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**Review of Inhalants:  
Euphoria to Dysfunction**

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## Toxicity

The deleterious acute effect of inhalant abuse represents a pharmacologic progression beyond the response desired by the host and occurs as a result of excessive doses. Because the respiratory tract provides a portal of entry into the blood stream for lipophilic substances that is almost equivalent to intravenous injection, elevated concentrations of inhaled substances in the blood are achieved almost immediately. The blood brain barrier is readily penetrated by lipophilic substances. The concentration in the central nervous system reflects the concentration of substances in inhaled air delayed only by the circulation time from the lungs to the brain. The combination of ease of administration and rapidity of response allows immediate feedback. While induction is very rapid, disappearance of effects is relatively slower because of retention of lipophilic substances in lipid pools in the body from which there is gradual release over a period of hours to days. Recurrent use of inhalants over a time interval shorter than the time required to clear fat depots of their retained substances may result in a gradual accumulation requiring many days for dissipation after the last use of the substance.

The effects of inhaled substances may be immediate, delayed, or remote with respect to the time frame within which the effects are manifest. Alteration of consciousness is an immediate effect as are cardiac conduction abnormalities. Delayed effects are manifest by persistent organic brain syndrome, peripheral nerve injury, reduction in hematopoietic activity, and liver and kidney damage. Remote effects may not be manifest for 10 to 30 years and consist of increased rate of cancer and genetic changes in germinal tissue.

## Exposure and Clinical Effects

The medical literature is spotted by case reports and reports of series of epidemiologically related cases of injury associated with the use of inhalants. The available medical literature cannot be construed as representative of injury associated with the use of inhalants alone. Publication in medical literature requires the occurrence of a clearly identified injury within reasonable temporal proximity of the use of inhalants. Consequently, medical literature is weighed heavily toward the more dramatic clinical manifestations that occur as an immediate or early effect of inhalant use. Chronic or delayed effects of inhalant use are not likely to be recognized clinically as associated with inhalants, and remote effects, by definition, require 10 to 30 years to be manifested. There exists no comprehensive data base emerging from the careful, systematic investigation of inhalant users with regard to their state of continuing health or disability. Much of the published literature on inhalant effects comes from inadvertent occupational exposure. While such exposure is assumed to be accidental, patients occasionally indicate the vapors inducing euphoria

## Chapter 4

# MEDICAL EVALUATION OF INHALANT ABUSERS

## Eric G. Comstock and Betsy S. Comstock

### INTRODUCTION

Inhalant abuse describes a pattern of behavior which involves the voluntary inhalation of gases or vapors in order to achieve a modified state of consciousness. The usual intent is to achieve a state of euphoria or "high." A sensation of dizziness, light-headedness, or floating ordinarily is associated with the euphoria. The state of dissociation from one's environment allows temporary escape from the troubles, concerns, and stresses of everyday living. The response induced by inhalation is dose-related and cumulative over short periods of time. The desired alteration in consciousness may be achieved by high concentrations of gas or vapor in air within 1 to 2 minutes, while lower concentrations may require 5 to 10 minutes to achieve the desired effects. Depending upon the substance and the dose, an altered state of consciousness may persist for a few minutes to several hours. With poor control of exposure, the intended effects may become excessive, leading to general central nervous system (CNS) dysfunction, depression, sedation, coma, and death due to respiratory depression or major cardiac arrhythmias. Depending upon the technique of administration, hazard exists for reduction of oxygen content of inhaled air with anoxia leading to unconsciousness and for death from respiratory failure.

are not actively avoided. Table 1 summarizes published reports stating briefly the circumstances of exposure and the clinical effects.\*

#### n-Hexane

n-Hexane exposure by inhalation clearly is associated with polyneuropathy, which is predominantly motor. A latent period of 6 to 10 weeks is usually necessary but months to years may elapse between initial exposure and clinical effects following lower levels of exposure. The question of persistent cerebral dysfunction following n-hexane polyneuropathy has not been addressed. Injury to other organ systems has not been identified.

#### Toluene

Toluene (C<sub>6</sub>H<sub>5</sub>CH<sub>3</sub>; methylbenzene, toluol, phenylmethane) is a substance preferred by many inhalant users. Commercial products containing toluene are sought after and used for long periods of time. Since commercial products containing toluene usually contain a wide variety of other volatile organics, generalizations from single case reports have precarious validity. In contrast with n-hexane there is no single predominating target organ system that shows a response to toluene. The diversity of responses associated with toluene suggests that other substances, either alone or in combination, are the primary toxic agents. Toluene users who do not develop significant injury are grossly underrepresented in the literature. Selected case reports are summarized in Table 1. Central and peripheral nervous system, liver, and kidney injury have occurred in association with toluene use.

