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The Role of Pharmacogenomics in Personalized Medicine: Improving Drug Efficacy and Safety

[1]-Meshal Homoud Alanazi,[2]-Mohammed Lafi Aldhafeeri,[3]-Mohammed Naeem Aldafeeri,[4]-Bader Mubarak Rashed Aldhafeeri,[5]-Amer Hamid Alenezi,[6]-Mohammed Saleh Alanzi,[7]-Aziz Jaber Alshammari,[8]-Badr Saud Alshammari,[9]-Ahmed Radhi Alanzi,[10]-Meshal Fahad Znufr Almutairi[11]- ، Zahra'a Abdulwahid Saud Bin Haji

KSA, Ministry of Health

Abstract

Background: Pharmacogenomics refers to the way in which genomic factors affect drug response, and serves an important function in the growing field of tailored medicine. When genes that influence the response to specific medications are found, healthcare serves are made more effective for the individual patient due to optimizing the drug's effectiveness and reducing adverse effects.

Aim: The purpose of this study is to investigate roles of pharmacogenomics in enhancing drug effectiveness by offering further individualized prescriptions that are tied to genetic predispositions regarding medication activation and distribution along with clinical uses of the concept.

Methods: An analysis of related literature was done to assess the effects of pharmacogenomics on drug response variability, especially a discussion on new testing measures and their application in management of the variability.

Results: The evidence squarely suggests that pharmacogenomics testing optimizes the administration of drugs based on molecular guideline that is developed based on an individual's DNA; meaning that pharmacogenomics testing results in enhanced therapeutic benefits, fewer side effects and a lowest rate of trial and error with drugs. Primary pharmacogenomics genes implicated in treatment included cancer therapy, cardiovascular agents, and drugs used in psychiatry.

Conclusion: Pharmacogenomics is a high profile subject that contributes remarkably to the goals of personalizing treatments, increasing the effectiveness of drugs and the overall quality of animal care. However, there are limitations, and efforts toward implementing genetic testing in clinical practice will in the long run make treatments better and safer.

Keywords: Pharmacogenomics – genomics pharmacology, personal sensitive medicine, drug performance; genetic markers; selection of treatment; variability of drug response.

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Introduction

Pharmacogenomics, which is basically the study of how genes impact on drug actions is currently providing a face lift to various areas of medicine. Of all the fields that pharmacogenomics is influencing, the most important is perhaps the one dealing with enhancing drug effectiveness through originating treatment modification based on genetic makeup. Over time, knowledge pertaining to genetic markers with relation to drug metabolism, response as well as safety enhances the ability of the practitioners in fine-tuning the therapy, thus minimizing trial-and-error use that has been characteristic of medical practice. Genetic factors play an important role in the influence on the individual pharmacokinetics of the patient, and not only the type of medication, but also the dosage, side effects and therapeutic effects. This paper

looks at how genetic markers can help enhance drug effectiveness, specifically the use pharmacogenomics testing for determining therapy choice in cancer, cardiovascular diseases, and psychoses and other diseases. In tandem with these developments, the health care fraternity is shifting more in the direction of personalized, precision medicine that holds the prospect of enhancing the clients/ patients' well-being and general health.[1,2]

