

# STRAIGHT TOX

## Arsenic *An old nemesis returns*

By Dwain Fuller, D-FTCB, TC-NRCC

I can count on one hand the number of arsenic cases I have investigated in my career and have a few fingers left over. Reaching way back to my days as a fledgling toxicologist, as I remember it, rarely was it necessary to even quantitate the arsenic level in the deceased; the circumstances of the death were so straightforward. The deceased typically had a container of arsenic-containing pesticide, a glass with pesticide residue, and often a note. Typically, one just had to perform the Reinsch test on the urine and/or liver to demonstrate the presence of arsenic. Done!

It seems a bit ironic that the poison that is almost universally named when the general public thinks about homicidal poisoning is rarely encountered anymore by the forensic toxicologist. Perhaps the chief reason for this is the effective removal of arsenic-based pesticides from the market by agencies charged with protecting of the environment, and rightly so.

As a kid, my family had a small herd of cattle. I remember my father using lead arsenate, also known as arsenate of lead, or as he called it, “arsenic lead”, for fly control. He would walk among the cattle throwing handfuls of lead arsenate powder onto their backs. Sometime in the mid 60’s lead arsenate was replaced by another, undoubtedly safer, product, but up until that time he used it just like all the other cattlemen did. These days arsenic is gone from pesticides and pressure-treated wood as well. However it has recently reappeared in the news due to the legacy of our past indiscriminate use of arsenic-based pesticides.

I’m sure that by now you are aware of the furor over arsenic in apple and grape juice. The first I heard of it was when I came home from work one day and my wife was watching Dr. Oz as he decried this fact. Not being a big fan of media-darling doctors, my first reaction was, “Whoa, wait a minute...are we talking organic or inorganic arsenic?” It actually sort of made me angry. I was thinking, “You can’t just yell arsenic in a



crowded theater!”... wait... that is something else... I mean, “You can’t just start talking about arsenic in apple juice to a populous that has no concept of the relative toxicities of the different forms of arsenic.” That’s better.



So what of these different forms of arsenic? I’m sure that most of you are aware that arsenic in environmental exposure occurs in two forms, organic and inorganic. Organic arsenic being arsenic bound to carbon-containing groups, like a methyl group, and inorganic being arsenic or arsenic compounds not so bound. In the death investigations of arsenic, described above, there was little reason to try to “speciate” or determine the type of arsenic exposure; the origin of the arsenic was quite evident, and of course, the person is dead, which is always an important and obvious clue to consider in assessing the potential lethality of an ingestion. However in environmental exposures in still-living individuals the arsenic species is a very important consideration.

According to the literature the relative toxicity of arsenic species as expressed by oral administration  $LD_{50}$  in mice is as follows: 3 mg/kg for arsine [ $AsH_3$ ]; 14 mg/kg for arsenite [As(III)]; 20 mg/kg for arsenate [As(V)]; 700-1800 mg/kg for monomethylarsonic acid (MMA); 700-2600 mg/kg for dimethylarsenic acid (DMA); and > 10,000 mg/kg for arsenobetaine and arsenocholine. Thus, it can be plainly seen that the inorganic species of arsenic are orders of magnitude more toxic than are the methylated forms, MMA and DMA, and arsenobetaine and arsenocholine are considered essentially non-toxic.

Initially the Food and Drug Administration (FDA) claimed that the most of the arsenic in juices and other foods was of the organic type and was “essentially harmless”, and I felt vindicated in my anger. However, an investigation by Consumer Reports magazine appears to show otherwise. Consumer Reports commissioned the testing of 88 samples of apple and grape juice, purchased in August and September of 2011 in Connecticut, New Jersey, and New York. Roughly 10% of the juice samples tested exceeded the 10 ppb federal drinking water standard and most of that arsenic was inorganic. Total arsenic concentrations in apple juice ranged from 1.1 to 13.9 ppb and in grape juice from 5.9 to 24.7 ppb. So why do I quote the federal drinking water standard? Because, believe it or not, there is no federal standard for juice.

