Biomedicine & Pharmacotherapy xxx (2016) xxx–xxx

Available online at
ScienceDirect
www.sciencedirect.com

Elsevier Masson France
EM|consulte
www.em-consulte.com/en

Phyto-anesthetics: A mini-review on herb–anesthesia drug interactions

Sepideh Vahabi[a,b], Ali Eatemadi[b,c,d,*]

[a] Lorestan University of Medical Science, Kamalvand, Khorramabad, Iran
[b] Razi Herbal Medicine Research Center, Lorestan University of Medical Science, Khorramabad, Iran
[c] Department of Medical Biotechnology, School of advanced Technologies in Medicine, Tehran University of Medical sciences, Tehran, Iran
[d] Department of Medical Biotechnology, School of Medicine, Lorestan University of Medical sciences, Khorramabad, Iran

ARTICLE INFO

Article history:
Received 17 October 2016
Received in revised form 31 October 2016
Accepted 31 October 2016

Keywords:
Anesthesia drug
Herbal drugs
Pharmacokinetics
Pharmacodynamics

ABSTRACT

Over the years studies have shown the high prevalence rate in the use of herbal drugs among patients, doctors and health workers as such there is a need to take care of any health consequences associated with herbal drugs administrations. Herbal drugs are made of pharmacologically effective constituents, that can interact with anesthesia drugs that risk the life of the patients in question. In addition, pharmacokinetics and pharmacodynamics of herbal drugs are yet to be fully understood thus still needs more study. In view of this anesthesiologist should take a thorough history of the patient in question, taking into full consideration earlier use of herbal medicine/drugs by the patient. The aim of this article is to provide a mini-review on herb–anesthesia drug interactions.

Contents

1. Introduction

The formulation of effective and potent therapeutic agents has been improved by harnessing the natural capabilities of medicinal herbs and plants. Studies reveal that about 80% of citizens of most developing countries still believes in the use of traditional alternative medicine as their primary health care. Any plants source administered either completely or partially with the aim to treat an injury can be referred to as an herbal drugs [1]. Simon and colleague corroborated this fact that herbal drugs are administered to treat diseases and injuries and are the most ancient form of health care available to man [2]. Over the years the World Health Organization (WHO) also has specific herbal drugs as complete, branded medicinal products made up of potent ingredients, however, WHO have stipulated and strict rules and guidelines setting the perimeters for the assessment of the safety, efficacy, and quality of herbal medicines [3].

Several medicine systems including homeopathic and ayurvedic and traditional medicine have their constituents fully grounded

* Corrosponding author at: Lorestan University of Medical Science, Kamalvand, Lorestan, Iran.
E-mail address: a-eatemadi@razi.ac.ir (A. Eatemadi).

http://dx.doi.org/10.1016/j.biopha.2016.10.100
0753-3322/

Table 1
Merits and demerits of herbal drugs.

Merits	Demerits
Less expensive compared to conventional drugs.	Not completely efficient for some diseases and accidents
Complete and easily accessible	Complexity in standardizations
Increased health protection	Risk with self-dosing
Potency and efficiency are very high.	Pharmacokinetics and pharmacodynamics still poorly understood.
Fewer side-effects have been reported as the case maybe	
Easily tolerable.	

in herbal drugs. Finally, past decades have witnessed an increase in the consumption of herbal drugs with no prescription from a qualified health worker. In this article, we will make a mini-review on the available interactions between anesthetic drugs and administered herbal drugs. See Table 1 for merits and demerits of herbal drugs.

1.1. Toxicity and safety classification for herbal drugs

In other to be sure of the safety and potency of various herbal drugs, the American Herbal Products Association has developed a safety classification in relation to their toxicity level [4–8]. In addition, these classifications only include herbs with detailed and reported traditional use. There are four identified safety classes for herbs (Fig. 1) [9]; Class 1: Safe herbs; Class 2: Herbs with specific restricted use; Class 3: Herbs to be administered or prescribed by a qualified and registered physician and finally Class 4: Herbs without enough safety data for classification.

Furthermore, the toxicity of herbal drugs can result from differences in cultivation and processing of different herbal drugs [10–13]. Toxicity related herbal therapy could be divided four groups namely: Class 1: Herbal drugs/plants with unknown toxicity; Class 2: Mistakenly known herbal drugs/plants with toxic activity; Class 3: Contamination of herbal drugs/plant with pesticides, heavy metals and other chemical materials; Class 4: Toxic Interaction of herbal drug/plants with conventional drugs.

1.2. Mechanisms of herb–anesthesia drug interactions

The overlapping substrate specificity in the biotransformational pathways of the physiologic systems is seen as the major reason for drug–drug, food–drug, and herbal drug interaction (HDI) [14]. The two main mechanisms of herb-drug interaction are the induction or inhibition of intestinal and hepatic metabolic enzymes particularly the CYP enzyme family. In addition, the similar effect on drug transporters and efflux proteins particularly the *p*-glycoproteins in the intestines is responsible in most other cases [15]. The pre-systemic activity of CYP and efflux proteins often influence oral bioavailability, thus the modulating activity of co-administered herbal products has been shown to result in pronounced reduction or increase in the blood levels of the affected drugs [16]. Majorly the interaction of herbal products with hepatic enzymes has been reported to cause pharmacodynamic effects [17,18]. Mechanism of liver injury may include bioactivation of CYP, oxidative stress, mitochondrial injury, and apoptosis [19]

1.3. Induction and inhibition of metabolic enzymes

Herbal drug interaction with conventional drugs may result in toxic reactions. There are few available fundamental proposed pathways but the basic molecular mode of action of this interaction is yet to be explained [20–22]. There are have been three proposed pathways responsible for herbal drug-anesthesia drug interaction: Firstly, variation in metabolic Phase I–III system by herbal drugs causing alterations in drug concentrations has been proposed as a pathway for herb-anesthesia drug interaction.

