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Occupational health risks of wine industry workers

Workers in vineyards and wineries can be exposed to a number of hazards, including toxic pesticides and low-oxygen environments.

ABSTRACT: Wine industry workers have a number of specific health risks associated with their occupation. Viticulture workers are at risk of work-related musculoskeletal problems, especially of the wrists and hands, from vine pruning work, and can develop allergic diseases, including occupational asthma, from exposure to insect pests growing on vines. They may also be at risk of illness from exposure to the many classes of pesticides used to keep vine pests in check. Wine production workers also face health risks. The most serious of these—working in confined spaces with low oxygen and high carbon dioxide levels—can cause death. Winemakers and wine tasters may suffer significant dental erosions and sensitivity as a result of the acidic nature of the wines they need to taste numerous times a day. This problem can seriously affect their ability to practise their profession. While work-related injuries are more commonly reported than work-related diseases in the wine industry, physicians assessing the medical problems of wine industry workers should be aware of the occupational health risks faced by these individuals.

The Canadian wine industry has become more sophisticated over the years and has seen improvements in product quality and competitiveness. Over the last decade, sales of domestic wines in Canada have increased by more than 50%.[1] British Columbia is a significant participant in this industry and has seen very rapid growth in wine production and the number of people employed. Wine industry workers in BC face specific health risks associated with their work. In addition to appreciating the fruits of this labor, physicians should be aware of the potential occupational health problems faced by their patients employed in this industry.

Viticulture workers

Workers in vineyards run the risk of the same accidental injuries faced by all agriculture workers. They are also exposed to the same hazards associated with outdoor work, such as noisy machinery, insects, snakes, inclement weather, solar radiation, and thermal stress.[2,3] In addition, viticulture workers are at risk of musculoskeletal disorders, asthma caused by mite exposure, and illness caused by pesticide exposure.

Musculoskeletal disorders

While tending vineyards, viticulture workers do a variety of highly repetitive tasks that predispose them to developing work-related musculoskeletal disorders, including back and neck strains as well as a variety of tendinopathies and neuropathies of the upper extremities.[4] Pruning vines can produce significant biomechanical strains because of the repetitive actions, forceful motions, and awkward postures required.[5] Workers generally have to make more than 30 cuts per minute, many hours a day, for many weeks during the growing season.

Viticulture workers who prune vines tend to have a high prevalence of symptoms affecting the upper extremities. One study of French viticulture workers found that 20% had signs and symptoms of carpal tunnel syndrome and there was a significant association of injury with number of vines cut per day.[6] In another study, Roquelaure and colleagues[7] found 37% of viticulture workers had nocturnal hand paresthesia, and 12% had hand-wrist pain, predominantly of the dominant hand. Risk factors included using manual shears, being female, being overweight, and pruning on a piece-work basis. Both studies, however, noted that the symptoms tended to be limited to the pruning season, with the majority of workers improving when they stopped this activity.

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Asthma caused by mite exposure

Spider mites (e.g., *Tetranychus mcdanieli*) are acarids that commonly infest fruit trees, greenhouse plants, and grape vines. They may occur in high numbers in vineyards, causing damage to the plants and reducing grape production by sucking on the leaves and buds. Spider mites can also cause allergic diseases in workers, including dermatitis and urticaria, conjunctivitis, rhinitis, and asthma.[8-10] Cross-reactions with other ubiquitous acarids, such as the common house dust mite and the storage mite, have been reported.[11,12] With workplace exposure, some affected individuals may have exacerbations of their underlying allergic diathesis.

Individuals who develop allergic disease after exposure to spider mites, especially asthma, should be identified early and removed from further exposure to ensure the best prognosis. Guidelines for evaluating occupational asthma are available.[13,14] The physician needs to first confirm the diagnosis of asthma by clinical assessment and objective testing, including pre- and post-bronchodilator response or methacholine challenge. Once the diagnosis is confirmed, the occupational relationship should be assessed. Typically, this includes a history of exacerbation of symptoms while working and improvement away from the workplace. Serial peak expiratory flow testing and methacholine challenges at work and away from work should provide objective confirmation of the relationship between reversible airway obstruction and the workplace.

Illness caused by pesticide exposure

British Columbia vineyards have many pests that reduce the production and vigor of vines. The diversity of pests, however, is less than that found in older, more established wine-growing regions in Europe and California.

