Radiological Emergency Response: The National Biological Dosimetry Response Plan

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Abstract – *This presentation will discuss new developments in emergency biological dosimetry and the CRTI (CBRN Research and Technology Initiative) National Biological Dosimetry Response Plan (NBDRP). Biological dosimetry is a technique used to estimate the biological consequences of a radiation exposure and is largely based on chromosome aberration detection. The NBDRP will establish a national network of laboratories to respond to a nuclear event for the purposes of rapid radiation dose estimation for crisis management and for long-term health risk assessment. In the event of a large-scale radiation accident or deliberate act of terrorism this will help guide the actions of emergency officials, emergency responders and health care personnel by providing timely biological dose estimates. The presentation will outline the research initiatives to develop modern techniques used for biological dosimetry. The overall purpose of this presentation is to provide the audience with a brief introduction to radiobiology, radiation-induced DNA damage, the health risks associated with radiation exposure, and the latest cytogenetic techniques used to estimate the risk.*

I. INTRODUCTION

In the case of a large scale nuclear/radiological event it is imperative to quickly identify exposed individuals for the purpose of medical intervention and to identify first responders who must be restricted from further exposure. In the absence of a personal physical dosimeter, individual exposure to radiation can be estimated using damage to the chromosomes of white blood cells. This method of dose estimation is called biological dosimetry. The Chemical, Biological, Radiological and Nuclear (CBRN) Research and Technology Initiative (CRTI) is a program to strengthen Canada's preparedness for, prevention of, and response to a CBRN terrorist attack through new investments in science, research and technology capacity. The CRTI mandate is to create clusters of federal and other government labs, create a fund to build science and technology capability in critical areas, accelerate technology for the First Response community and other operational authorities, and fund areas where national science and technology capacity is deficient (obsolete equipment/facilities, inadequate scientific teams). Projects accepted for funding by the CRTI include 'Biological Dosimetry and Markers of Nuclear and Radiological Exposures' whose goal is to develop a National Biological Dosimetry Response Plan (NBDRP) using the classic dicentric chromosome assay (1). The NBDRP will consist of several laboratories across Canada that will be standardized to perform this assay. The project will also develop faster, more automated methods (e.g. the dicentric chromosome assay (DCA) performed by flow cytometry, premature chromosome condensation (2), spectral karyotyping (3) and electron spin resonance in human tooth enamel (4)) to detect radiation damage for screening of large numbers of people in a short period of time. Combining several assays will provide a more accurate dose estimate as well as evaluate future health risks for the exposed individuals.

II. BIOLOGICAL DOSIMETRY

The Radiobiology Unit of Health Canada has performed biological dose estimates for human exposure to radiation using the DCA for over 30 years. Standard dose-response curves have been generated from which dose estimates can be prepared. The Radiobiology Unit is the only standardized laboratory in Canada recognized by the Canadian Nuclear Safety Commission (CNSC) to perform these estimates. However, the Health Canada laboratory would not be able to handle a large number of samples. Furthermore, the current sample turnover time is too long to be used for medical triage purposes.

To enhance present biological dosimetry services in Canada, a collaborative agreement between four existing laboratories with complementary capabilities is being implemented. Health Canada, Defense Research Development Canada, Atomic Energy of Canada Limited, and AECL have a Lab Cluster Management and Operations agreement to expand surge capacity of the existing biological dosimetry service. This collaborative dosimetry service network will be better prepared to address national and/or regional needs in a nuclear/radiological event as it comprises most of the existing radiobiological dosimetry expertise in Canada.

Even with this collaboration, large scale events would quickly overwhelm the available resources. Canada

needs fast, robust, triage-quality biological monitoring techniques that could be implemented in many sites with little setup time. We are currently working to develop faster, automated methods to screen large numbers of people in a shorter period of time. To this end, several new and promising techniques for rapid detection of radiation damage are being developed: 1) a rapid flow cytometry based assay to identify dicentric chromosomes, 2) premature chromosome condensation (PCC)-fluorescence in situ hybridization (FISH), 3) spectral karyotyping (SKY) techniques to monitor future health risks, 4) electron spin resonance (ESR) in tooth enamel as an early indicator of dose and, 5) plasma markers of radiation exposure using high throughput assays. All of these methods will be validated against the DCA.

To better predict individual health risks, we propose to identify and validate novel biomarkers of radiation exposure. While at present there are a handful of clinical radiotherapy biomarkers (e.g. cytokines) available, it is our intention to extend the list to permit improved specificity of the markers chosen for evaluation of radiation insult at the individual level. This work will begin with analysis of gene expression responses to radiation, and culminate in a list of potential plasma protein and cytokine targets which can be assessed for sensitivity and specificity to radiation response.

This collaborative project was initially funded for four years (2003-2007). The work was divided into two main areas: A) National Biological Dosimetry Response Plan Development - scaling up and expanding upon existing capabilities ending with large scale testing involving labs across Canada and potentially around the world; B) Biological Dosimetry Research Program - development and validation of of new methods for biological dosimetry and detection of biological markers for exposures based on individual responsiveness.

This collaboration will enable improved crisis response by providing rapid biological (ionizing-radiation) dose estimates for potentially exposed individuals for use in medical triage and diagnosis of casualties. Rapid assessment of potentially exposed individuals will not only reduce short and long term health effects, but is also essential to mitigate public reaction to a radiological/nuclear event thus reducing psycho-social stress. Psycho-social stress is believed to be one of the most important health outcomes following a nuclear/radiological emergency. Public confidence can be improved by reducing the uncertainty about the extent of individual exposures and through the knowledge that such information can be ascertained. The NBDRP would also assist in consequence management for concerned First Responders whose exposure may prove to be minimal or non-existent. Some of the assays being developed within the NBDRP may also be applicable for biological and/or chemical events.

By addressing these CRTI priority needs, the NBDRP will be an essential component of an integrated national response plan in the event of a radiological/nuclear incident.

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