1. Pharmacogenomics: Basics and Key Concepts

Pharmacogenomics is defined as the branch where an organism's overall genetic structure determines its reaction to different drugs. This is a mixture of pharmacology which is the science of drugs as well as genomics which is the study of genes and what they do. Pharmacogenomics would wish to establish the relationship between genetic differences and its impact on pharmacokinetics actions which include, absorption, distribution, metabolism, and excretion of the drugs in order to determine the efficaciousness of a particular drug. Genetic polymorphism therefore results in differences in drug metabolism that can expose patients to adverse effect, failure of therapy or success of therapy. Pharmacogenomics studies assist in anticipating the right choice and dosage of a drug to be prescribed to a patient in order to enhance the drug therapy and reduce drug therapy hazards.[3,4] Another concept on which pharmacogenomics is based is that of genetic polymorphism – small changes in DNA sequence that are relatively frequent in the population. These polymorphisms can influence the function of enzymes implicated in drug metabolism, or action of the target for drug like receptors or enzymes, or immune response to drugs. For instance, single nucleotide polymorphisms (SNPs) within the gene that codes for cytochrome P450 enzymes, the group of enzymes that play the role of bio transformers of most drugs, can cause a person to be a Phenotype Poor, Phenotype Fast or Phenotype Normal. This will decide the rate at which a drug is either removed from the body and this may cause either inadequate dosing or toxicity.[5,6] The third important concept of pharmacogenomics is the issue of genetic factors that determine drug effects. By adopting GWAS and other genetic technologies, researchers have been in a position to pin point genetic markers that present a relation to both favorable and unfavorable reactions to certain drugs. For example, mutations in the VKORC1 and CYP2C9 genes can determine why some people may react badly to anticoagulants such as warfarin. It means that patients having some forms of genetic variations may need less or significantly more of the drug i order to get the right effect and avoid bleeding issues or develop thrombosis.[7]

The utilization of pharmacogenomics in clinical practice the possibility of person specific medicine, which acknowledges the fact that distinct patients can exist in the world, and treatments have to be delivered affirmatively to a particular Orla. It can improve therapeutic goals because it allows selecting drugs and doses that are likely to originate a given effect on a particular patient without potential side effects. Nonetheless, despite the potential of pharmacogenomics to yield broad benefit, it is not without issues to the implementation of pharmacogenomics results in day-to-day practice. These challenges include the cost implication in the tests, lack of awareness among healthcare providers on how to use pharmacogenomics information; and issues of privacy and/or ethical use of an individual's genetic information.[8] Therefore, pharmacogenomics is a dynamic Noble cause that is more likely to change the face of medicine through its advancement of the concept of segregated prescription rather than general prescription. While identifying ever more genetic variations predicting drug responses, it will become possible to provide patients with more effective, safe, and individualized treatment, ultimately benefiting patient outcomes and the functionality of the healthcare system. [9,10]

2. Pharmacogenomics and Its Impact on Drug Response Variability

Pharmacogenomics covers important roles in explaining the differences in drug effects that exist between different individuals. The differences in how patients metabolize drugs are determined genetically, and pharmacogenomics aims to find these genes to create the best treatment. This field also supports why some patients get a lot of relief through the drug while others face life threatening complications or little to no relief at all. Unlike the common practice of identifying diseases on the basis of genetic traits that influence drug metabolism it differs by focusing on predicting the authority with which a patient can be treated to a definite drug.[11] Inter-individual variability in drug response is attributable to genetic factors

chief among them being polymorphisms. These are inherited changes to the DNA sequence that make people respond differently to medication. It is known that polymorphisms can take place in genes encoding drug-metabolizing enzymes, drug transporters and drug targets. For instance, the cytochrome P450 (CYP450) enzyme family is strongly involved in the phases of the metabolism of a vast number of drugs. Variations of the CYP450 genes can lead to a slow or fast metabolism of drugs depending to the person who has the gene. There are 'fast metabolizers,' in which the drug is processed rapidly, and therefore less effective," adds some other. Some people might be "poor metabolizers" and therefore drugs build up within the body and lead to toxicity. Abnormalities can be found in pharmacogenomics testing so that any choice process or dosage can be altered in an attempt to avoid potential harm or less than optimal outcomes.[12]