A variety of pesticides are used to control pests in British Columbia, including organophosphates, carbamates, organochlorines, pyrethroids, fungicides, and herbicides.[15] Each pesticide group has its own specific toxicity profile. The most important routes of occupational exposure are inhalation and dermal absorption. Ingestion is less typical. All workers who handle pesticides or are near areas of pesticide application risk exposure and illness. Most pesticides can cause a variety of dermatoses, including irritant and allergic contact dermatitis.[16,17] Re-entry into a sprayed field too soon after application may result in unwanted exposure. As a general rule, reentry should be restricted to 24 to 48 hours after spraying, depending on the inherent toxicity of the pesticide. Manufacturer recommendations should be followed.

All workers who handle pesticides or are near areas of pesticide application risk exposure and illness.

A brief overview of some of the pesticides commonly encountered in vineyards follows. More detailed reviews, which include medical management of pesticide exposure, are available elsewhere.[18,19]

Organophosphates: These compounds irreversibly bind and inactivate acetylcholinesterase, thus inhibiting the breakdown of acetylcholine at nerve synapses and muscle neural endplates, and inducing a hypercholinergic state.[20]

In addition to inhalation, dermal absorption is an important route of occupational exposure for many organophosphates. The severity of signs and symptoms of acute exposure depends on the absorbed dose. Signs and symptoms may include myosis, blurred vision, headache, nausea, dizziness, sweating, salivation, lacrimation, rhinorrhea, bronchorrhea, bronchospasm, chest tightness, cough, wheezing, pulmonary edema, vomiting, abdominal cramps, diarrhea, muscle fasciculation, weakness, tremors, incoordination, anxiety, restlessness, depression, memory loss, confusion, bizarre behavior, loss of consciousness, incontinence, convulsions, respiratory depression, toxic cardiomyopathy, and bradycardia. Death can result from respiratory failure and sinus arrest.

After the resolution of the acute symptoms, the intermediate syndrome occurs, typically 24 to 96 hours (1 to

4 days) after exposure. This manifests as respiratory paresis and muscular weakness, particularly of facial and neck muscles as well as those of the proximal limbs. Cranial nerve palsy and decreased deep tendon reflexes can occur.

Measuring erythrocyte acetylcholinesterase activity is a good way to monitor viticulture workers for organophosphate exposure and pre-clinical toxic effects.

Organophosphates can also produce a rare condition called organophosphate-induced delayed neuropathy (OPIDN). This manifests as weakness or paralysis and paresthesia of the extremities, especially the legs, and can last for weeks or years.

Some individuals can have long-term neuropsychiatric sequelae, including memory, concentration, and mood problems, as well as poorer performance on neuropsychological testing.[21]

Blood tests for organophosphate exposure primarily measure acetylcholinesterase of red blood cells. Plasma pseudocholinesterases can also be measured in cases of acute exposure. In some cases, specific organophosphate metabolites can be measured in the blood or urine.

Measuring erythrocyte acetylcholinesterase activity is a good way to monitor viticulture workers for organophosphate exposure and pre-clinical toxic effects. Plasma pseudocholinesterase tends to be too variable and unreliable for monitoring purposes. Since erythrocyte acetylcholinesterase activity can demonstrate relatively high interindividual fluctuations, a reference value for each individual should be available. A pre-exposure blood sample for the enzyme activity serves this purpose. Post-exposure erythrocyte acetylcholinesterase activity can be compared with the pre-exposure levels. The same laboratory and assay technique should be used for pre- and post-exposure evaluations. A decrease to 70% baseline or less of acetylcholinesterase activity can be attributed to overexposure to cholinesterase inhibitors.[22] If this occurs, the worker should be removed from further pesticide exposure and work practices should be assessed. Return to work can be considered when the erythrocyte acetylcholinesterase activity has improved to greater than 80% baseline and the workplace exposure factors have been mitigated.

Carbamates: The toxicity profile of carbamates resembles that of organophosphates. Like organophosphates, carbamates also inhibit acetylcholinesterases. However, this is a reversible process and carbamate exposure generally tends to have less severe and less prolonged effects than organophosphate exposure.

Organochlorines: Acute effects from organochlorine[23] pesticide exposure involve primarily nervous system hyperactivity. Signs and symptoms of toxicity include headaches, dizziness, nausea, vomiting, incoordination, confusion, paresthesias, tremors, and hyperreflexia. Generalized seizures can follow a severe exposure and can be difficult to treat. Coma and respiratory depression can also occur. Some of the organochlorines are fat soluble; they can be stored in the body for years and can be found in human breast milk; they may also act as neuroendocrine disrupters. Cancer risk associated with this class of pesticides is believed to be related to co-exposure with dioxin-contaminated herbicides.