Phase I: The oxidative action of cytochrome P450(CYP) mono-oxygenase on xenobiotics. Herbal drugs have been identified to stimulate or suppress the activities of this enzymes thereby leading to altered metabolism of conventional drugs [23–25]. The CYP superfamily is generally involved in the oxidative, peroxidative, and reductive biotransformation of xenobiotics and endogenous compounds [26]. It is conventionally divided into families and subfamilies based on nucleotide sequence homology [27]. The most important CYP subfamilies responsible for drug metabolism in humans are 1A2, 2A6, 2C9, 2C19, 2D6, 2E1, 3A4, and 3A5 [28]. Induction is the increase in intestinal and hepatic enzyme activity as a result of increased mRNA transcription leading to protein levels higher than normal physiologic values. Certain herbal products have been shown to be capable of inducing CYP. Concomitant administration of enzyme-inducing herbal products and prescription drugs can, therefore, result in sub-therapeutic plasma levels of the latter with therapeutic failure as a possible clinical consequence. Apart from enzyme induction, herbal products can also inhibit enzyme activities. The inhibition of CYP and other metabolic enzymes is usually competitive with instantaneous and inhibitor concentration-dependent effects [29].
Phase II: Besides their influence on the enzymatic activities of CYP, herbal medications can alter the absorption of concomitantly administered medicines through a number of mechanisms. Changes in the gastrointestinal pH and other biochemical factors can alter dissolution properties and the absorption of pH-dependent drugs such as ketoconazole and itraconazole. Complexation and chelation, leading to the formation of insoluble complexes and competition at the sites of absorption especially with site-specific formulations can greatly affect the absorption of medicines. Anthranoid-containing plants – cassia, Cascara, rhubarb and soluble fibers including guar gum and psyllium can decrease drug absorption by decreasing GI transit time. They are known to increase GIT motility. On concomitant use with prescribed medication, significant alteration in the absorption of the latter has been reported due to decreased GI transit time [30].

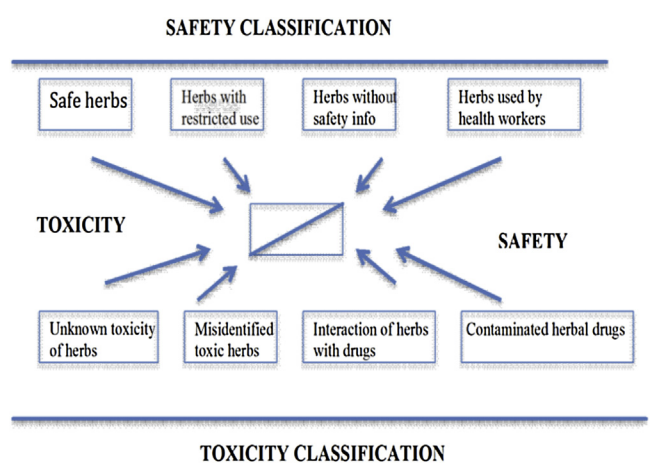

Fig. 1. Classification of toxicities related to herbal drugs and safety classification of herbal drugs. This figure was reproduced from [9].

Please cite this article in press as: S. Vahabi, A. Eatemadi, Phyto-anesthetics: A mini-review on herb–anesthesia drug interactions, Biomed Pharmacother (2016), http://dx.doi.org/10.1016/j.biopha.2016.10.100

The absorption of drugs such as phenoxymethylpenicillin, metformin, glibenclamide, and lovastatin may be reduced by high-fiber herbal products through the sequestration of bile acids [31]. Mochiki and his team also reported the ability of Kampo, a traditional Japanese medicine, to stimulate elevated intestinal blood flow, and to induce increased secretion of gastrointestinal hormones including motilin, vasoactive intestinal peptide, and calcitonin gene-related peptide [32]. **Phase III**: Transporter proteins are responsible for the dumping of xenobiotic compounds out of the cell, however, natural compounds like herbal drugs inhibit the actions of these transporter proteins most importantly, ATP-binding cassette (ABC) transporter and P-glycoprotein [33]. The ATP-binding cassette (ABC) family of drug transporters plays significant roles in the absorption, distribution, and elimination of drugs. P-gp, the most studied member of this family is a 170-kDa-plasma glycoprotein encoded by the human MDRI gene. It is constitutively expressed in a number of body tissues and concentrated on the apical epithelial surfaces of the bile canaliculi of the liver, the proximal tubules of the kidneys, the pancreatic ductal cells, the columnar mucosal cells of the small intestine, colon, and the adrenal glands [34]. It is actively involved in drug absorption and elimination from the intestines the liver, kidneys, and the brain. Specifically, these proteins are involved in the processes of hepatobiliary, direct intestinal, and urinary excretion of drugs and their metabolites [35]. Thus, the modulation of P-gp, or competitive affinity as substrates for its binding sites by co-

Table 2
Important Herbal-Drugs interactions from Anesthesia Perspective.