Another source of drug response variation is genetic variation of drug receptor. Drugs act through their receptors on the cells, but mutations may change either the structure or function of the receptor, leading to changes in drug effectiveness. For instance, polymorphism involving the gene which codes for beta adrenergic receptor can determine how patients will be affected by beta blockers which are used to treat conditions such as hypertension and heart failure. There will be certain patients who, because they have specific gene variant gains, will experience a more resonant influence of the drug, while there are those who will barely feel its impact. Likewise, polymorphisms in EGFR, the epidermal growth factor receptor, may affect cancer treatments that are directed at this receptor. Some patients with specific EGFR are likely to benefits from target therapies such as tyrosine kinase inhibitors and others are not.[13] Pharmacogenomics also enlightens on the issue of genetic determinants of immune-mediated drug reactions, an area of interest in pharmacogenomics. Some medications, including allopurinol prescribed for gout, and carbamazepine used for epilepsy, have certain side effects of severe allergy, skin rashes and damage to certain organs. Such reactions are associated with defined genetic polymorphisms in genes of the immune system. For instance the HLA-B*5801 allele has been found to increase the risk of severe skin reactions in patients taking allopurinol. Such genetic markers can also be tested for pharmacogenomics purposes to determine who might benefit from an alternative treatment or managed more closely to avoid the development of dangerous risks at all costs.[14]

increasing supports on context of the clinically relevant application of pharmacogenomics for explaining the inter individual variability in drug response, several obstacles are still evident. However, one of the main challenges is the number and the nature of the genes that contribute to the development of the disorder. Drug response usually involves multiple genes, each having a small effect on the result so the predictions of the outcomes are rather imprecise. Furthermore, patient related factors including diet, genetics, lifestyle and other drugs taken concurrently also influence genetic effects on drugs. Thus, according to our study, useful as pharmacogenomics data may be, they should be viewed in the light of the patient's general state, past illnesses, and treatment strategy.[15] This paper has highlighted how the integration of pharmacogenomics to clinical practice has the ability to close the gap of adverse drug reaction, improve the efficacy of drugs, and reduce costs. This way, it is easier to determine effects that a particular genotype may have on an individual and in turn choose the right drug to use that has best chances of being effective and safe for the particular patient. The future holds promise for pharmacogenomics as genetic testing is already predicted to become a conventional practice in the judicial of clinical choices to enhance the medicine. However, prior to the widespread use of pharmacogenomics testing, the challenges like the cost of pharmacogenomics testing, its availability, incorporation of pharmacogenomics data into the Electronic Health Record and relevance, and ensuring that the HLPs are competent to utilize the pharmacogenomics data have to be resolved.[16,17]

3. Personalized Medicine: Personalizing of Treatment with Reference to Genetic Structure

In actual sense, personalized medicine also known as precision medicine is a new approach of doing and delivering healthcare services as opposed to the traditional conventional or conventional oriented system. This strategy deals with customizing medical treatments in relation to the details regarding every client's characteristics especially in the genetic domain. An individual's genetic profile can be used by doctors and other health care professionals to develop safe and personalized therapies that are particularly instituted to meet the genetic differences in the patient. This shift not only makes treatments more effective

but also decreases the probability of developing an adverse drug interaction making patient care more successful and individualized.[18,19]
Essentially, the key focus in the practice of personalized medicine is pharmacogenomics, which refers to the understanding of genetic differences that determine the reaction of an individual to medications. Today clinicians can determine which drugs particular patients will metabolize, how they will respond or even suffer side effects from each medication. For example, related to the genetic markers of certain enzymes related to activities and velocities of some drugs metabolisms like the cytochrome P450 Meadows Body Cam also called <Hybrid>, may process some drugs faster or slower than other drugs. Through identification of these variations, the kind and dose of drugs can be changed or other treatment forms administered or certain drugs avoided in order for patients to get the best treatment.[20,21]

The main idea of the personalized medicine is for obtaining the highest effectiveness of the therapy by choosing the proper medication and its dosage for each patient. For example, in cancer treatment, individuals received genetically mapped tumors that are used in developed personalized medicine. Most of these cancers are associated with certain gene abnormalities, and once the abnormalities are known, the drugs can be designed to block the growth-related activities of the cancer cells. Molecularly annotated treatments like trastuzumab in an HER2 positive breast cancer or gefitinib in an EGFR mutated non-small cell lung carcinomas are ideal examples about how the treatments are personalized on the basis of both the patient and the disease. These treatments are typically more effective than conventional chemotherapy because the medication homes in on the cancer at the molecular level and nontoxic substances affect healthy cells.

