
Cleansing of the Human Body

A Daily Essential Process

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Toxic exposure is a fact of life and a health risk that is faced on a daily basis by patients regardless of how carefully they attempt to limit environmental sources of exposure. It is important to also look within the body to understand how to control the toxic load that arises from the body's inability to process and eliminate toxic substances. This is also relevant to the body's creation of toxins resulting from metabolic processes.

This article reviews some common toxic substances. It offers an overview of detoxification processes and how they can be supported clinically to maximize the body's healthy functioning and confer optimal protection.

What, exactly, qualifies as a "toxin?" A toxin is a substance that has a detrimental effect on the functioning or structure of a living cell, with deleterious effects ranging from minimal to fatal to a host organism. Although there are tens of thousands of toxic substances that affect the human body adversely, they can be categorized into the following five general groups: (1) toxic chemicals; (2) endotoxins and exotoxins; (3) heavy metals; (4) dietary breakdown products; and (5) products of altered metabolic homeostasis.

Environmental Chemicals

Environmental chemicals include, but are not limited to, prescription, over-the-counter, and illegal drugs; cigarette smoke; solvents; alcohol; pesticides; herbicides; and food additives. One needs only visit a suburban neighborhood or home to

observe the extent to which potentially toxic chemicals permeate people's lives. One finds lush green and weed-free lawns well-fertilized, pest-free gardens, which are the result of using herbicides and pesticides. There are also sparkling homes with the "fresh scent of clean," thanks to the advent of cleaners, grout and tile mildew retardants. And there are shiny vinyl floors still off-gassing in the summer sun and pervasive deodorizing chemicals. These are but a small sample of the total and daily exposure that people in the Western world endure from childhood throughout life. Time spent away from home means additional exposures in classrooms, offices, grocery stores, and cars.

Microbial Toxins

Toxic amines, carcinogenic substances, and other health-damaging chemicals are produced by microbes within the human body and by pathogens in the human environment. Microbe-derived toxic loads can arise from consumption of contaminated foods or from disturbances in microflora in the gastrointestinal (GI) tract and elsewhere in the body. Besides botulism and salmonella, more subtle toxic loads can result from GI bacterial imbalances. Such disturbances may cause direct toxin production but equally significant are disruptions of metabolic processes that normally occur with the proper functioning and maintenance of "friendly" flora. Antibiotic use and imbalances caused by fecal-oral contamination may increase the potential toxic burden.

Dietary Breakdown Products

Toxic breakdown products of protein metabolism include urea and ammonia. The old saying "input equals output" can

be mirrored with the saying that "output equals input." The breakdown processes that fuel the body by breaking down food yield toxic metabolic byproducts. Thus, it is important for patients to maintain a balanced diet and avoid excess that can strain biochemical pathways and provide extra demands on already challenged detoxification processes.

Heavy Metals

Aluminum, arsenic, cadmium, lead, mercury, nickel, and other heavy metals abound in the human environment, where they are found in pesticides, cooking utensils, paint, tin cans, solder, cigarettes, dental fillings, contaminated fish, some cosmetics and antacids, and industrial products and byproducts. Battery makers, gas station attendants, agricultural workers, printers, jewelers, and dentists, for example, face increased heavy metal exposure risks.

Products of Altered Metabolic Homeostasis

Physiologic, psychologic, and pathologic stressors may interfere with metabolic homeostasis and cause excess toxic burdens. Numerous disease processes and stressors can result in dysfunction of normally functioning, sufficient pathways. Oxidative, physiologic, and psychologic stressors can contribute to such impairments. Such stressors can result in direct increases in free-radical production as a result of altered biochemical pathways shunted to cope with such stressors. As a consequence of these altered biochemical pathways, over the course of time, disease processes can take hold within the

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body. These disease processes can also have devastating consequences such as those that arise from diabetes mellitus, including glycosylation of proteins and accumulation of sorbitol.

Controlling Toxic Risk

Wellness is the state of existence that arises when health-sustaining homeostatic balance is gained and maintained. Individual and cumulative toxic exposures threaten this optimal homeostatic state. However, identifying and compensating for toxic exposure can minimize the detrimental effects of the exposure.