Herbal drugs	Common Use	Interacting Drugs	Effects	References
Garlic	Most commonly used by individuals with high cholesterol, heart disease, and high blood pressure	Warfarin General anesthetics	Alters bleeding time Antagonistic effect on immunosuppressing medications	[52] [53]
Ginkgo biloba	To improve memory and prevent or treat Alzheimer disease and other dementias	Warfarin, aspirin, ticlopidine, clopidogrel, dipyridamole Trazodone Levodopa	Increased bleeding risk Coma Increases “off” periods in Parkinson patients Bilateral subdural hematoma	[54] [53]
Ginger	Anti-inflammatory agent, analgesic, antioxidant, thermogenic, and antibiotic	Warfarin Chemotherapy	Alteration of bleeding time Reduces side effect of chemotherapy (nausea)	[55]
Ginseng	To increase a sense of well- being (physical, mental, and/or emotional)	Warfarin Chlorpropamide Phenelzine sulfate	Decreases blood concentration of warfarin Hypoglycemia Induction of mania	[56]
St. John’s wort	Treatment of mild-to- moderate depression, anxiety, or sleep disorders	Cyclosporine, Midazolam, Tacrolimu Amitriptyline, Digoxin, Indinavir, Warfarin, Phenprocoumon, Theophylline, Irinotecan, Alprazolam, Dextromethorpha, Simvastatin Sertraline, paroxetine, and Nefazodone Antidepressantor serotonergic drugs	Decreases blood concentrations of these drugs Serotonin syndrome Gastrointestinal disorder, allergic reactions, fatigue, dizziness, confusion, dry mouth, photosensitivity	[57]
Flaxseed	To lower serum cholesterol levels and as a laxative	Laxatives	Flaxseed may cause diarrhea and should be taken with ample water to preventconstipation and intestinal obstruction These products should not be taken with other dietary supplements or medications because the high fiber content may lower the body’s capacity for absorption	[58]
Aloe	Laxative	Digoxin Thiazide diuretic Laxatives Antidiabetic agents	Increases potential for potassium loss which may increase the risk of toxicity Increases laxative effect may cause excessive fluid/ electrolyte loss May potentiate hypoglycemia	[48]
Karela or bitter melon	Used as a folk remedy for a variety of ailments like stomach complaints	Chlorpropamide	Less glycosuria	[59]
Liquorice	To relieve a spasmodic cough and gastric ulcers	Pregnisolone Hydrocortisone Oral contraceptives	Decreases plasma clearance, and increases plasma concentrations prednisolone Potentiates of cutaneous vasoconstrictor response Hypertension, edema, hypokalemia	[60]
Psyllium	Dietary fiber and lower serum cholesterol	Lithium	Decreased lithium concentrations	[30]
Shankhapushpi	To improve memory	Phenytoin	Decreased phenytoin concentration loss of control of seizures	[53]
Chilli pepper	General analgesic	ACE inhibitors Theophylline	Cough Increased absorption and bioavailability	[53]
Black cohosh	The herbal antidote for such menopausal symptoms as hot flashes.	Oral contraceptives Tamoxifen Warfarin	Contains coumarin constituents Increases potential for bleeding	[61]
Milk thistle	Treatment of liver, spleen and kidney diseases	Acetaminophen Cyclosporine Cisplatin	Reduce liver toxicity because of these drugs	[53]
Kava	Treatment of anxiety and depression	Anti-Parkinson drugs Hepatotoxic drugs	Possible additive effects May increase risk of developing liver Damage	[62]
Goldenseal	Treatment of gastrointestinal disturbances, urinary disorders, skin ailments, and various infections	Debrisoquine Midazolam	Decreases urinary recovery ratio Increases blood concentration	[62]

administered herbs presents a potential for alteration in the pharmacokinetic profile of the drug. Pharmacokinetic interaction occurs when herbal drugs inhibit or decrease the normal activity level of drug transporters through a competitive or non-competitive mechanism. Interactions can also occur through the induction of transport proteins via the increase of the mRNA of the relevant protein. Studies have identified a number of clinically important P-gp inhibitors including phytochemicals – flavonoids, furanocoumarins, reserpine, quinidine, yohimbine, vincristine, vinblastine among others [36,37] reported that mobile ionophores such as valinomycin, nonactin, nigericin, monensin, calcimycin, and lasalocid inhibit the efflux of anthracycline by P-gp. The activation or suppression of signal transduction pathways might be another route for herb-anesthesia drug interaction. Fang and colleagues reported the importance and potency of technologies like transcriptomic and proteomic in detecting any modifications in signal transduction pathways resulting in herb-drug interactions [38].

1.4. Implications of herb–drug interaction

Several studies have reported the existences of pharmacological effects if herbal drugs that may lead to unhealthy and harmful herbal-drug interactions with prescribed with conventional medicines. Aged patients have been identified has the largest patronize of prescription medications and as such are more exposed to the risk of medication-related harmful events [39]. Antiplatelets and anticoagulants drugs are commonly prescribed for patients with cardiovascular and cerebrovascular diseases, however, [G1] patients with theses diseases can also seek help in alternative medicine through the concomitant use of herbal medication [G2] with conventional medication to reduce their risk of developing arterial or venous thrombosis and stroke [40]. It should be noted that the number of these herbal drugs consumed actually increases the risk for drug interactions. Furthermore, patients do complicate issues by adding several over-the-counter medications/drugs with the already prescribed medication by a doctor thereby leading to poly-pharmacy in clinical practice [41,42]. Interactions between several administered herbs as reported by Raghuram and colleagues in the case of fenugreek (Trigonella foenum-graecum L., Faba- ceae) responsible for lowering blood sugar levels, and when consumed with other herbs like Momordica charantia L. (Cucurbitaceae), necessary cares in the place of dose adjustments is required [43]. Basila and co-worker reported cases of coagulation and blood loss caused by the use of garlic, ginseng, and ginkgo during a surgical procedure [44]. The effect of general anesthesia can be potentiated by kava and valerian, which are known to possess sedative properties [45].The hepatic microsomal enzyme cytochrome P450 3A4 is stimulated by St. John's wort and has been observed to alter the metabolism of an immunosuppressant and oncological chemotherapy [46]. Cheng and co-worker also reported the harmful interference of the use of herbal drugs with anesthesia drugs among pre-surgical patients without the knowledge of the anesthetists [47] Any alteration in the diagnostic and therapeutic action of a drug caused by another administered specific exogenous drug or herbs is called drug interaction. The concept of drug interaction especially between herbal drugs and conventional drugs has been extensively studied [48]. See Table 2 for important herb–drug interactions. Several studies have reported Herbal–drug interactions including anesthesia drugs occurring in situations like the use of herbal drugs for weight reduction, performance and so on[13,49–51].