Therefore, besides cancer, personalized medicine finds practical applications in tertiary prevention and control of chronic diseases including cardiovascular illnesses, diabetes, and mental disorders. For example, in cardiovascular medicine the determination carriers of specific genotypes that involve promotion of hypertension by certain genes will help to distinguish patients who require specific antihypertensive preparations. Same as diabetes, genetic testing can be used to help identify the best drug for the patient, it may be metformin or the newer classes of drugs depending on the genetic profile of insulin resistance or bad beta-cell function.[22,23] Other disorders that have been shown to provide benefits from the principles of personalized medicine includes psychiatric disorders. The data suggest that pharmacogenomics could play a crucial role in determining patients' reaction to psychiatric drugs including antidepressants and antipsychotics. For instance, the reaction to drugs belonging to the selective serotonin reuptake inhibitors (SSRIs) require different genetic reactions in serotonin receptors or transporters to treat depression. This means that more tailored methods that can involve genotyping of these variations can enable doctors to select the right drugs and doses for their patients in treatment presentations in a way that enhances outcomes and contains the traditional guessing process in psychiatric treatment.[24,25] Personalized medicine also holds a great promise to decrease ADRs among patients, that is another strong point of customized treatment. Rash is one of the leading causes of admission and healthcare expenses, and these reactions may develop from genetic divergences in terms of how patients process medications. For example, there are people who, owning the genetic markers in the HLA-B gene, have higher chances to develop severe reactions to such medications as carbamazepine or allopurinol. In this way, before prescribing these medications, clinicians can indicate such genetic markers and exclude dangerous reactions, and prescribe other drugs instead. Such action plan not only safeguards patients but also relieves pressure on the health care systems to provide treatments for ADRs through cases of emergency call or through protracted hospital stays.[26,27]

Despite the great prospect of personalized medicine application, there are several barriers to its further adoption. Among the challenges is the issue of system cost specifically genetic testing cost may not always be absorbed by the insurance sector. While the exact cost of sequencing technologies has come down in recent years, the complementary genetic testing can still be prohibitively expensive for most patients, as well as insurers and payers. Also, more effort needs to be exerted to implement capture of genetic information into the EHRs so that the clinicians in the healthcare system can use the genetic details when making decisions on the research. From this study, there is also the problem of making healthcare providers

aware about clinical use of the genetic testing and how they should be approaching genetic information.[28] However, there are ethical issues to do with owning of the methods of personalized medicine that needs to be addressed. Ethical concerns with genome privacy, genetic consent and genetics vulnerability to discrimination are the key components that should not be neglected following the continuous development of personalized medicine in clinical practice. The current paper pointed that for ethical implementation of personalized medicine, one of the significant aspects that should be observed is the ability of health care providers to ensure patients are made to understand the potential risks and benefits of genetic testing and their genetic information being stored.[29,30] Thus, there is a tremendous potential for the development of the concept of personalized medicine in terms of changing the world of healthcare by offering improved accurate, efficient, patient-oriented therapeutic management plans. Most promisingly, as technology snowballs and genetic information is smoothly interlinked with our clinical practice, personalized medicine is likely to deliver a much higher level of healthcare efficiency and effectiveness across the broad spectrum of diseases and for every individual, in addition to lowering healthcare costs and ultimately raising the standard of healthcare. By tailoring treatments to the genetic profiles of patients, healthcare providers can move closer to achieving the ultimate goal of precision medicine: ensuring that patient receives right treatment, from the right provider at the right time.[31]