#### Gasoline

Gasoline (petrol) vapor inhalation occurs primarily among younger children or in isolated cultures where a very limited variety of volatile substances is available. Various gasoline additives present special hazards. Triorthocresyl phosphate (TCP) is an established cause of both upper and lower motor neuronal degeneration with spastic muscle wasting disorders. Benzene, a common ingredient, is an established cause of subacute and chronic disorders of the hematopoietic system, including various combinations of cytopenia and delayed occurrence of leukemia. Organic lead additives may cause acute and chronic lead encephalopathy. The diversity of clinical effects reported in gasoline inhalers is consistent with the effects of these various additives.

\*Although the inhalants described in the following paragraphs and in Table 1 are listed by categories of major or identified constituent, the physiological effects may not be associated solely with this agent or may be due to an action of this and other agents present in the commercial mixture.

TABLE 1  
SUMMARY OF CLINICAL SYNDROMES OF SELECTED CASES FROM THE LITERATURE\*

Chemical Compound/Product	Neurologic - CNS Effects	
	Clinical Effects	Diagnostic/Pathologic Findings
<b>N-HEXANE PRODUCTS</b>		
Yamamura, 1969:		
Author presents a study checking 1,667 workers in Japanese industries with exposure to n-hexane	Quadriplegia, muscle weakness, dysesthesia, muscle atrophy, hypesthesia	Polyneuropathy, axonal degeneration
Herskowitz et al., 1971:		
A report of 3 cabinet workers who developed neuropathy while exposed to n-hexane	Muscle weakness, hypesthesia, areflexia	Neuropathy, increased number of neurofilaments, axonal degeneration
Gonzalez and Downey, 1972:		
Case history of 20-year-old male with 15-month history of glue sniffing (80% n-hexane) who presented with progressive polyneuropathy. Improvement occurred after 2-6 months of admission	Muscle weakness, hypesthesia, paresthesia, muscle atrophy	Polyneuropathy, neurogenic atrophy
Goto et al., 1974:		
Report of 4 cases primarily motor polyneuropathy caused by inhalation of an adhesive agent. Weakness and sensory impairment developed in 7-30 months with symptom progression noted after cessation of activity. Glue also contained toluene	Muscle weakness, muscular atrophy, flaccid quadriplegia, hypesthesia, areflexia, foot and wrist drop	Polyneuropathy, axonal degeneration, neurogenic atrophy, decreased nerve conduction rates
Shirabe et al., 1974:		
Report of 2 patients involved in glue sniffing: one for a 3-year period, one for 2 years plus. Glue first used contained small amounts of n-hexane (0-30% n-hexane, 70-100% toluene)	Paresthesia, flaccid paralysis of extremities, muscular atrophy, hypesthesia	Polyneuropathy, axonal degeneration, denervation atrophy

\* Although the inhalants described in Table 1 are listed by categories of major or identified constituent, the physiological effects may not be associated solely with this agent or may be due to an action of this and other agents present in the commercial mixture.

TABLE 1  
SUMMARY OF CLINICAL SYNDROMES OF SELECTED CASES FROM THE LITERATURE (con.)

Chemical Compound/Product	Neurologic - CNS Effects		
	Clinical Effects	Diagnostic/Pathologic Findings	Other Effects
<b>N-HEXANE PRODUCTS (con.)</b>			
<u>Korobkin et al., 1975:</u> Case report of 29-year-old male with 5-year history of contact cement inhalation. Several months prior to symptom onset, patient changed to brand containing n-hexane. Improvement followed avoidance of n-hexane exposure	Muscle weakness, paresthesia, muscle atrophy of distal extremities	Peripheral neuropathy, axonal abnormalities, decreased nerve conduction rates	
<u>Poulson and Weylonis, 1976:</u> Authors review situation in a small plant using n-hexane in which at least 8 of 50 employees (in 25-year period) developed mild neuropathy. Four patient summaries are presented.	Muscle weakness, hyporeflexia	Polynuropathy	
<u>Towfighi et al., 1976:</u> Report of 2 cases exhibiting chronic glue sniffing behavior. Both patients initially used glues containing no n-hexane (pt. 1, 5 yr. hx., pt. 2, 10 yr. hx.) and experienced good health. Both changed to brand containing n-hexane with onset of symptoms appearing in 1-2 months.	Paresthesia, muscle weakness, atrophy of distal extremities, areflexia	Neuropathy, neurogenic atrophy, axonal swelling, decreased nerve conduction rate	
<b>TOLUENE PRODUCTS</b>			
<u>Grabski, 1961:</u> Author presents case of irreversible cerebellar degeneration following continuous pattern of toluene sniffing lasting several years.	Ataxia, intention tremor posterior column signs, adiadochokinesis	Cerebellar degeneration	Hepatomegaly