1.5. Mechanisms of herb–anesthesia drug interactions

Pharmacokinetics and pharmacodynamics are the two broad groups that mechanisms for herbal-anesthesia drug interaction

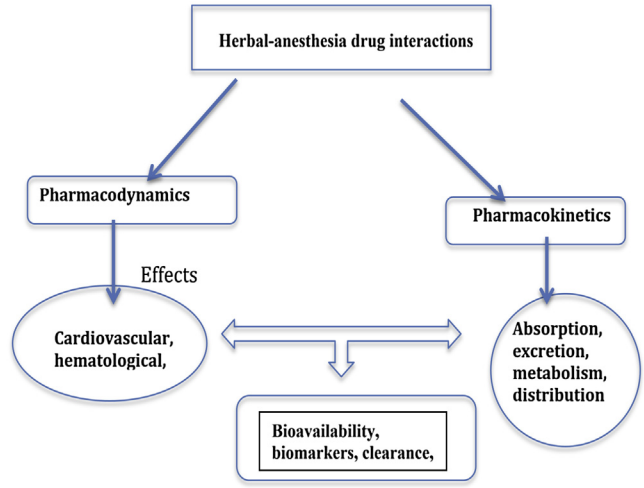

Fig. 2. Mechanisms of herb– anesthesia drug interactions. This figure was reproduced from [67].

can be divided [63–66]. When drugs either drug–drug or herbal-drug are co-administered resulting into one drug affecting the rate of metabolism of the other drug via induction of the drugs metabolizing enzymes is termed pharmacokinetic drug interaction (Fig. 2) [67].

Herbals like aloe gel, flaxseed, and psyllium that contain hydrocolloidal fibers, gums, and mucilage may experience abnormal absorption when administered together, they also have the ability to suppress other drugs absorption rate by binding to them thereby decreasing their systemic availability [68–70]. Furthermore, herbs like aloe latex, rhubarb, and senna have been reported by Kuhn and co-worker that they can cause loss of potassium ions and fluid that may result in toxicity when administered with digoxin [71]. Pharmacodynamic interactions are associated with any actions that can affect organ systems, receptor sites as a result of changes in the pharmacologic activity of the interacting agents. In addition, pharmacodynamic interactions have been found to be additive or synergetic as in the case of the increased hypnotic activity of benzodiazepines as a result of co-administration with valerian. In another case when lengthy doses of acetaminophen are concurrently administered with a hepatotoxic herbal drug it can result in increased risk of organ toxicity. However, no accurate or scientific, pharmacological and clinical based data are available for a vast majority of the herbal drugs as such the concepts of anesthesia drug-herbal drug interaction still remains unclear [64,68,72–78].

2. Conclusion

Though there have been several reported cases on herb–drug interactions but few reports have been made on herbal drug-anesthesia drug interaction [79–83]. In many of the reported cases of herbal-conventional drugs, no scientific basis have been provided for the mechanism as such extra care should be taken in administering herbal drugs with anesthesia drugs for pre-operative surgical patients [84–87]. However, if herbal drugs are to be continued to be administered for precise diagnose and treatment, qualified health workers will have to make an explicit assessment of the use of herbal drugs. Conclusively, more detailed and in-depth scientific research on the administration of herbal drugs and their co-administration with conventional drugs should be carried out rather than on the scantily reported data [88–91].

Please cite this article in press as: S. Vahabi, A. Eatemadi, Phyto-anesthetics: A mini-review on herb–anesthesia drug interactions, Biomed Pharmacother (2016), http://dx.doi.org/10.1016/j.biopha.2016.10.100

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

SV and AE conceived of the study and participated in its design and coordination. SV supervised the whole study. All authors read and approved the final manuscript.

Acknowledgments

The authors thank Department of Medical Biotechnology, School of Advanced Technologies in Medicine, Tehran University of Medical Sciences and Department of Anesthesiology, Lorestan University of Medical Sciences, Khoramabad, Iran.