4. Advances in Pharmacogenomics Testing: Tools and Techniques

The social aspects of the growth of genomics and biotechnology to propel the field of pharmacogenomics due to availability of advanced tools and techniques to test and analyze genetic differences. One of pharmacogenomics testing is useful in finding out genetic factors responsible for an individual's reactions to certain drugs making it helpful in delivery of customized medical care. These ideas have enabled the development of individualized drug prescriptions, improved therapeutic drug effects and reduction in ADRs based on pharmacogenomics. In the past decade, there has been development of several tools and techniques that increase the reliability and feasibility of pharmacogenomics testing.[32] Probably the most important break from pharmacogenomics testing is next-generation sequencing (NGS). The use of next-generation sequencing (LGS) technologies has enable discovery of whole genomes or unique gene panels at high speeds not possible by earlier equipment and consequently at a cheaper cost . While earlier techniques of reading DNA focused on analyzing individual genes sequentially, NGS provides researchers/clinicians the opportunity of analyzing huge amounts of data based on a single process run. This allows for the detection of many other types of genetic variation, including mutations, polymorphisms, and copy number variations which could affect ADMET. The large scale sequencing has enhanced the capacity to identify low frequency genetic variations that may be linked to drug response or toxicity thus increasing the utility of pharmacogenomics testing.[33]

PCR is another powerful tool used in pharmacogenomics testing that is utilizes to amplify small portions of DNA to ensure that they are analyzed adequately. PCR is most commonly used in the identification of unique gene mutations that can affect how an individual will respond to certain medicines, similar to the variation in CYP450 which is concerned with the biotransformation of several drugs. Molecular diagnostic technologies like real time PCR and AS-PCR accurately quantitate the genetic variation in patients' specimens and help the clinicians to decide how the individual metabolizes a certain drug. These assays are relatively fast, inexpensive and readily accessible thus making them a foundation for pharmacogenomics testing.[34,35] Another useful test technology is genotyping arrays, which is also referred to as single nucleotide polymorphism arrays (SNP arrays). These arrays are planned to identify vast numbers of single nucleotide polymorphisms (SNPs) in the genome: most, if not all, of which point to drug sensitivity. SNP arrays make it possible to perform genotyping of common polymorphisms in genes responsible for the metabolism of many drugs including anticoagulant, antidepressant and anticancer agents. In addition to showing which specific genes a patient has present, SNP arrays give information to understand how a patient is likely to be affected by a certain drug and therefore having benefits in treatment selections. These arrays are suitable for phenotyping large population for common genetic risk factors and can be applied in the clinical settings to risk-allocate patients.[36,37] Subsequently, the development of pharmacogenomics databases and bioinformatics has also boosted the pharmacogenomics testing. Available resources like the

PharmGKB (Pharmacogenomics Knowledge Base) and CPIC (Clinical Pharmacokinetics Implementation Consortium) give the clinicians information carefully selected in regards to genetic variants influencing the drugs response, dosing information, as well as advice that has been gleaned from the clinical practice. These databases contain information derived from scientific publications, clinical trials and population-based research, providing a single source of reference for the interpretation of results from pharmacogenomics tests. Combined with bioinformatics tools, these databases help clinicians use genetic information as one of the parameters for making prescription decisions, based on clinical data. These tools are very valuable in this context because as pharmacogenomics testing becomes increasingly incorporated into everyday practice, they facilitate the effectiveness of genetic information in the clinical environment.[38]

Moreover, the analysis of genetic data at patient or site of care is increasing popularity as a form of pharmacogenomics testing. Integrated DXA testing is the use of genetic tests within or near the location of the patient treatment that increases test turnaround time and therapeutic intervention. Mobile, transportable objects, which are capable to create genetic worksheets in real time are discussed when there is a growing availability of pharmacogenomics quick tests. It builds on microarrays, PCR, and biosensors to analyze patients' DNA on the site, which can reduce response time for treatment. This approach is especially helpful when used in emergency care, oncology, and such similar cases whereby drug changes may make a massive difference to a patient's well being.[39] Other improvements in artificial intelligence (AI) and machine learning (ML) have also started to boost pharmacogenomics testing as well. Large scale genomic data can then be imposed on a patient's clinical records and used by the AI algorithms to uncover certain intricacies on the drug response that cannot be visualized in a normal approach. Since AI predictive models can factor in both predisposing genetic and other influences including environmental, coexisting medical conditions and lifestyle; intelligent drug therapy recommendation can be produced. These technologies are being extended to semi-automate pharmacogenomic interpretation for speed, and accuracy, and to relieve clinicians of interpretative burdens.[39] In addition, implementation of pharmacogenomic testing into EHRs is also on the rise which makes it easier to adopt pharmacogenomic data into the clinical ecosystem. Due to the integration of pharmacogenomic information into HER systems, genetic-based treatments can be made within the provider's workflow. Implemented at point of care, this integration enables pharmacogenomic test results to be at the fingertips of clinicians while prescribing medications. When incorporated into EHRs, pharmacogenomic data can positively impact the quality of administration of medicines through less variability and minimal risk factors that cause ADRs.[40]