TABLE 1  
SUMMARY OF CLINICAL SYNDROMES OF SELECTED CASES FROM THE LITERATURE (con.)

Chemical Compound/Product	Neurologic - CNS Effects		
	Clinical Effects	Diagnostic/Pathologic Findings	Other Effects
<b>TOLUENE PRODUCTS (con.)</b>			
<u>Masengale et al., 1963:</u> Summary of 27 children chronically habituated to inhalation of cement vapors. Toluene was major component of glue used. Two detailed case histories are presented.			Microscopic hematuria
<u>Satran and Dodson, 1963:</u> Summary of patient presenting with 10-year history of toluene inhalation who presented because of loss of consciousness. No systemic abnormalities were found.			
<u>Knox and Nelson, 1966:</u> This paper discusses the report and conclusion of Grabski, 1961.	Ataxia, nystagmus tremor, diffuse EEG, Babinski's reflex	Permanent encephalopathy, corticobulbar damage, diffuse cerebral atrophy, corticospinal damage	Jaundice, hepatocellular damage; anuria, hematuria, proteinuria
<u>O'Brien et al., 1971:</u> Case history of 19-year-old male with 6-year history of glue sniffing. Presentation followed 6-hour sniffing of a liquid cleaner.			
<u>Taher et al., 1974:</u> Two case histories are presented, one patient with a 3-year history of glue sniffing, with a 1-year history of toluene sniffing, other patient with 5-6 day history of sniffing paint (60.4% toluene)	Muscle weakness, flaccid quadriplegia, areflexia		Renal tubular acidosis

TABLE 1  
SUMMARY OF CLINICAL SYNDROMES OF SELECTED CASES FROM THE LITERATURE (con.)

Chemical Compound/Product	Neurologic - CNS Effects		
	Clinical Effects	Diagnostic/Pathologic Findings	Other Effects
<b>TOLUENE PRODUCTS (con.)</b>			
<u>Kelly, 1975:</u> Presentation of case history of 19-year-old female with 1-year history of paint sniffing. Toluene was common in all brands she sniffed.	Intention tremors, impossible tandem gait, ataxia	Cerebellar dysfunction	
<b>GLUE SNIFFING GENERAL</b>			
<u>Glaser and Messingale, 1962:</u> An overview of glue sniffing among children. The authors note that in a 2-year period in Denver, 130 (average age 13) were arrested for glue sniffing. Six detailed case histories are presented.			
<u>Merry and Zachariadis, 1962:</u> Case history of 20-year-old man presenting with an 18-month history of glue sniffing. Presentation was precipitated by the inhalation of 6 tubes of cement glue which resulted in a semi-comatose state.	Tetany		
<u>Powers, 1965:</u> Paper describes 5 adolescents (all with sickle cell disease) who developed hematologic disorders associated with glue sniffing.	Wallerian degeneration, neuronal death		Septicemia, Aplastic anemia, reticulocytopenia, hypoplasia, pancytopenia
<b>GASOLINE PRODUCTS</b>			
<u>Esson, 1962:</u> Two cases of gasoline inhalation in children (ages 11 and 14) are presented in which a degree of physical tolerance is indicated.	"Borderline EEG"		

TABLE 1  
SUMMARY OF CLINICAL SYNDROMES OF SELECTED CASES FROM THE LITERATURE (con.)