References

[1] L.C. Winslow, D.J. Kroll, Herbs as medicines, Arch. Intern. Med. 158 (1998) 2192–2199, doi:http://dx.doi.org/10.1001/archinte.158.20.2192.
[2] P.A.G.M. De Smet, The role of plant-derived drugs and herbal medicines in healthcare, Drugs 54 (1997) 801–840, doi:http://dx.doi.org/10.2165/00003495-199754060-00003.
[3] Who, WHO Guidelines on Safety Monitoring of Herbal Medicines in Pharmacovigilance Systems, World Heal. Organ., Geneva, 2004, pp. 82. http://www.regione.emilia-romagna.it/agenziasan/mnc/pdf/documenti/oms/who_guid_pharmacovig.pdf.
[4] H.T. Aiyelabegan, S.S.Z. Zaidi, S. Fanuel, A. Eatemadi, M.T.K. Ebadi, E. Sadroddiny, Albumin-based biomaterial for lungs tissue engineering applications, Int. J. Polym. Mater. Polym. Biomater. 4 (2016) 16–24.
[5] S. Beiranvand, A. Eatemadi, A. Karimi, New updates pertaining to drug delivery of local anesthetics in particular bupivacaine using lipid nanoparticles, Nanoscale Res. Lett. 11 (2016) 1–10.
[6] H. Daraee, A. Eatemadi, E. Abbasi, S. Fekri Aval, M. Kouhi, A. Akbarzadeh, Application of gold nanoparticles in biomedical and drug delivery, Artif. Cells Nanomed. Biotechnol. 44 (2016) 410–422.
[7] H. Daraee, A. Etemadi, M. Kouhi, S. Alimirzalu, A. Akbarzadeh, Application of liposomes in medicine and drug delivery, Artif. Cells Nanomed. Biotechnol. 44 (2016) 381–391.
[8] A. Eatemadi, M. Darabi, L. Afraidooni, N. Zarghami, H. Daraee, L. Eskandari, H. Mellatyar, A. Akbarzadeh, Comparison, synthesis and evaluation of anticancer drug-loaded polymeric nanoparticles on breast cancer cell lines, Artif. Cells Nanomed. Biotechnol. 44 (2016) 1008–1017.
[9] M. McGuffin, C. Hobbs, R. Upton, A. Goldberg, et al., Upton, Botanical Safety Handbook, CXRC Press, New York, 1997.
[10] A. Eatemadi, H. Daraee, H. Karimkhanloo, M. Kouhi, N. Zarghami, A. Akbarzadeh, M. Abasi, Y. Hanifehpour, S.W. Joo, Carbon nanotubes: properties, synthesis, purification, and medical applications, Nanoscale Res. Lett. 9 (2014) 1–13.
[11] A. Eatemadi, H. Daraee, N. Zarghami, H. Melat Yar, A. Akbarzadeh, Nanofiber: synthesis and biomedical applications, Artif. Cells Nanomed. Biotechnol. 44 (2016) 111–121.
[12] M. Ghafarzadeh, A. Eatemadi, Z. Fakhravar, Human amniotic fluid derived mesenchymal stem cells cause an anti-cancer effect on breast cancer cell line in vitro, Cell. Mol. Biol. (2016) 102–106.
[13] S. Jaferian, B. Negahdari, A. Eatemadi, Colon cancer targeting using conjugates biomaterial 5-flurouracil, Biomed. Pharmacother. 84 (2016) 780–788.
[14] S. Marchetti, R. Mazzanti, J.H. Beijnen, J.H.M. Schellens, Concise review: clinical relevance of drug and herb drug interactions mediated by the ABC transporter ABCB1 (MDR1, p-glycoprotein), Oncologist 12 (2007) 927–941, doi:http://dx.doi.org/10.1634/theoncologist.12-8-927.
[15] D. Farkas, R.I. Shader, L.L. von Moltke, D.J. Greenblatt, Mechanisms and consequences of drug–drug interactions, Preclinical Development Handbook: ADME and Biopharmaceutical Properties, (2008), pp. 879–917, doi:http://dx.doi.org/10.1002/9780470249031 (ch25).
[16] L. Brown, O. Heyneke, D. Brown, J.P.H. van Wyk, J.H. Hamman, Impact of traditional medicinal plant extracts on antiretroviral drug absorption, J. Ethnopharmacol. 119 (2008) 588–592, doi:http://dx.doi.org/10.1016/j.jep.2008.06.028.
[17] A. Dasgupta, L. Kidd, B.J. Poindexter, R.J. Bick, Interference of hawthorn on serum digoxin measurements by immunoassays and pharmacodynamic interaction with digoxin, Arch. Pathol. Lab. Med. 134 (2010) 1188–1192, doi:http://dx.doi.org/10.1043/2009-0404-OA.1.
[18] S.M.B. Asdaq, M.N. Inamdar, Pharmacodynamic interaction of captopril with garlic in isoproterenol-induced myocardial damage in rat, Phyther. Res. 24 (2010) 720–725, doi:http://dx.doi.org/10.1002/ptr.3009.
[19] J.M. Cullen, Mechanistic classification of liver injury, Toxicol. Pathol. 33 (2005) 6–8, doi:http://dx.doi.org/10.1080/01926230590522428.
[20] H. Mellatyar, A. Akbarzadeh, M. Rahmati, M.G. Ghalhar, A. Etemadi, K. Nejati-Koshki, N. Zarghami, A. Barkhordari, Comparison of inhibitory effect of 17-DMAG nanoparticles and free 17-DMAG in HSP90 gene expression in lung cancer, Asian Pac. J. Cancer Prev. 15 (2014) 8693–8698.
[21] F. Mohammadian, A. Eatemadi, Drug loading and delivery using nanofibers scaffolds, Artif. Cells Nanomed. Biotechnol. (2016) 1–8.
[22] S. Nadri, H. Mahmoudvand, A. Eatemadi, Magnetic nanogel polymer of bupivacaine for ankle block in rats, J. Microencapsul. (2016) 1–23.
[23] S.-F. Zhou, C.C. Xue, X.-Q. Yu, C. Li, G. Wang, Clinically important drug interactions potentially involving mechanism-based inhibition of cytochrome P450 3A4 and the role of therapeutic drug monitoring, Ther. Drug Monit. 29 (2007) 687–710, doi:http://dx.doi.org/10.1097/FTD.0b013e31815c16f5.
