

original article

Detection of bioterrorism agents and related public health threats utilising matrix-assisted laser desorption/ionisation mass spectrometry (MALDI-MS)

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ABSTRACT

Biodetection is an emerging field of mass spectrometry. Increasing amounts of time and energy have been devoted by researchers to create portable mass spectrometers capable of rapid detection of biological agents. As the U.S. and other countries remain at a heightened alert of bioterrorism, few rapid response mechanisms are in place to warn of biological attacks. Currently, biological outbreaks are still primarily identified in medical offices or emergency rooms rather than in the field, where early detection would be most beneficial. In addition, methods to rapidly identify a biological attack are still limited.

The purpose of this paper is to identify the capabilities of new mass spectrometric technology as it pertains to biodetection and contrast these capabilities with the needs of the public health system. Public health needs include the availability of rapid and sensitive techniques that are capable of identifying multiple bioagents simultaneously. Additionally, these techniques should be automated and reproducible for highest quality results. Addressing these technologic and scientific needs in a public health framework is a first and important step in bridging the gap between research and practical applications.

Matrix-assisted laser desorption/ionisation mass spectrometry (MALDI-MS) can be utilised in several fashions as a means of identifying and assessing biological attacks and outbreaks. It is a rapid and versatile technique, which uses minimal sample quantities per analysis. MALDI-MS can be used to detect multiple bacterial species using a single analysis. The current technology lacks standardised sample preparation methods and comprehensive databases needed for automated identification. This paper serves to define the evolving technology associated with MALDI-MS for biodetection, and to address the strengths and weaknesses of mass spectrometry for confronting public health needs nationally in the US and globally.

Keywords: Anthrax, environmental monitoring, pathogen identification, portable mass spectrometer, MALDI-TOF

INTRODUCTION

The dissemination of anthrax spores through the mail in 2001 demonstrated that the threat of bioterrorism is real in the United States.¹ Yet, the public health field relies to a large extent on outdated technology to identify such events. Often, medical surveillance is utilised to identify biological outbreaks, which results in delayed diagnosis that can lead to increased morbidity and mortality.² Other methods used to identify the causative agents behind biological outbreaks are agent-specific and relatively slow.³ Methods must be developed that are rapid, sensitive and that have the capability of identifying a broad range of agents obtained through a variety of methods.

Matrix-assisted laser desorption/ionisation mass spectrometry (MALDI-MS) has been used for several decades to detect biological compounds including proteins.⁴ In recent years, the analytical capabilities of the technique have been expanded to include the study of whole organisms. The shift toward bioanalysis has created an opportunity to study a wide range of pathogenic and beneficial organisms as well as their byproducts.^{5,7} Whereas analytical techniques have evolved in the past several years, the gap between technological capabilities and existing public health needs remains ill defined, which hinders progress toward integration of these techniques to the benefit of public health in the US and worldwide.

Public Health Needs

While successful advancements have been made in the field of mass spectrometry, there continues to be a gap in continuity between the technology and its potential applications in the public health sector. This disconnect is fostered by poor communication of the specific needs in the public health field to the research community. Too often, applications are used to address research questions, and a broader view of the potential of the technology is not recognised. Identification of public health concerns will serve to connect the technological potential with the range of applications that are possible but remain to be implemented.

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