General signs, symptoms, and risks that may indicate the presence of a high risk for toxic load include diabetes; congestive heart failure; obesity; history of alcohol abuse; psoriasis and other skin disorders; heavy exposure to industrial or household chemicals; frequent or recurrent use of medications; use of hormonal therapy, including hormone replacements and oral contraceptives; and disease states that alter liver, kidney, or GI functioning.

The review below of the mechanisms of some of the most important protective and detoxifying pathways offers insights into how best to cope with and accommodate toxic burden risk factors, and how to intervene naturally.^{1,2}

Detoxifying Processes

The body processes toxic substances in two fundamental ways: (1) by excreting or eliminating them; or (2) by neutralizing them. Excretion and elimination occur primarily via the urine (kidneys) and feces (liver and intestines). The skin and lungs provide ancillary support for these processes.

Neutralization occurs via a series of complex processes by which toxic chemicals are metabolized to either inert or more readily excretable substances until elimination occurs. When detoxification pathways fail, toxins may accumulate in body tissues, most frequently in fat tissue. This situation emphasizes the importance of nutrient support for antioxidant functioning and detoxification processes for any patient who is experiencing rapid weight loss, when that patient's fat tissues release their toxic loads.

The Liver

The liver is, without question, the leading detoxification organ. On the macroscopic level, the liver filters 2 liters of blood per minute, filtering out large toxins. The liver synthesizes bile and cholesterol that help to bind fat-soluble toxins for excretion. On the microscopic level, this organ neutralizes chemical substances metabolically.

Microscopic level functions include:

- *Filtration*—The liver filters blood that arrives directly from the intestines. Under ideal circumstances, the liver eliminates 99 percent of bacteria and other toxins successfully before the blood enters the general circulation. This filtration minimizes the passage of endotoxins, antigen-antibody complexes, certain foreign proteins, and numerous chemicals into the circulatory system.
- *Bile*—Every day, the liver produces and secretes 1 quart of bile that serves as the vehicle by which fat-soluble toxic substances enter the bowel, become bound by dietary fiber, and are eliminated. Insufficient fiber within the bowel or elevated β -glucuronidase from bacterial

overgrowth, however, can result in reabsorption and thus increase total toxic burden as a result of adding the reabsorbed load to the toxic load generated each day.

On the microscopic level, toxins are neutralized. The enzymes involved in the neutralizing process function in two distinctive phases. Phase 1 of the process modifies toxic substances to facilitate the conjugation reactions these chemicals undergo during phase 2 detoxification.

Chemical compounds that are neutralized include drugs, pesticides, hormones, inflammatory chemicals, and toxins absorbed from the intestinal tract. Phase 1 detoxification generates more chemically active substances, which, in turn, require proper functioning of phase 2 detoxification to eliminate these metabolic intermediates.

Phase 1 Detoxification

In general, phase 1 detoxification arises from the function of a group of some 50–100 enzymes referred to as cytochrome P450. The healthy functioning of this pathway depends upon an individual's nutritional status, genetics, and level of exposure to chemical toxins. Thus, an individual's risks of developing disease states arising from insufficient detoxification varies greatly. Indeed, this can explain the great variability in patients' susceptibility to, and manifestation of, disease processes such as cancer from environmental pollutants such as smoking.

Clinical evaluation of a patient's risk entails a twofold consideration: (1) that of total toxin load and (2) that of his or her ability to process the exposure. Phase 1 detoxification become less active with aging. Complicating this decreased func-