Pyrethroids: These compounds are synthetic analogs of naturally occurring pyrethrin, which is produced by chrysanthemums. One product commonly used in vineyards, permethrin, has a very low toxicity profile. If applied on moist skin it may cause transient paresthesias. Sensitization and allergies have been reported.

Fungicides: The most commonly used fungicides in BC vineyards consist of the various sulfur preparations. Sulfur can be irritating to the skin, eyes, and respiratory tract.

Fungicides such as benomyl and iprodine have little or no reported systemic toxicity in humans. Benomyl may cause photoallergic dermatitis.[24]

Copper-containing fungicides can be irritating to the skin, the respiratory tract, and especially the eyes. Copper sulfate can be corrosive to mucous membranes and the cornea. With chronic exposure, a mixture of copper sulfate and lime known as “Bordeaux mixture” can cause “vineyard sprayer’s lung,” a granulomatous fibrosing lung disease.[25,26]

Herbicides: Most herbicides specifically affect plant metabolism and therefore tend to have low toxicity profiles for mammals. Glyphosate can cause photodermatitis.[27] Paraquat, a nonselective contact herbicide sometimes used in BC vineyards, can be highly toxic if improperly used.

Paraquat is poorly absorbed by inhalation. Paraquat exposure occurs primarily from ingestion (accidental or purposeful) or dermal absorption though damaged skin. The primary target organ is the lung. Following systemic absorption, paraquat accumulates in pneumocytes causing oxidative damage to the lungs. Death commonly follows from circulatory failure or in a week or two from pulmonary damage and fibrosis. Paraquat can cause skin irritation and contact dermatitis, as well as nail damage and loss.[28,29]

Wine production workers

Individuals working in the quality-control laboratories of wineries are frequently exposed to small quantities of toxic chemicals. Wine production workers may be exposed to small quantities of chemical additives in the making of wine. They may also be exposed to chemical products used to clean and sterilize winemaking equipment. The substances are often caustic and irritating to the skin, mucous membranes, and respiratory tract. Some of the additives, such as sulfites and metabisulfites can result in allergic reactions, including occupational asthma.[30] Adequate ventilation, the use of fume hoods, and personal protective equipment can generally reduce the risk from these types of exposures.

Confined space risks

One of the most serious occupational risks faced by wine production workers involves working in a confined space. Avoidable fatalities have occurred too many times because appropriate safety measures and procedures were ignored.[31] Such a tragedy occurred in a small wine operation in Oliver, BC, in 2002. The owner of the facility was trying to open the jammed hatch of a 500-gallon wine storage tank when the hatch gave way and he fell through a small opening. His upper body was stuck in the tank and he quickly lost consciousness. A friend attempted to rescue him but was unable to pull him out. The rescuer then pushed the unconscious man into the tank and proceeded to enter the tank himself in order to push the man out from the inside. The rescuer also quickly lost consciousness and both men perished.

Confined spaces are defined as enclosed or partially enclosed areas with restrictive means of entry. In the wine industry these consist mainly of storage and fermentation tanks. Hypoxic environments frequently occur in these tanks as a result of the biologic activity of fermenting wines. The hemoglobin saturation and the oxygen content of blood can decline very rapidly at low atmospheric oxygen concentrations. Entry into these areas without adequate respiratory protection, including supplied air, can result in rapid hypoxemia with decreased exercise capacity and mentation ability. Loss of consciousness, apnea, and cardiac standstill can occur quickly in an atmosphere of less than 6% oxygen.[32]

Hypoxic environments frequently occur in wine storage and fermentation tanks as a result of the biologic activity of fermenting wines.

In addition to creating a low-oxygen environment, wine fermentation can produce large quantities of carbon dioxide, which can then attain very high concentrations in a confined space. The fatality investigation at Oliver concluded that the carbon dioxide concentration in the head space of the storage tank was over 100 000 ppm or 10% (normal atmospheric carbon dioxide concentration is approximately 350 ppm or 0.04%) and the oxygen was at 16%. At moderate concentrations, carbon dioxide behaves as a simple asphyxiant replacing oxygen. However, at higher concentrations carbon dioxide can be directly toxic to central nervous system function, producing narcosis. Breathing carbon dioxide at concentrations greater than 10% can produce unconsciousness in less than 1 minute and, failing rescue, death.[31,32]

Dental erosions

Decalcification of human teeth can occur with repeated exposure to acidic solutions such as fruit juices and carbonated soft drinks, or with frequent emesis and regurgitation as seen among alcoholics and bulimics. Demineralization of enamel commences at a pH of less than 5.7.