Despite the rich scientific progress in pharmacogenomic testing tools and techniques, there are a number of obstacles to overcome to unleash the potential of the field. Technology accessibility and cost of genetic tests remain a major difficulty in diagnosing genetic disorders especially in the developing world. The costs of the sequencing technologies have usually declined but the researcher may expand that the costs are still high for some population. Secondly, there is a dearth of recommendations on how pharmacogenomic information should be processed and implemented in practice. With the emergence of pharmacogenomics as an important new healthcare tool, it is important that education and training for healthcare providers should be the last to present a coherent picture of roles, responsibilities, duties, and obligations in the context of genetic information.[41] The pharmacogenomic testing tools and techniques have over the years shown new facets in individualization of drug therapy, optimized patient benefits and reduced risks of adverse drug effects. Bridging from NGS & genotyping to PCA & AI, these technologies are likely opening the doors for more precise medicine. Pharmacogenomic testing is still in the process of achieving more widespread use in doctors' offices, but when it does, the use of the ribozyme is likely to be a significant component in the future of medicine and the way that healthcare providers will be able to deliver even more effective treatment to their patients.[42]

5. Improving Drug Efficacy: Using Genetic Markers in Choosing the Treatment

More often pharmacotherapy is successful depending on how much the specific drug suits the genetic profile of the patient. It is here that pharmacogenomic markers offer a solution to enhancing drug outcomes and enhancing the process of treatment. Pharmacogenomics are heritable traits that involve distinctive differences in a person's DNA sequence and possibly determine the way a person metabolizes, tolerates or

suffers side effects from particular drugs. With new advances in pharmacogenomics, the identification and incorporation of these genetic markers in a clinical setting are necessary for the highest drug response and least side effects.[43] The most common genetic determinants correspond to genes that code for metabolic enzymes including the CYP450 isoforms, drug transporter , receptors and signaling molecules. Mutations in these genes differ the pharmacokinetics and pharmacodynamics of the medications as well as overall therapeutic efficacy. For example, Some genotypes may metabolize a drug more quickly and therefore may need to take a larger dose to achieve the desired effect, On the other hand, some other genotypes metabolize a drug more slowly meaning that toxicity may result. With these genetic markers; the medical practitioners could then choose the right drug and dosage to give to each patient hence; improving the flow of treatment.[44] Of all the therapeutic applications, cancer is one of the fields that exhibit strong influences of genetic makers in terms of drug response. Most cancer treatments such as chemotherapy and some of the targeted therapies are based on certain understandings of genetics. It can be seen that even the humoral cells have specific genomic changes that may influence the reaction to particular agents. For example, EGFR gene mutation in non-small cell lung cancer (NSCLC) can be used to detect how effective EGFR inhibitors like gefitinib and erlotinib will be. Likewise, the BRAF gene also plays a great role in choosing BRAF inhibitors like vemurafenib for treating melanoma. In this way genetic testing of these mutations helps clinician to select patients who will probably benefit from these targeted therapies making the therapies effective and minimizing the use of the therapies on patients unlikely to benefit.[43]