Table 1. Phase 1 and Phase 2 Detoxification Modulators^a

	Phase 1 inducers	Phase 2 inducers	Phase 1 inhibitors	Phase 2 inhibitors
Drugs				
Acid blockers			X	
Alcohol	X			
Antihistamines			X	
Ascorbic acid	X			
Benzodiazepines			X	
Birth control pills		X		
Ketoconazole			X	
Nicotine/smoking	X	X		
Nonsteroidal anti-inflammatory drugs				X
Phenobarbital	X	X		
Probenecid				X
Sulfaphenazole			X	
Sulfonamides	X			
Steroids	X			
Foods/herbs/nutrients				
Betaine		X		
Broccoli	X	X		
Brussels sprouts	X	X		
Cabbage	X	X		
Caraway	X	X		
Cayenne (capsaicin)			X	
Char-broiled meat	X			
Choline		X		
Clove oil (eugenol)			X	
Cobalamin (vitamin B ₁₂)		X		
Cobalamin (vitamin B ₁₂) deficiency				X
Curcumin (tumeric; <i>Curcuma longa</i>)		X	X	
Cysteine		X		
Dill	X	X		
Fish oil		X		
Folic acid		X		
Folic acid deficiency				X
Glycine		X		
Glutathione deficiency				X
Grapefruit juice			X	
Limonene (peels)	X	X		
Methionine		X		
Molybdenum deficiency				X
N-acetylcysteine			X	
Niacin (vitamin B ₃)	X			
Oranges	X			
Pantothenic acid deficiency				X
Protein (high)	X			
Protein (low)				X
Riboflavin (vitamin B ₂)	X			
Riboflavin (vitamin B ₂) deficiency				X
Selenium deficiency				X
St. John's wort (<i>Hypericum perforatum</i>)	X			
Tangerines	X			
Taurine		X		
Vitamin C	X			
Vitamin C deficiency				X
Zinc deficiency				X
Chemical Toxins				
Air pollutants	X			
Carbon tetrachloride	X			
Dioxin	X			
Endotoxins/exotoxins			X	
Herbicides	X			
Pesticides	X			
Solvent fumes	X			
Tartrazine				X

From refs. 4,13,14; and Nagabhushan, M., et al. Curcumin as an inhibitor of cancer. *J Am Coll Nutr* 11:192-198, 1992.

^aNote: Because of the complexity of phase 2 detoxification, the induction and inhibition substances listed above have not been broken down to the individual pathways within the phase 2 system; instead, they are reported in a generalized format.

Many disease states have been correlated with suboptimal functioning of an amino-acid conjugation pathway.

tion is that blood flow through the liver also diminishes with age. Not surprisingly, there is an increased susceptibility to adverse drug reactions among older adults, whose detoxification capabilities have diminished.

Studies have shown a fivefold variability of phase 1 functioning among healthy individuals.³ In light of this range of activity, there is also a significant oscillating need for antioxidant protection, because each toxin that is processed via phase 1 detoxification generates a free radical that either requires quenching or neutralization by phase 2 conjugation. Thus, phase 1 and phase 2 processing must be kept in balance to prevent the accumulation of highly reactive intermediates and to minimize the requirement for antioxidants to protect against free radicals. Many drugs, foods, nutrients, and chemicals can cause phase 1 and phase 2 detoxification processes to become desynchronized. Factors that affect the efficiency of phase 1 and phase 2 detoxification processes are summarized in Table 1.

There are clearly numerous substances that both affect induction and inhibition of these enzyme pathways positively and negatively.

When grapefruit or grapefruit juice rich in naringenin is consumed while a patient is taking certain medications, there can be potentially serious deleterious consequences; for example, this could happen in the case of nifedipine.⁴

Phase 2 Detoxification

Phase 2 detoxification can be broken down into well-defined detoxification pathways, each with unique abilities for addressing certain toxin categories. Phase 2 detoxification occurs principally via the pathways of

acetylation, amino-acid conjugation, glucuronidation, glutathione conjugation, methylation, sulfation, and sulfoxidation.

Acetylation

Conjugation of toxins with acetyl coenzyme A promotes the elimination of sulfa drugs. Acetylation is dependent upon pantothenic acid, thiamine, and vitamin C. Consumption of B-vitamin rich foods, such as whole grains and yeast, and of vitamin-C-abundant sources such as citrus fruits, cabbage, and peppers, can support this pathway.⁵

Amino-Acid Conjugation

Numerous amino acids, including, but not limited to, arginine, glutamine, glycine, ornithine, and taurine, combine with toxins and neutralize them. Glycine is most commonly involved in phase 2 detoxification. Many disease states have been correlated with suboptimal functioning of an amino-acid conjugation pathway. These disease states include alcoholic liver disease, arthritis, cancers, hepatitis, hypothyroidism, eclampsia, and chemical overload. Low-protein diets can result in lowered efficacy of this detoxification system.