Wines contain approximately 5 to 8 g/L of tartaric and malic acids, 1 to 3 g/L of lactic acid, and smaller amounts of other acids, including succinate and citrate. The pH of wines ranges from 3.2 to 3.8. Winemakers may do 5 to 50 tastings per day, holding and swirling each wine in the mouth for approximately 15 seconds at a time for adequate degustation. A winemaker will typically taste thousands of wines in his or her career. One professional wine taster was estimated to have had 245 000 acidic wine exposures over a 23-year period.[33] Given this level of exposure, it is not surprising that the phenomenon of dental erosions has been described among winemakers and wine tasters.[33,34]

The affected individual typically complains of a sore mouth with general discomfort of the teeth, especially when consuming anything cold. Examination reveals extensive and widespread erosion. Without treatment, this problem can seriously hamper the individual's livelihood and dental consultation is advisable. Application of topical fluoride may reduce erosion. Frequent rinsing with an alkaline solution or other solutions can help neutralize the acidity. For obvious reasons any treatment should not interfere with the individual's sense of taste.

Conclusions

WorkSafeBC data do not permit reliable identification of wine industry worker claims, but available information indicates that from 1990 to 2005 (15 years), only 5 claims for occupational disease were filed, compared with almost 500 claims for injury from 1997 to 2005 (9 years). The occupational disease claims included 3 cases of irritant contact dermatitis following cutaneous metabisulfite exposure; 1 case of sulfurous powder inhalation resulting in transient upper respiratory tract irritation; and 1 mild case of carbon dioxide poisoning caused by failure of a CO_2 detector. The majority of the injury claims were for traumatic injuries, including 19 cases related to repetitive activity. A very small number of claims involved other injuries caused by noise exposure, insect bites, and exposure to welding light.

Care must be taken when interpreting this crude data, but the general impression is that injuries are much more common than diseases among wine industry workers. While these numbers may indicate a higher risk of injury relative to disease among wine industry workers, they may also reflect a failure of the medical community to recognize occupational diseases among these workers.

Given the potential for work-related illness revealed by this brief review of some occupational health risks facing wine industry workers, physicians should always consider their patients' work activities when assessing their medical problems. A specific cause of illness may be identifiable, and once identified it may be rectified. Just as important is the need to identify high-risk activities such as working in confined spaces. A physician who has any doubts about the safety of work practices or knows workers are being exposed to hazards should contact WorkSafeBC's Prevention Services to request a workplace evaluation (1 888 621-7233). Action in some cases can be lifesaving.

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Competing interests

None declared.

References

1. Canadian Vintners Association. Statistics: The Canadian wine market. www.canadianvintners.com/canadianwines/statistics.htm (accessed 8 October 2005).
2. Langley RL, Meggs WJ. Farmers and farm personnel. In: Greenberg MI, Hamilton RJ, Phillips SD, et al. (eds). Occupational, Industrial, and Environmental Toxicology. Philadelphia, PA: Mosby; 2003:154-161.
3. Shalat SL, Robson MG, Mohr SN. Agriculture workers. In: Rosenstock L, Cullen MR, Brodkin CA, et al. (eds). Clinical Occupational and Environmental Medicine. Toronto, ON: Elsevier Saunders; 2005:193-200.
4. Meyers J, Miles JA, Faucett J, et al. CAL OSHA ergonomics standards: What does it mean for vineyard employers? Practical Winery & Vineyard May/June 2000.www.practicalwinery.com/mayjune00/calosa.htm (accessed 9 October 2005).
5. Roquelaure Y, Dano C, Dusolier G, et al. Biomechanical strains on the hand-wrist system during grapevine pruning. Int Arch Occup Environ Health 2002;75:591-595.
6. Matray D, Larbre JP, Teisseire C, et al. Syndrome du canal carpien declenches par la taille de la vigne. Arch Mal Prof 2001;62:92-95.
7. Roquelaure Y, Gabignon Y, Gillant JC, et al. Transient hand paresthesia in Champagne vineyard workers. Am J Ind Med 2001;40:639-645.
8. Astarita C, Freanzese A, Scala G, et al. Farm workers' occupational allergy to *Tetranychus urticae*: Clinical and immunologic aspects. Allergy 1994;49:466-471.
9. Delgado J, Gomez E, Palma JL, et al. Occupational rhinoconjunctivitis and asthma caused by *Tetranychus urticae* (red spider mite). A case report. Clin Exp Allergy 1994;24:477-480.
10. Jeebhay MF, Baatjies R, Lopata A. Environmental determinants of work-related