Why apples and where did it come from? That brings us back to the widespread use of arsenic-based pesticides in the past. The use of lead arsenate was terminated in the early 1950’s in Massachusetts, in New York and other states in the mid 1960’s, but not until 1984 in Washington State, a large apple growing region. It wasn’t until 1988 that the Environmental Protection Agency (EPA) banned lead arsenate as a pesticide. Although lead arsenate-based pesticides haven’t theoretically been used since 1988, over 20 years

ago, the arsenic is now likely being introduced into apples from the tainted soil of the orchards.

Additionally, it should be noted that although inorganic arsenic-containing compounds are largely off the market, organic arsenic containing feed additives are still being fed to poultry and swine to increase growth rate by the controlling parasitic diseases. While these compounds apparently pass through the animal without contaminating the meat, often the arsenic-bearing wastes of these animals are used to fertilize nearby croplands. The concern is the potential for organic arsenic to be converted to inorganic arsenic in the environment.

Should we be concerned about drinking apple and grape juice? Obviously, I can't decide for anyone but myself, but let's examine the risks. To me, the fact that apple or grape juice may have somewhat over 10 ppb of arsenic, the federal standard for drinking water, is not a huge concern, because I only have an occasional glass of apple or grape juice compared to the amount of water I consume. However, a number of children drink significant quantities of apple and grape juice in comparison to their water intake, not to mention their lower body weight. Furthermore, children who are actively growing and developing, are likely to be at greater risk for arsenic toxicity.



Studies show that childhood exposure to arsenic in drinking water is associated with reduced intellectual function, poorer scores in language, visuospatial skills, executive function, and increased mortality from lung cancer and bronchiectasis as young adults, as well as an increased prevalence of Type 2 diabetes in adults.

So what will come of this? I suspect we will be seeing federal standards for arsenic in fruit juices very soon. And that is good. Obviously, none of us want to be ingesting large quantities of arsenic, especially inorganic arsenic, much less allowing our children to do so.

Perhaps this is another reason to drink Scotch instead of wine.

## References and Further Reading

Arsenic in Your Juice: How Much is Too Much?, Consumer Reports Magazine, January 2012, Accessed online 1/18/12, <http://www.consumerreports.org/cro/2012/01/arsenic-in-your-juice/index.htm>

The Global Problem of Lead Arsenate Pesticide, Lead Action News, Vol. 10, No. 3, June 2010, Accessed online 1/28/12, <http://www.lead.org.au/lanv10n3/lanv10n3-7.html>

Momplaisir GM, Rosal CG, Heithmar EM. Arsenic Speciation Methods for Studying the Environmental Fate of Organoarsenic Animal-Feed Additives. U.S. EPA. NERL-Las Vegas, 2001. Available at [www.epa.gov/esd/chemistry/labmonitor/arsenic.pdf](http://www.epa.gov/esd/chemistry/labmonitor/arsenic.pdf)

Wasserman GA, Liu X, Parvez F, Ahsan H, et al. Water Arsenic Exposure and Children's Intellectual Function in Araihasar, Bangladesh, Environmental Health Perspectives, Vol. 112, No. 13, Sept. 2004

O'Bryant, SE, Edwards M, Menon CV, Gong G, Barber R. Long-Term Low-Level Arsenic Exposure Is Associated with Poorer Neuropsychological Functioning: A Project FRONTIER Study. Int. J. Environ. Res. Public Health, Vol. 8, 2011

Navas-Acien A, Silbergeld EK, Pastor-Barriuso R, Guallar E. Arsenic Exposure and Prevalence of Type 2 Diabetes in US Adults. JAMA, Vol. 300, No. 7, August 20, 2008

Smith AH, Marshall G, Yuan Y, et al. Increased Mortality from Lung Cancer and Bronchiectasis in Young Adults after Exposure to Arsenic in Utero and in Early Childhood. Environmental Health Perspectives, Vol. 114, No. 8, August 2006

Meharg AA, Sun G, Williams PN, et al. Inorganic Arsenic Levels in Baby Rice are of Concern. Environmental Pollution, Vol. 152, 2008



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