Glucuronidation

Glucuronidation, involving the incorporation of glucuronic acid with toxins, helps to detoxify the body of numerous drugs, aspirin, menthol, synthetic vanilla, benzoates and other food additives, and some hormones. Patients can support this pathway by consuming the sulfur-rich foods listed below in the sulfation-pathway discussion. Gilbert's

disease affects 1 in 20 individuals and results in fasting serum bilirubin levels in the range of 1.2–3.0 mg/dL. Consumption of S-adenyl methionine (SAME), which fuels glucuronidation, has been shown to help support individuals with this condition.⁶ Also of potential clinical significance is consumption of limonene-rich foods such as caraway oil, citrus peel, and dill-weed seed, to support UDP-glucuronyl transferase, the enzyme required for glucuronidation.

Glutathione Conjugation

This pathway assists in making fat-soluble toxins water-soluble, allowing for excretion via the kidneys. Because this pathway is glutathione-dependent it is indirectly dependent upon the presence of sufficient cysteine and methionine in the body. Vitamin C has also been shown to be effective in supporting the maintenance of glutathione levels.⁷ Consumption of foods that stimulate glutathione conjugation, such as orange-peel oil, turmeric, artichoke, and dill and caraway seeds, can be recommended therapeutically. If phase 1 detoxification generates excess free radicals, glutathione depletion can occur, thereby preventing or stalling the glutathione-conjugation pathway.

Methylation

Methylation involves the conjugation of methyl groups to toxic substances. Primary methyl groups come from SAME, which requires sufficient methionine, choline, vitamin B₁₂, and folic acid for synthesis. Foods that are rich in these nutrients include whole grains and

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legumes (sources of vitamin B₆), green leafy vegetables (sources of folic acid), and animal products and yeast (sources of vitamin B₁₂).

Sulfation

Binding sulfur-containing compounds can conjugate potentially toxic steroidal hormones and thyroid hormone, and promote the elimination of neurotransmitters. Diets that are low in protein, and thus low in cysteine and methionine, diminish sulfation. Evidence shows that taking more than 100 mg per day of vitamin B₆ or consuming excess molybdenum can slow this pathway.⁸ Consuming the amino acid taurine and sulfur-rich foods such as broccoli, Brussels sprouts, egg yolks, garlic, and red peppers can support sulfation activity.

Sulfoxidation

The enzyme sulfite oxidase helps to metabolize toxic substances such as transforming sulfites to sulfate. This detoxification pathway is essential for the elimination of sulfur-containing drug and food substances. Sources of sulfites include certain processed foods, including commercial potato salad, dried fruits, salad commonly found at salad bars, and certain drugs, such as some medicines for asthma. This pathway can be supported by molybdenum because sulfite oxidase is dependent upon this trace mineral.⁹ Legumes and whole grains are typically high in molybdenum as long as they are grown in soil that is replete with trace minerals.

Supporting Detoxification Within the Body

Using this overview and framework of principal mechanisms of liver detoxification, it is wise to focus on essentials for therapeutic intervention, ensuring

that the proper balance between phases 1 and 2 detoxification stages is maintained.

It is believed that up to 90 percent of cancer cases arise from the effects of exposure to environmental chemicals such as those found in air pollution, tobacco, chemically contaminated food, and antimetabolites that deplete nutrients that are essential for proper detoxification.^{10,11} Therefore, choosing nutrients and botanical medicines to support detoxification can improve quality of life, alleviate acute signs and symptoms of excess toxic load, and confer protection over the course of a patient's life.

The sections below cover key botanicals, nutrients, and dietary constituents that represent potential clinical interventions for treating acute or chronic cases of toxicity, depending on each patient's condition.

Botanicals

Three major botanicals used in detoxification are curcumin, silymarin, and St. John's wort.