asthma symptoms on table grape farms—indoor domestic mites or outdoor spider mites? Curr Allergy Clin Immunol 2003;16:98-100.
11. Carbonell M, Lavaud F, Bailly R. Les acariens de la vigne sont-ils susceptibles de provoquer une allergie respiratoire? A propos de sept observations. Rev fr allergol 1986;26:171-178.
12. Kroidl R, Maasch HJ, Wahl R. Respiratory allergies (bronchial asthma and rhinitis) due to sensitization of type I allergy to red spider mite (*Panonychus ulmi KOCH*). Clin Exp Allergy 1992;22:958-962.
13. Chan-Yeung M. ACCP consensus statement: Assessment of asthma in the workplace. Chest 1995;108:1084-1117.
14. Tarlo S, Boulet LP, Cartier A, et al. Canadian Thoracic Society guidelines for occupational asthma. Can Respir J 1998;5: 289-300.
15. BC Ministry of Agriculture, Food and Fisheries. Management guide for grapes for commercial growers 2000/2001. Kelowna: MAFF and BC Wine Institute, 2000.
16. Sharma VK, Kaur S. Contact sensitization by pesticides in farmers. Contact Dermatitis 1990;23:77-80.
17. Spiewak R. Pesticides as a cause of occupational skin diseases in farmers. Ann Agric Environ Med 2001;8:1-5.
18. Reigart JR, Roberts JR. Recognition and Management of Pesticide Poisonings. Washington, DC: EPA;1999.
19. Keifer MC, Wesseling C, McConnell R. Pesticides and related compounds. In: Rosenstock L, Cullen MR, Brodkin CA, et al. (eds). Clinical Occupational and Environmental Medicine. Philadelphia, PA: Elsevier Saunders; 2005:1099-1126.
20. Bey TA, Sullivan JB, Walter FG. Organophosphate and carbamate insecticides. In: Sullivan JB, Krieger GR (eds). Clinical Environmental Health and Toxic Exposures. Philadelphia, PA: Lippincott Williams & Wilkins; 2001:1046-1057.

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21. Baldi I, Filleul L, Mohammed-Brahim B, et al. Neuropsychologic effects of long-term exposure to pesticides: Results from the French Phytoner study. Environ Health Perspect 2001;109:839-844.
22. Lewalter J, Domik C. Acetylcholinesterase (AChE; acetylcholine-acetylhydrolase EC 3.1.1.7) and cholinesterase (ChE; acylcholine-acylhydrolase EC 3.1.1.8). In: Angerer J, Schaller KH (eds). Analyses of Hazardous Substances in Biological Materials. Vol 1. Weinheim: VCH; 1985:45-49.
23. Van Ert MD, Sullivan JB. Organochlorine pesticides. In: Sullivan JB, Krieger GR (eds). Clinical Environmental Health and Toxic Exposures. Philadelphia, PA: Lippincott Williams & Wilkins; 2001:1057-1082.
24. Savitt LE. Contact dermatitis due to benomyl insecticide. Arch Dermatol 1972; 105:926-927.
25. Villar TG. Vineyard sprayer's lung. Clinical aspects. Am Rev Respir Dis 1974; 110:545-555.
26. Plamenac P, Santic Z, Nikulin A, et al. Cytologic changes of the respiratory tract in vineyard spraying workers. Eur J Respir Dis 1985;67:50-55.
27. Hindson C, Diffey B. Phototoxicity of glyphosate in a weedkiller. Contact Dermatitis 1984;10:51-52.
28. Hearn CE, Keir W. Nail damage in spray operators exposed to paraquat. Brit J Ind Med 1971;28:399-403.
29. Botella R, Sastre A, Castells A. Contact dermatitis to paraquat. Contact Dermatitis 1985;13:123-124.
30. Agard C, Nicolet-Akhavan F, Bouillard J, et al. Asthme professionnel aux metabisulfites—trois observations. Rev Mal Respir 1998;15:537-540.
31. Guillemin MP, Horisberger B. Fatal intoxication due to an unexpected presence of carbon dioxide. Ann Occup Hyg 1994; 38:951-957.
32. Wilkenfeld M. Simple asphyxiants. In: Rom WN (ed). Environmental and Occupational Medicine. Philadelphia, PA: Lippincott-Raven; 1998:651-655.
33. Chaudhry SI, Harris JL, Challacombe SJ. Dental erosion in a wine merchant: An occupational hazard? Br Dent J 1997; 182:226-228.
34. Ferguson MM, Dunbar RJ, Smith JA, et al. Enamel erosion related to winemaking. Occup Med 1996;46:159-162. BCMJ