[24] S. Zhou, Drugs behave as substrates, inhibitors and inducers of human cytochrome P450 3A4, Curr. Drug Metab. 9 (2008) 310–322, doi:http://dx.doi.org/10.2174/138920008784220664.
[25] B. Wang, S.-F. Zhou, Synthetic and natural compounds that interact with human cytochrome P450 1A2 and implications in drug development, Curr. Med. Chem. 16 (2009) 4066–4218 CMC – AbsEpub – 045 [pii].
[26] M. Hiratsuka, In vitro assessment of the allelic variants of cytochrome P450, Drug Metab. Pharmacokinet. 27 (2012) 68–84, doi:http://dx.doi.org/10.2133/dmpk.DMPK-11-RV-090.
[27] P. Fasinu, P.J. Bouic, B. Rosenkranz, Liver-based in vitro technologies for drug biotransformation studies – a review, Curr. Drug Metab. 13 (2012) 215–224, doi:http://dx.doi.org/10.2174/138920012798918426.
[28] J.-F. Wang, K.-C. Chou, Molecular modeling of cytochrome P450 and drug metabolism, Curr. Drug Metab. 11 (2010) 342–346, doi:http://dx.doi.org/10.2174/138920010791514180.
[29] Z.-Y. Zhang, Y.N. Wong, Enzyme kinetics for clinically relevant CYP inhibition, Curr. Drug Metab. 6 (2005) 241–257, doi:http://dx.doi.org/10.2174/1389200054021834.
[30] A. Fugh-Berman, E. Ernst, Herb-drug interactions: review and assessment of report reliability, Br. J. Clin. Pharmacol. 52 (2001) 587–595, doi:http://dx.doi.org/10.1046/j. 0306-5251.2001.01469.x.
[31] C. Colalto, Herbal interactions on absorption of drugs: mechanisms of action and clinical risk assessment, Pharmacol. Res. 62 (2010) 207–227, doi:http://dx.doi.org/10.1016/j.phrs.2010.04.001.
[32] E. Mochiki, M. Yanai, T. Ohno, H. Kuwano, The effect of traditional Japanese medicine (Kampo) on gastrointestinal function, Surg. Today 40 (2010) 1105–1111, doi:http://dx.doi.org/10.1007/s00595-010-4388-8.
[33] T. Eichhorn, T. Efferth, P-glycoprotein and its inhibition in tumors by phytochemicals derived from Chinese herbs, J. Ethnopharmacol. 141 (2012) 557–570, doi:http://dx.doi.org/10.1016/j.jep.2011.08.053.
[34] M.K. DeGorter, C.Q. Xia, J.J. Yang, R.B. Kim, Drug transporters in drug efficacy and toxicity, Annu. Rev. Pharmacol. Toxicol. 52 (2012) 249–273, doi:http://dx.doi.org/10.1146/annurev-pharmtox-010611-134529.
[35] H. Glavinas, P. Krajcsi, J. Cserepes, B. Sarkadi, The role of ABC transporters in drug absorption, distribution, metabolism, excretion and toxicity (ADME-Tox), Drug Discov. Today 13 (2008) 379–393, doi:http://dx.doi.org/10.1016/j.drudis.2007.12.010.
[36] K. Iwanaga, M. Hayashi, Y. Hamahata, M. Miyazaki, M. Shibano, M. Taniguchi, K. Baba, M. Kakemi, Furanocoumarin derivatives in Kampo extract medicines inhibit cytochrome P450 3A4 and P-glycoprotein, Drug Metab. Dispos. 38 (2010) 1286–1294, doi:http://dx.doi.org/10.1124/dmd.110.032847.
[37] C.P. Yu, P.P. Wu, Y.C. Hou, S.P. Lin, S.Y. Tsai, C.T. Chen, P.D.L. Chao, Quercetin and rutin reduced the bioavailability of cyclosporine from Neoral, an immunosuppressant, through activating P-glycoprotein and CYP 3A4, J. Agric. Food Chem. 59 (2011) 4644–4648, doi:http://dx.doi.org/10.1021/jf104786t.
[38] H. Fang, K. Wang, J. Zhang, Transcriptome and proteome analyses of drug interactions with natural products, Curr. Drug Metab. 9 (2008) 1038–1048, doi:http://dx.doi.org/10.2174/138920008786927802.
[39] J.H. Gurwitz, T.S. Field, L.R. Harrold, J. Rothschild, K. Debellis, A.C. Seger, C. Cadoret, L.S. Fish, L. Garber, M. Kelleher, D.W. Bates, Incidence and preventability of adverse drug events among older persons in the ambulatory setting, JAMA 289 (2003) 1107–1116, doi:http://dx.doi.org/10.1001/jama.289.9.1107.
[40] S.J. Grant, Y.S. Bin, H. Kiat, D.H.-T. Chang, The use of complementary and alternative medicine by people with cardiovascular disease: a systematic review, BMC Public Health. 12 (2012) 299, doi:http://dx.doi.org/10.1186/1471-2458-12-299.
[41] P. Namdari, H. Daraee, A. Eatemadi, Recent advances in silicon nanowire biosensors: synthesis methods properties, and applications, Nanoscale Res. Lett. 11 (2016) 406.
[42] K. Seidi, A. Eatemadi, B. Mansoori, R. Jahanban-Esfahlan, D. Farajzadeh, Nanomagnet-based detoxifying machine: an alternative/complementary approach in HIV therapy, J. AIDS Clin. Res. (2014).
[43] T.C. Raghuram, R.D. Sharma, B. Sivakumar, B.K. Sahay, Effect of fenugreek seeds on intravenous glucose disposition in non-insulin dependent diabetic patients, Phyther. Res. 8 (1994) 83–86, doi:http://dx.doi.org/10.1002/ptr.2650080206.
[44] D. Basila, C.-S. Yuan, Effects of dietary supplements on coagulation and platelet function, Thromb. Res. 117 (2005) 49–53, doi:http://dx.doi.org/10.1016/j.thromres.2005.04.017.
[45] M.K. Ang-Lee, J. Moss, C.S. Yuan, Herbal medicines and perioperative care, JAMA 286 (2001) 208–216.