Curcumin

This common herb, used frequently in the form of turmeric (*Curcuma longa*), has antioxidant and anti-inflammatory properties. Curcumin has been shown to help inhibit the carcinogenic effects of benzopyrene that arise from the consumption of char-broiled meat. This herb has been shown to inhibit phase 1 detoxification while inducing phase 2 of the process. When 1.5 g of turmeric was given to 16 smokers and 6 nonsmokers (control subjects), it was shown that, after 30 days of consuming turmeric, urinary excretion of mutagens in smokers was nearly equivalent to that of nonsmokers. This study demonstrated that turmeric is an effective inhibitor of phase 1 detoxification, preventing the excess accumulation of toxic metabolite conversion of smoke byproducts, which

have been linked as major contributors to increased risks of cancer development.¹²

Milk Thistle

Silymarin, an extract of milk thistle (*Silybum marianum*), is particularly renowned for its antioxidant and hepatoprotective effects. When toxic exposures and burdens are elevated, it is vital to pay special attention to supporting and protecting the liver as it detoxifies the body. This herb's antioxidant effects have been reported to be several times greater than those of vitamin C or vitamin E. Silymarin also helps to support detoxification by preventing glutathione depletion. Research has shown that silymarin can increase glutathione levels by more than 35 percent. Silymarin has increased the reduced form of glutathione (GSH) in the liver by more than 35 percent and by more than 50 percent in rats.¹³

St. John's Wort

St. John's wort (*Hypericum perforatum*) induces intestinal and hepatic CYP3A4 enzyme activity, thus speeding this phase of detoxification.¹⁴ However, this treatment requires additional antioxidant support and appropriate counter-support for complete liver detoxification. Further research is required to appreciate fully the potential clinically relevant liver detoxification modulating effects.

Other Herbs

There are numerous other herbs that can provide meaningful support for liver detoxification, including gambir (*Uncaria* spp.), green tea (*Camellia sinensis*), and schisandra (*Schisandra chinensis*). Space constraints for this overview do not permit more details on these other herbs.

Dietary Approaches

Fiber, indole, and limonene, found in foods, also help to support detoxification.

Research has shown that silymarin can increase glutathione levels by more than 35 percent

Fiber

Sufficient fiber consumption can support detoxification in several ways. Primarily, fiber binds excreted toxins, helps to limit initial absorption of toxins from the intestines, supports proper bowel transit times, and increases the frequency of bowel movements. The importance of sufficient daily bowel movements cannot be overemphasized; the longer fecal material is retained in the lower colon, the more toxins are absorbed, burdening the entire body. A diet rich in fiber also commonly helps to support healthy intestinal flora, assisting in controlling excess endotoxin production.

Indole

Members of the *Brassica* family such as broccoli, Brussels sprouts, and cabbage are rich in glucosinolates, including indole-3-carbinol and sulforaphane. This combination supports both phase 1 and phase 2 toxin processing.¹⁵ Thus, these foods have both direct and indirect anticarcinogenic properties.

Limonene

A phytochemical found in oranges, tangerines and caraway and dill seeds,¹⁶ limonene has anticarcinogenic properties and induces both phase 1 and phase 2 detoxification pathways.

Nutrients

Copper

This ubiquitous mineral is required for phase 1 detoxification. Supplementation is not usually necessary unless a deficiency has been identified, if excess body stores of zinc have been confirmed, or if zinc supplementation has exceeded 30 mg per day for more than a few weeks. Of significance, however, is that copper, in turn, can displace zinc, which also supports detoxification.

Glutathione

This tripeptide, comprised of cysteine, glutamic acid and glycine, is the most important antioxidant in neutralizing free

Table 2. Detoxification Pathway Dysfunctions

Dysfunction	Symptoms
<i>Phase 1</i>	
Phase 1—overactive	Can sleep after consuming 16 ounces of caffeinated beverage
Phase 1—underactive	Small amount of caffeine causes insomnia, and perfumes and chemical smells make one ill
<i>Phase 2</i>	
Phase 2—underactive	
Amino acid conjugation	Toxemia in pregnancy; gastrointestinal toxicity
Glucuronidation	Yellow eyes (non-hepatitis-related); Gilbert's syndrome ^a
Glutathione conjugation	Chronic exposure to toxins
Sulfation	Gastrointestinal toxicity, including gastroenteritis, irritable bowels, or enterocyte damage
Sulfoxidation	Poor response to sulfites, found in salads from salad bars and in commercially prepared potato salad; reactive airways upon eating out; garlic intolerance; asparagus causes urine odor

From ref. 11.