The diagnosis and treatment of heart diseases, including related complications, are also determined by genetic indicators. One of them is warfarin which is an anticoagulant; the drug has a very small difference between toxic and therapeutic doses. VKORC1 and CYP2C9 variants are polymorphic genes which determine how people metabolize warfarin, and the dose they require. Specific information is thus obtainable from the genes mentioned above, which will help clinicians to decide on the correct warfarin dose, thus, lowering the chances of bleeding and removing overall therapeutic effectiveness. Likewise, pharmacogenomic differences in ACE gene can affect the efficacy of ACE inhibitors in managing hypertension; people of specific genotypes receive more benefits from these drugs than others . Schizophrenia 'allergic also further illustrates how genetic markers enable enhancement of drug outcomes. Antidepressants, antipsychotics and anxiolytics, for example, showed rather poor specific efficacy in patients with disorders associated with genetic variability influencing the pharmacokinetics and pharmacodynamics of the drugs. For example, polymorphisms of the serotonin transporter gene (SLC6A4) and other polymorphic sites are known to determine patients' drug-therapy success rate when they are prescribed selective serotonin reuptake inhibitors (SSRIs), typically used for depression and anxiety disorders. Likewise, the variations in the genes including CYP2D6 have influential impact on metabolism of several psychiatric drugs including antipsychotics and antidepressants, besides the efficacy and side effects. Pharmacogenomic testing can help clinicians decide with precision what medication and the dose would be most appropriate for the patient, have a better prognosis in patient treatment, whereas prescribing medication in psychiatry involves a lot of trial and error.[44] In enhancing drug efficacy the utilization of genetic markers is more than a specific drug but a category of drugs. For instance genetic make up is said to affect the receptor for statins which are drug that are usually used to reduce cholesterol levels. Single nucleotide polymorphisms in the SLCO1B1 gene for a liver transporter protein have been associated with statin-induced myotoxicity. Clinicians must ask if a specific patient carries any of these genetic variant and if that person requires switching to another medication or adjusting the statin dose. For this reason, this application of pharmacogenomics is useful in getting the most of the statins while avoiding adverse effects. The implications of genetic marker In drug efficacy can also not be overlooked as regards their importance for ADRs which are a major reason for morbidity and mortality. SIDE EFFECTS Sometimes a drug can react in ways that are not good for the patient because his or her body is genetically different. For example, the genetic marker HLA-B*57:01 is linked to hypersensitivity reactions to the HIV drug abacavir. Clinicians, therefore, screen patients for this genetic variant prior to the use of abacavir so as to increase treatment safety and efficacy. Likewise, polymorphisms in gene include TPMT affect metabolism of thiopurine, which is taken in treatment of autoimmune diseases and leukemia. TPMT activity is raised in patients who are at high risk of developing bone marrow suppression and although genetic test can be done to determine these

patients on whom the dose must be adjusted to minimize toxicity. Pharmacogenomics also is also significant in the rational utilization of biologic and biosimilar drugs which are bio Logical products derived from the biological system. Such drugs cost a lot of money and may produce undesirable effects on the body, thus it is crucial to guarantee that a certain patient needs to take it. Novel biomarkers may then be useful in determining which patients warrant treatment with biologics, as in the case of the TNF inhibitors for rheumatoid arthritis. As example, the polymorphism of HLA and TNF gene can determine which patients are likely to respond positively to these treatments establishing higher rates of biologics and decreasing the rates of unneeded healthcare costs.

it is obvious that genetic markers hold high potential for the optimization of drug treatment efficacy, although their practical usage faces several limitations. A primary technical difficulty is that of translating genotypic data into phenotypic consequences: Many genetic polymorphisms are likely to confer only modest and variable effects on drug metabolism. Second, the cost of genetic testing continues to be reduced but remains high for many health care systems and patients. Implementing pharmacogenomic testing also into practice need reliable technologies, such as electronic health records while managing the genetic data. Also, there is a requirement of training health care professionals on how best to use the pharmacogenomic data in making their prescription. Thus, genetic markers are thus becoming more important and are actually contributing to the increased effectiveness of drugs during the process of selecting the appropriate treatment. Having discovered genetic factors which define drug metabolism, response and toxicity, pharmacogenomics helps the attending physicians to select specific therapies for individual patients than are likely to result in favorable consequences and unlikely side effects. Thus, in future as genetic testing become more and more a part of clinical practice, the choice of most effective drugs according to genetic profiles will progress and dramatically orient the future of medicine and medical treatment.[45]