[46] M. Mannel, Drug interactions with St john's wort: mechanisms and clinical implications, Drug Saf. 27 (11) (2004) 773–797. http://dx.doi.org/10.2165/00002018-200427110-00003.
[47] B. Cheng, C.T. Hung, W. Chiu, Herbal medicine and anaesthesia, Hong Kong Med. J. (2002) 123–130, doi:http://dx.doi.org/10.1093/bjaceaccp/mkr023.
[48] E. Ernst, Herb-drug interactions, Perfus 25 (2012) 69, doi:http://dx.doi.org/10.1055/s-0032-1315285.
[49] M. Namdari, A. Eatemadi, B. Negahdari, Natriuretic peptides and their therapeutic potential in heart failure treatment: an updated review, Cell. Mol. Biol. (Noisy-Le-Grand) 62 (2016) 1.
[50] M. Ghafarzadeh, M. Namdari, A. Eatemadi, Stem cell therapies for congenital heart disease, Biomed. Pharmacother. 84 (2016) 1163–1171. http://dx.doi.org/10.1016/j.biopha.2016.10.055.
[51] M. Namdari, A. Eatemadi, Nanofibrous bioengineered heart valve—Application in paediatric medicine, Biomed. Pharmacother. 84 (2016) 1179–1188. http://dx.doi.org/10.1016/j.biopha.2016.10.058.
[52] F. Borrelli, R. Capasso, A.A. Izzo, Garlic (Allium sativum L.): adverse effects and drug interactions in humans, Mol. Nutr. Food Res. 51 (2007) 1386–1397, doi:http://dx.doi.org/10.1002/mnfr.200700072.
[53] Z. Hu, X. Yang, P.C.L. Ho, Y.C. Sui, P.W.S. Heng, E. Chan, W. Duan, L.K. Hwee, S. Zhou, Herb-drug interactions: a literature review, Drugs 65 (2005) 1239–1282, doi:http://dx.doi.org/10.2165/00003495-200565090-00005.
[54] W. Abebe, Herbal medication: potential for adverse interactions with analgesic drugs, J. Clin. Pharm. Ther. 27 (2002) 391–401, doi:http://dx.doi.org/10.1046/j.1365–2710.2002.00444.x.
[55] J.H. Beijnen, J.H.M. Schellens, Drug interactions in oncology, Lancet Oncol. 5 (2004) 489–496, doi:http://dx.doi.org/10.1016/S1470-2045(04)01528-1.
[56] S. Zhou, L.Y. Lim, B. Chowbay, Herbal modulation of P-glycoprotein, Drug Metab. Rev. 36 (2004) 57–104, doi:http://dx.doi.org/10.1081/DMR-120028427.
[57] F. Ruschitzka, P.J. Meier, M. Turina, T.F. Lüscher, G. Noll, Acute heart transplant rejection due to Saint John's wort, Lancet 355 (2000) 548–549, doi:http://dx.doi.org/10.1016/S0140-6736(99)05467-7.
[58] S.C. Cunnane, S. Ganguli, C. Menard, a C. Liede, M.J. Hamadeh, Z.Y. Chen, T.M. Wolever, D.J. Jenkins, High alpha-linolenic acid flaxseed (Linum usitatissimum): some nutritional properties in humans, Br. J. Nutr. 69 (1993) 443–453 (S0007114593000479 [pii]).
[59] M. Jung, M. Park, H.C. Lee, Y.-H. Kang, E.S. Kang, S.K. Kim, Antidiabetic agents from medicinal plants, Curr. Med. Chem. 13 (2006) 1203–1218, doi:http://dx.doi.org/10.2174/092986706776360860.
[60] M.B. Izzat, A.P.C. Yim, M.H. El-Zufari, A taste of chinese medicine!, Ann. Thorac. Surg. 66 (1998) 941–942, doi:http://dx.doi.org/10.1016/S0003-4975(98)00624-9.
[61] A.A. Izzo, E. Ernst, Interaction between herbal medicines and prescribed drugs: a systematic review, Drugs 61 (2001) 2163–2175, doi:http://dx.doi.org/10.2165/00003495-200161150-00002.
[62] B.J. Gurley, A. Swain, M.A. Hubbard, D.K. Williams, G. Barone, F. Hartsfield, Y. Tong, D.J. Carrier, S. Cheboyina, S.K. Battu, Clinical assessment of CYP2D6-mediated herb-drug interactions in humans: effects of milk thistle, black cohosh, goldenseal, kava kava, St. John's wort, and Echinacea, Mol. Nutr. Food Res. 52 (2008) 755–763, doi:http://dx.doi.org/10.1002/mnfr.200600300.
[63] S. Vahabi, T. Shoja, S275 effect of postoperative topical administration of magnesium sulfate on pain relief in pediatric adenotonsillectomy, Eur. J. Pain 5 (Suppl) (2011) 243.
[64] S. Vahabi, A.H. Kazemi, Effects of Clonidine as a premedication on plasma renin activity, serum and urine electrolytes and body fluids in general anaesthesia, Middle East J. Anaesthesiol. 21 (2011) 71–76.
[65] K.O. Coskun, A.F. Popov, S.T. Coskun, U. Blanz, K. Bockhorst, M. El Arousy, H.H. Weitkemper, J. Hinz, R. Körfer, L. Spadavecchia, et al., Current issue minerva pediatrica, Minerva Pediatr. 62 (2010) 233–237.
[66] S. Vahabi, M. Heidari, A.H. Kazemi, M. Birjandi, E. Iran-Pour, Assessment of clonidine effect as premedicative drug on kidney function, J. Pak. Med. Assoc. 60 (2010) 570.
[67] C. Ioannides, Pharmacokinetic interactions between herbal remedies and medicinal drugs, Xenobiotica 32 (2002) 451–478, doi:http://dx.doi.org/10.1080/004982502101.
[68] S. Akbari, S. Vahabi, M. Khaksarian, et al., A study of β-human chorionic gonadotropin level in preeclamptic and normotensive pregnant women, Res. J. Biol. Sci. 4 (2009) 468–471.
[69] S. Vahabi, M. Heidari, A.H. Kazemi, M. Birjandi, E. Iran-Pour, Online submission, Assessment. (2010).
