Meng, J Clinic Experiment Pathol 2013, S6
DOI: 10.4172/2161-0681.S6-e001

Clinical & Experimental Pathology

Editorial Open Access

Mass Spectrometry Applications in Clinical Diagnostics

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Mass Spectrometry (MS) is an analytical technique used for determining the elemental composition of samples, quantifying the mass of particles and molecules, and elucidating the chemical structure of molecules. Various types of MS with high specificity, such as Liquid Chromatography (LC-MS), Gas Chromatography (GC-MS), and Matrix-Assisted Laser Desorption/Ionization/Time-Of-Flight (MALDI-TOF MS), are being increasingly valued and utilized as tools in clinical laboratories [1]. These MS techniques overcome the limitations of immunoassays and offer many advantages over earlier approaches.

Clinical laboratories use the MS technology for disease screening, diagnosis of disease and metabolic disorders, monitoring of drug therapy, identifying drug toxicity and poisoning, and discovering new biomarkers. Therapeutic monitoring of immunosuppressant drugs using MS is well established. Limitations of immunoassays such as nonspecific binding of the antibody and cross-reactivity with metabolites that often result in overestimation have made the more accurate LC/MS/MS methodologies the assays of choice [2]. LC/MS/MS has become the standard for assay of steroid hormones for diagnosis of endocrine disorders. Vitamin D analysis by LC/MS/MS is widely used in the clinical laboratory today. Whereas immunoassays are unable to distinguish between 25-hydroxy vitamins D2 and D3, the LC/MS methodologies are able to measure these levels separately so the contribution of each to the total can be determined.

The capability of measuring thyroid hormones by tandem MS was developed recently and this has overcome the issues associated with immunoassays [3]. Triple quadrupole MS/MS is the preferred methodology for toxicology screening and for toxic drug quantitation [4]. In newborn and prenatal screening programs, electrospray tandem MS has made possible identification of inborn errors in metabolism or genetic defects so that preventive and medical intervention can be implemented promptly to relieve or treat the disease [5]. One of the new ways that MS technology is being used is in proteomics, for quantitative identification of small amounts of proteins or molecules in blood to serve as biomarkers. This has opened up the discovery of new tumor markers as a potentially promising area of application of MS [6]. The intensive research into metabolomics, the assessment of endogenous metabolites as new disease biomarkers, is another promising applications of MS, which has been demonstrated to be very well suited to discovery and clinical application of metabolite profiles [7]. Another area of increasing interest is the use of automated MALDI-TOF MS for rapid identification of microorganisms in clinical microbiology laboratories [8].

Yet, there are still challenges in the clinical application of this technology, including sample preparation, online extraction, throughput, automation, laboratory information system interfacing, inter-instruments standardization and harmonization, and FDA regulation. With emerging technologies in MS, we expect to see more robust and reliable MS applications with a broad menu of tests that will become routine diagnostic tools in clinical laboratories in the near future.

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Received March 21, 2013; **Accepted** March 23, 2013; **Published** March 25, 2013

Citation: Meng QH (2013) Mass Spectrometry Applications in Clinical Diagnostics. J Clinic Experiment Pathol S6: e001. doi:10.4172/2161-0681.S6-e001