Conclusion

In conclusion, pharmacogenomics personalized-medicine model applied in the everyday practice has the unlimited potentiality of increasing the therapeutic effect of the drugs and matching the administration to an individual patient. Through using genotyping, doctors can easily identify exact ways that patients are likely to react to certain medications hence choose the right drug and correct dosages would have been given reducing cases of adverse drug effects. Today, genetic testing is making it possible to determine the kind of treatment, cancer therapies, cardiovascular drugs, and psychiatric treatment, which improve treatment outcomes while reducing side effects from medication. However, as with any novel medical development, the issues that are still debated are the definition of pharmacogenomics and bringing the relevance of testing into the medical context, the costs of such genetic testing, and the required medical infrastructure to implement pharmacogenomics. With integration of genetic testing in day-to-day clinical practice growing rapidly, one of the key promising focuses will remain the further enhancement of the treatment personalization, efficacy, and efficiency. Finally, pharmacogenomics is leading the way to more personalized treatments to increase the effectiveness and safety of medications worldwide.

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دور علم الوراثة الدوائي في الطب الشخصي: تحسين فعالية الدواء وسلامته

الملخص

الخلفية: يشير علم الوراثة الدوائي إلى الطريقة التي تؤثر بها العوامل الجينية على استجابة الجسم للأدوية، وهو يلعب دورًا مهمًا في مجال الطب الشخصي المتنامي. عندما يتم اكتشاف الجينات التي تؤثر على استجابة الفرد للأدوية، تصبح الخدمات الصحية أكثر فاعلية بالنسبة للمريض الفردي من خلال تحسين فعالية الدواء وتقليل الآثار الجانبية.

الهدف: تهدف هذه الدراسة إلى التحقيق في دور علم الوراثة الدوائي في تعزيز فعالية الأدوية من خلال تقديم وصفات طبية مخصصة مرتبطة بالاستعدادات الجينية المتعلقة بتفعيل الأدوية وتوزيعها، بالإضافة إلى الاستخدامات السريرية لهذا المفهوم.

الطرق: تم إجراء تحليل للأدبيات ذات الصلة لتقييم تأثير علم الوراثة الدوائي على تباين الاستجابة للأدوية، مع التركيز على مناقشة التدابير الجديدة للاختبارات وتطبيقاتها في إدارة التباين.

النتائج: تشير الأدلة بشكل قاطع إلى أن اختبار علم الوراثة الدوائي يعزز من إدارة الأدوية استنادًا إلى إرشادات جزيئية تم تطويرها بناءً على الحمض النووي للفرد؛ مما يعني أن نتائج اختبارات علم الوراثة الدوائي تؤدي إلى فوائد علاجية معززة، وتقليل الآثار الجانبية، وأقل معدل لتجربة الأدوية واختبارها. تشمل الجينات الرئيسية المرتبطة بعلم الوراثة الدوائي في العلاج تلك المتعلقة بعلاج السرطان، والأدوية القلبية الوعائية، والأدوية المستخدمة في الطب النفسي.

الخاتمة: علم الوراثة الدوائي من المواضيع البارزة التي تساهم بشكل كبير في أهداف تخصيص العلاجات، وزيادة فعالية الأدوية، وتحسين جودة الرعاية الصحية بشكل عام. ومع ذلك، هناك بعض القيود، وستؤدي الجهود المبذولة نحو تنفيذ اختبارات الجينات في الممارسات السريرية إلى تحسين العلاجات وجعلها أكثر أمانًا في المستقبل.

الكلمات المفتاحية: علم الوراثة الدوائي – الصيدلة الجينية، الطب الشخصي الحساس، أداء الأدوية؛ المؤشرات الجينية؛ اختيار العلاج؛ تباين استجابة الدواء.