology,[2] psychology,[3] and behaviour studies.[3,4]

Why bother?

The Human Genome Project was completed in February 2001 and revealed 3 billion base pairs of coding information in our body.[5] Among them, only 1% present as single nucleotide polymorphisms which translate to interpersonal variability in traits, characteristics and disease susceptibility. These base pairs are clustered into 25 000–30 000 recognised regions of variable lengths, more commonly known to us as 'genes'. We now understand that many human diseases can be traced to changes in a gene (eg. monogenic disorders such as polycystic kidney disease[6]) or multiple genes (eg. polygenic inheritance such as diabetes,[7] hypertension[8] and depression[9]). General practitioners are at the forefront of making diagnoses, arranging investigations, initiating pharmacological treatments, monitoring progress and assessing prognoses. They practise daily according to their knowledge base, complemented by a dynamic body of acquired practical wisdom.

Within the next decade, I envisage that genomics, and its related disciplines, will dramatically enhance our daily practice in the following ways: screening, diagnosis, management, disease monitoring, prognosis and prevention.

Screening

Today, mass population screening is the mandate for breast, cervical, and colon cancer for patients within the defined age group or for those with a family history of malignancy. By 2020, patients may present with a 'smartcard' that gives GPs high security access to a centralised genomic database with the patient's genetic inventory and polymorphisms, detailing disease risks from the rare glycogen storage disease to the more common breast cancer and colorectal cancer.[10] Based on such data, the GP will be able to individualise screening strategies[11] as per the patient's genomic profile, and therefore economise national resources on mass population screening.

Diagnosis

General practitioners now send cultures and swabs for microbiology and either observe the patient or initiate tentative antimicrobial treatment while waiting for the report for 48 hours. By 2020, GPs will probably be able to send the same samples for microbiogenomic assays which will return the exact identity and antigenic subtype(s) of the pathogen(s) together with antibiotic sensitivities, all within the same hour. The GP will wait for these results before prescribing and thus avoid the hassle of calling up the patient to switch to the correct antibiotics. Similarly, definitive genomic and proteomic markers will yield histopathological diagnoses of biopsies with pinpoint accuracy. In addition a disease risks profile from individual patients will enable GPs to be more assertive in diagnosing and phenotyping

chronic diseases such as diabetes, essential hypertension and familial hypercholesterolaemia and hereditary haemochromatosis[12] when the relevant indices are abnormal. General practitioners will also be able to assess familial risks of diseases with remarkable accuracy.

Management

Most GPs have often wondered why patient 'X' had no response to the diabetic medications prescribed and why patient 'Y' suddenly developed a drug rash while taking usual medications. Thanks to the advances of pharmacogenomics, in the next 10 years, GPs are likely to have practical data to genetic susceptibilities of patients X and Y toward their specific medications and work out the reason for patient X's nonresponse or patient Y's adverse drug reactions. In fact, the GPs first prescription for every new patient will be extremely effective and safe, as the genomic data will enable them to stratify every patient into the specific pharmacological and metabolic phenotype for the best indicated treatment.[13] Moreover, gene therapy will be the gold standard for selected genetic diseases such as retinitis pigmentosa, Leber congenital amaurosis[14] and type 1 diabetes.[15]

Disease monitoring

At present GPs adopt lipid profiles and Framingham risk scores for assessing cardiovascular risks, and HbA1c and urinary micro-albumin for detecting diabetic nephropathy. By 2020, GPs may have a repertoire of genomic and proteomic biomarkers for most chronic diseases[16–18] to monitor progress and prevent unwanted complications, to the extent of enabling personalised care in malignancies.[19]

Prognosis and prevention

It is never easy for a GP to prognosticate for a patient with malignancy or to suggest preventive measures for a patient with a family history of cancer. Such dilemmas can be removed in the next decade when genomics and proteomics equip GPs with highly specific oncomarkers to assess risks,[20] detect actual disease,[21] monitor disease progress,[10] and prognosticate outcome[19] for most malignant diseases.

Potential pitfalls: ethics and data protection

However, at best, genomics data serve to enhance our clinical capacity but they are by no means absolute indicators. A patient who profiles with an oncogene will have a 67% chance of developing a certain cancer in their lifetime, so what does that mean? How should a GP counsel the patient in realistic terms? How can the GP be sure the patient will understand the disease probability versus the projected risk? Would it be ethical for the GP to withhold the data if they believed the patient could not deal with the information intellectually or emotionally? General practitioners must be competent to answer such questions in order to interpret clinical genomic data in their proper context, ie. not to underrate it and miss the opportunity for monitoring and risk reduction, or overrate it and risk unnecessary patient concern and redundant testing. Thanks to Moore's Law and the dawn of nanocarbon technology, it is most likely the next decade will see the emergence of biochip computers that can directly interface our brains with computers via touch – neurohaptic technology. However, as we utilise genomic data, we must stringently protect them as the intellectual property of our patients in order to comply with patient privacy. Hopefully by the time this information is available at our fingertips, 256-bit encryption technology will be the norm to address the issue of privacy. It would also be a bonus for governments and regulatory bodies to support bioinformatics and nanocarbon computing as core topics of continuous professional development to ensure standards of clinical practice in the genomic era.

Conclusion

Patient centred care has always been the tenet of general practice. I believe that genomics and related technologies will eventually result in personalised medicine where medications are individually tailored according to the genetic make-up of patients to achieve the best efficacy and the least adverse effects – family medicine and genomics share this common goal. Genomics and its related disciplines are no longer exclusive to bench scientists or remote academia. They have begun to affect practising clinicians from all specialties. In fact, a recent study has suggested the need to incorporate genomics data in the clinical context of managing chronic diseases.[22]

So, we GPs should all stay tuned.

Conflict of interest: none declared.

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