Human Biomonitoring: An Overview

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Overview of Biomonitoring:
Biomonitoring is the measurement of specific chemicals in human tissues – a picture of the amount absorbed & retained in the body from a variety of sources.
History dates back to the late 1800s – physicians treating patients with rheumatism measured salicyluric acid in urine. The occupational implementation of biomonitoring began in the 1890s, when workers had blood / urine lead levels measured in an attempt to quantify and limit their exposure to avoid toxicity.

CDC has assumed a leadership role to broaden the scope of use of biomonitoring data. 1st National Report on Human Exposure to Environmental Chemicals published in 2001 looked at only 27 chemicals, 2nd Report issued in 2003 – 116 chemicals, latest version – more than 145 chemicals will be evaluated.

Biologic Media used in testing –
Blood and serum most widely utilized, regularly replenished so can track substances over time, common pathway for chemicals and their metabolites, blood lipids useful for fat soluble substances, downside that some people are resistant to having blood drawn, young subjects are problematic in obtaining large sample volumes, short half life of most substances in blood limits assessing past exposure.

Urine, widely used, popular because test is noninvasive. Disadvantages – few parent compounds are excreted unchanged, metals, metabolites often tracked, sometimes not as good of a measurement – chemicals with slow metabolism – detailed analysis would involve 24 hour samples, patient compliance with longer term collection of urine samples can be problematic.

Fat – useful for fat-soluble substances, but testing method is invasive and unpopular, while laboratory capabilities regarding blood lipids have advanced markedly, therefore fat biopsies used less often.

Hair – useful for exposure to certain metals. Disadvantages – location of sampling on individual hair can significantly impact the values that are measured, shampoos/conditioners can leach out substances or add substances confounding the analysis. Not many standards exist for chemicals in hair – mostly it has been used as screening tool.

Breast milk - Fat soluble chemicals concentrate in breast milk, it is easy to collect, developing babies/infants are the end of the exposure chain – but not many reports in literature that babies are in fact at increased risk for exposure compared to adults.

Saliva / sputum – saliva easy to collect, used to look at endogenous hormones, promise for future testing (in development with some biotechnology companies), sputum – samples are varied in quality (ability to produce a cough etc), there are some invasive

procedures to improve sample collection. Some researchers feel it will be more important in future.

Semen – has been used for quality of sperm bank samples (infectious point of view), collection of samples complicated, again future uses are foreseen.

Biomarkers – definition – characteristic that is objectively measured and evaluated as an indication of normal biologic and pathologic processes.
Biomarkers of exposure – measurement of exogenous substances in body
Biomarkers of effect – look in body for what has been altered or changed
Biomarkers of susceptibility – seeks to determine, on a genetic basis usually, to see what makes them more susceptible to disease

What makes a good biomarker? Sensitivity, Specific to disease process or condition, biologically relevant, practical/economically feasible (state funding)

Costs to measure chemicals – lead metals $10-50 per test; dioxins etc $100-1000s; when evaluating populations, costs of testing can very quickly become significant.

CDC leadership – $10 million over 2 years distributed to 33 states for planning of biomonitoring programs ($300,000 per state per year max); implementation side has had $3 million in first half of fiscal year 2004 distributed to 8 states, so still very early on implementation curve.

Sources of chemicals
Man made (anthropogenic) - Workplace, consumer products, food processing and manufacturing, air water soil from leaching form manufacturing
Chemicals measured that result from normal biologic processes, metabolism of absorbed substances
Chemicals naturally occurring in food – e.g. phytoestrogens
Chemicals from the environment – forest fires

CDC reasons for biomonitoring
1 – to define where are we seeing chemicals being absorbed, who are they and how high are the levels
2 – for chemicals known to be hazardous (e.g. lead) it is valuable to know who has high levels, who to target for effectiveness programs
3 – to establish reference ranges for physicians and other professionals
4 – to assess effectiveness of programs to diminish levels. (removal of lead from gasoline)
5 - Desire to figure out if exposure levels are higher in subsets of our society: elderly, ethnic, women of childbearing age, etc.
6 - Track trends of exposure levels over time
7 - Set priorities for what we should devote research monies to

Considerations

Measuring body burdens is a wonderful measure of what people have been exposed to and absorbed – don't have to rely on assumptions of models of exposure.
Actual measurements are much more valuable than extrapolations from environment.
Useful for individually specific information (useful in litigation).
Need to compare levels for normal (background levels) compared to high level exposure
Useful if one obtains environmental data at the same time as human individual data.
Then can correlate the two measurements – can develop more accurate extrapolations.
Many people have multiple sources of exposure – often difficult to ascertain which exposure was responsible for generating the level in body
One measurement can only be representative of one point in time.
Detection of past exposure does not necessarily lead to increased risk

Limitations
Presence of biomarker does not reveal the source or route of exposure for any substance.
Detection advances in analytical chemistry have accelerated more rapidly than our ability to perform quality clinical trials to determine what levels mean for risk of disease. – reasons for not being able to complete these studies include cost, time, etc.
Metabolism curve for various substances measured – some are so rapid that it is difficult to obtain accurate and consistent biomonitoring data, some are there so long that it is difficult to separate from other exposure situations.

Proper use of biomonitoring data
Not used to its fullest – tightrope between reporting a possible hazard and scaring the public. Example of California and persistent organic pollutants and pregnant/nursing women - Table on POPs in report – if you didn't take the time to get the full context of information provided, a person would be at high risk to conclude that breast milk is harmful to babies and that the risks do not outweigh the benefits. As a result of the improper reporting of biomonitoring data, many respected health bodies (EPA, WHO, FDA, etc) felt compelled to report that breast milk remains the best nutritional source for infants and should continue to be the number one choice for mothers to feed their babies. It was irresponsible to report that breast milk was dangerous without delivering the information in proper context, generating unneeded public fear and inappropriately diverting the attention of our public health leaders that could have been focused on addressing other pressing societal concerns.

Proponents of scare tactics fall back on the precautionary principle – better to do nothing than to do something that has the chance to cause harm.
Criticisms of the precautionary principle – every new technology has the possibility for risk – but it may have positive benefits.
Need to look at overall risk and benefit (malaria / pesticides).
Would like people to consider that all substances at some concentration can be poisonous – depends on the dose – chemicals can also be useful or beneficial – need to look at risk assessments to determine allowable levels in society. For many substances, can do animal testing to look for response at a certain dose, then fit a dose-response curve – but often there is a problem in looking at chemicals only present in the environment at very low concentrations. Animal study extrapolations of risk may not be relevant as human

exposure experienced in the environment may be more than 100 times lower than where you see undesirable effects in animals during testing.

State of CA (Senate bill 600) – to develop a biomonitoring program to measure contaminants in humans - established a 16 person (8 scientists, 8 representing communities of concern) panel that is not compensated, creates educational materials and training for scientists and health professionals. Program, however, does not explain how it intends to relate biomonitoring data to health problems and has the risk of again generating large quantities of data that we don't know how to respond to.

Conclusions
Biomonitoring is a powerful tool with many potentially positive benefits
Results of studies should be carefully communicated to public
Legislation and policy needs to assess total societal impact of its decisions
Costs of biomonitoring are a fraction of cost that needs to be assumed by society to determine if the levels measured are in fact associated with a measurable health hazard
Science should rule the day, not emotion.