^aAny patient who presents with yellow eyes must be evaluated to rule out more serious liver disorders.

radicals produced by phase 1 detoxification pathways. Glutathione is also required for phase 2 detoxification. When high toxic loads burden phase 1 detoxification and elevate production of free radicals, increased glutathione may be required to prevent depletion that can lead to a cessation of phase 2 glutathione-dependent pathways. Glutathione is available via diet or supplementation. Dietary sources include fresh fruits and vegetables (e.g., asparagus, avocados, walnuts) and cooked meat and fish. Glutathione supplementation has shown variable and sometimes negligible effects in increasing blood levels of this tripeptide. However, vitamin C, glycine, methionine and N-acetylcysteine (NAC) support glutathione synthesis. It appears that vitamin C and NAC have maximal effects.

In a case study of supplementation therapy for an individual with an inherited glutathione deficiency, either 3000 mg of vitamin C per day or 800 mg of NAC were given to the patient for 1–2 weeks. Vitamin C supplementation increased GSH in red blood cells fourfold and plasma GSH eightfold. NAC

increased GSH in white blood cells 3.5-fold and was increased in plasma two- to fivefold.¹⁷

Magnesium

Deficiency of magnesium prevents proper phase 1 detoxification and leads to increased toxicity risks for people who are taking numerous medications.

Methionine

Methionine plays a pivotal role in helping to ensure proper phase 2 detoxification. When toxic load increases, methionine is also converted to cysteine and glutathione to support maximal detoxification. Being that methionine can feed the pathway that results in excess homocysteine generation, other approaches should be implemented first. If methionine is used, monitoring homocysteine levels is warranted.

N-Acetylcysteine

A rich source of sulfur in the form of cysteine, NAC helps to support glutathione-dependent detoxification. (See section entitled, Glutathione, above)

Detoxifying the body of toxic substances is a continual process.

Vitamin C

Essential for phase 1 detoxification, vitamin C, a potent water-soluble antioxidant, helps to quench free-radical damage and helps to fuel glutathione preservation. (See section entitled Glutathione, above.)

Zinc

Crucial for phase I detoxification, this multifaceted mineral has both antioxidant and immune-supportive effects. Supplementation with zinc seems to be warranted for numerous reasons and long-term use would be particularly significant in male patients because zinc helps to inhibit the 5- α -reductase conversion of testosterone to dihydrotestosterone.

Other Therapeutic Supplements

The above elements are merely representative of numerous potential interventions; others worth consideration include choline, inositol, dandelion (*Taraxacum officinale*), artichoke, beet greens, selenium, B vitamins, and numerous amino acids.

Symptoms That Suggest Detoxification Imbalance

Numerous tests can be conducted to measure liver detoxification functioning. Measurement of metabolite levels before and after challenges with acetaminophen, caffeine, or other chemicals, can provide detailed information about an individual's detoxification functions. There are, however, a number of readily observable signs that suggest that an individual may have overactive or underactive detoxification functions.

Table 2 summarizes some of the more commonly noted detoxification pathway dysfunctions and their symptoms.

Conclusion

Detoxifying the body of toxic substances is a continual process. Yet, the body's detoxification mechanisms can become overwhelmed. Thus, nourishing these pro-

TECTIVE defenses properly is of paramount importance. Equally important is the active avoidance of undue exposure to minimize total toxic load.

Numerous detoxification products are available for supporting a balanced approach to minimizing the likelihood of imbalances in phase 1 or phase 2 detoxification, either via induction or inhibition. Most of these products can also be used in combination with antioxidant support during a fasting routine. Whenever there is weight loss, whether or not this is intentional on the part of a given patient, the released toxins in that patient's body must be quenched.

Finally, some toxic exposures cause catastrophic, permanent, and irreversible damage, either immediately or by promoting and inducing a cascade of disease processes. Therefore, the preventively minded clinician can achieve exceptional results when addressing disease processes by searching for and addressing the triggers within the body that have become the disease cascade that manifests as symptoms. □

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