[70] S. Akbari, S. Vahabi, A.H. Kazemi, Knowledge of women working in Hospitals of Lorestan Medical Sciences University about smoking effects on fertility, J. Reprod. Infertil. 3 (2002).
[71] M.A. Kuhn, Herbal remedies: drug-herb interactions, Crit. Care Nurse 22 (2002) 22–28 (30, 32; quiz 34).
[72] S. Vahabi, J. Akhlaghi, T606 comparison of local anesthetic effects of tramadol and lidocaine used subcutaneously in minor surgeries with local anesthesia, Eur. J. Pain 5 (Suppl) (2011) 82.
[73] S. Vahabi, M. Heidari, M. Ahmadinejad, J. Akhlaghi, M. Birjandi, Comparison of local anesthetic effects of tramadol and lidocaine used subcutaneously in minor surgeries with local anesthesia, Middle East J. Anesthesiol. 21 (2011) 9–14.
[74] S. Vahabi, T. Shoja, S. Chaibakhsh, M. Khak, N. Saljoughi, Effect of postoperative topical administration of magnesium sulfate on pain relief in paediatric adenotonsillectomy: a randomised controlled study, HK J. Paediatr. 17 (2012) 109–114.
[75] S. Vahabi, S. Nadri, F. Izadi, The effects of gabapentin on severity of post spinal anesthesia headache, Pak. J. Pharm. Sci. 27 (2014) 1203–1207.
[76] S. Vahabi, A. Abaszadeh, F. Yari, N. Yousefi, Postoperative pain, nausea and vomiting among pre-and postmenopausal women undergoing cystocele and rectocele repair surgery, Korean J. Anesthesiol. 68 (2015) 581–585.
[77] S. Vahabi, M.R. Moradkhani, B. Farzan, F. Zareei, Z.H. Akhlaghi, Comparison between local anesthetic effects of tramadol and lidocaine used subcutaneously in minor surgeries, Middle East J. Anesthesiol. 21 (2011) (2008) 9–14.
[78] S. Vahabi, M. Ghafarzadeh, N. Lorzadeh, M.R. Moradkhani, B. Farzan, P. Geranghadr, The effect of menstrual cycle phase on the meperidine and metoclopramide consumption rate for controlling postoperative pain, nausea and vomiting, YAFT-E 9 (2007) 15–22.
[79] M. Mohamadi, B. Namdari, A. Rasoulian, Pre-exposure to normobaric hyperoxia has no effect on myocardial injury biomarkers after percutaneous transluminal coronary angioplasty, Cardiology (2015) 281.
[80] B.B. Ahmadi, M. Namdari, H. Mobarakeh, Erectile dysfunction as a predictor of early stage of Coronary artery disease, J. Tehran Univ. Hear. Cent. 9 (2014) 70.
[81] A.R. Khosravi, A. Raoufi, M. Pourmoghadas, N. Paydari, M. Gharipour, M. Namdari, A. Khaledifar, M. Khosravi, A. Bahonar, M. Ostovan, et al., Late clinical events of drug eluting versus bare metal stenting; OPCES'ancillary study, Pak. J. Med. Sci. 29 (2013) 258–263.
[82] T. Tolabi, Z. Vanaki, R. Memarian, M. Namdari, Quality of nursing documentations in CCU by hospital information system (HIS), J. Crit. Care Nurs. 5 (2012) 53–62.
[83] M. Namdari, M. Ghafarzadeh, M.A. Nikoo, Efficacy of intramuscular methyl prednisolone in preventing restenosis after coronary artery stenting with bare-metal stainless steel stent: a double-blind, randomised, controlled clinical trial, Cardiovasc. J. Afr. 22 (2011) 67.
[84] S. Nadri, H. Teimori, F. Sabzi, V. Hassani, H. Mahmoudvand, Base deficit in immediate postoperative period of open heart surgery and outcome of patients, Acta Med. Iran. 1 (2016) 227–232.
[85] S. Nadri, H. Mahmoudvand, M. Ahmadinejad, M. Farrokhfar, Z. Obeidavi, Effect of oral Gabapentinon post-operative pain, morphine consumption, nausea and vomiting in patients with urgent appendectomy: a randomized double-blind placebo-controlled trial, Int. J. Adv. Biol. Biomed. Res. 4 (2016) 202–207.
[86] M. Ahmadinejad, A. Aliepour, K. Anbari, M. Kaviani, H. Ganjizadeh, S. Nadri, N. Foroutani, M. Meysami, V. Almasi, Fine-needle aspiration touch imprint, and crush preparation cytology for diagnosing thyroid malignancies in thyroid nodules, Indian J. Surg. 77 (2015) 480–483.
[87] P. Singh, A.R. Devi, H.R. Sharma, H.M. Sharma, International journal of current research and academic review, Int. J. Curr. Res. Acad. Rev. 3 (2015) 102–114.
[88] G. Goudarzi, F. Tahmasbi, K. Anbari, M. Ghafarzadeh, Distribution of genes encoding resistance to macrolides among staphylococci isolated from the nasal cavity of hospital employees in khorramabad, iran, Iran, Red Crescent Med. J. 18 (2016).
[89] G. Goudarzi, M. Ghafarzadeh, P. Shakib, K. Anbari, Culture and real-time PCR based maternal screening and antibiotic susceptibility for group B streptococcus: an Iranian experience, Glob. J. Health Sci. 7 (2015) 233.
[90] F. Janani, S. Kohan, F. Taleghani, M. Ghafarzadeh, Challenges to implementing physiologic birth program (pbp): a qualitative study of midwives opinion in Iran, Acta Med. Mediterr. 31 (2015) 1373–1380.
[91] P. Shakib, S. Ghafourian, G. Goudarzi, M. Ghafarzadeh, H. Noruzian, Prevalence of listeria monocytogenes in pregnant women in khoram abad, Iran, J. Pure Appl. Microbiol. 7 (2013) 475–477.