Chemical Compound/Product	Neurologic - CNS Effects		
	Clinical Effects	Diagnostic/Pathologic Findings	Other Effects
<b>GASOLINE PRODUCTS (con.)</b>			
<u>Tolan and Ling, 1964:</u> Two cases of adolescents with history of gasoline inhalation are presented.	"Model psychosis"		
<u>Karani, 1966:</u> A case report of a 20-year-old mechanic with a 3-year history of gasoline consumption and inhalation. Author attributes diagnosis to Triorthocresyl phosphate component of gasoline.	Muscle weakness, moderate-severe areflexia, bilateral foot drop, bilateral claw deformity, muscle atrophy, paresthesia	Peripheral neuritis, neurogenic muscular atrophy	
<u>Law and Nelson, 1968:</u> Report of a 41-year-old female presenting with 8-month history of leaded gasoline sniffing (3-4 hr/day) exhibiting a chronic psychosis.	Ataxia, tremor, psychotic behavior, recent memory impairment	Lead encephalopathy	Anemia
<u>Carroll and Abel, 1973:</u> Case report of chronic gasoline inhalation (6 years) in a 14-year-old male.	Choreiform movements, diffuse EEG delirium	Diffuse encephalopathy	Mild liver congestion
<b>AEROSOL PRODUCTS</b>			
<u>Bass, 1970:</u> The author discusses the incidence of sudden sniffing deaths (without plastic bag suffocation) in the 1960's. Details of 5 case histories are presented. In 4 of the 5 cases autopsies were performed which showed no anatomical cause of death. Death occurred after sniffing followed by some stressful situation, i.e., exercise.			

TABLE 1  
SUMMARY OF CLINICAL SYNDROMES OF SELECTED CASES FROM THE LITERATURE (con.)

Chemical Compound/Product	Neurologic - CNS Effects		
	Clinical Effects	Diagnostic/Pathologic Findings	Other Effects
<b>AEROSOL PRODUCTS (con.)</b>			
<u>Traffert, 1974:</u> The author discusses sudden sniffing death problem and the mechanism of death.			Hypercapnia; severe cardiac arrhythmia, ventricular fibrillation
<u>Wenzl et al., 1974:</u> Discussion of 4 teenagers who sniffed PVA.			Acute renal tubular necrosis, proteinuria, uremia; azotemia
<u>Kamm, 1975:</u> Report of a 16-year-old male who inhaled Arid Extra Dry deodorant. Death followed immediately after inhalation.	Cerebral edema		Pulmonary edema, mild to moderate pulmonary vascular congestion; ventricular fibrillation
<u>Poklis, 1975:</u> Report of case history of adolescent death due to aerosol propellant inhalation.			Pulmonary and laryngeal edema at autopsy
<u>Stenderfer, 1975:</u> Case history of 13-year-old male who died following inhalation of fluorocarbons F11 and F12 in cooking spray.			Lung congestion; cardiac arrhythmia
<u>Wilde, 1975:</u> Discussion of inhalation of spray paints with particular reference to those which contain metals, i.e., zinc and copper.	Stepping gait		Systemic absorption of metals
<u>Carlton, 1976:</u> Discussion of 12 cases of death due to fluorocarbon inhalation from 1971-1975. Postmortem: are nonspecific. excitation precedes death.	Anesthetic		

TABLE 1  
SUMMARY OF CLINICAL SYNDROMES OF SELECTED CASES FROM THE LITERATURE (con.)

Chemical Compound/Product	Neurologic - CNS Effects		
	Clinical Effects	Diagnostic/Pathologic Findings	Other Effects
<b>AEROSOL PRODUCTS (con.)</b>			
<u>Crawford, 1976:</u> Report of the death of an adolescent following inhalation of fluorocarbons.			Cardiac arrhythmia
<b>LACQUER THINNER</b>			
<u>Prockop et al., 1974:</u> Seven cases of severe peripheral neuropathy are reported as seen in 7 males (ages 17-22 years) with history of chronic inhalation of lacquer thinner. Syndrome progression was predominately motor.	Muscle weakness, hypalgnesia, hypesthesia, decreased nerve conduction, acute denervation paralysis, paresthesia	"Haffer's" neuropathy, neurogenic muscular atrophy, corticobulbar neuropathy	Respiratory distress, diminished vital capacity
<u>Oh and Kim, 1976:</u> Summary of findings in case of 20-year-old male with 2-year history of "huffing" lacquer thinner.	Muscle weakness, hyperesthesia, moderate areflexia, decreased nerve conduction	Peripheral neuropathy, giant axonal swelling	
<b>LIGHTER FLUID</b>			
<u>Ackerly and Gibson, 1984:</u> Summary of 12 cases of lighter fluid inhalation among children in the San Antonio, Texas, area. Duration of involvement ranged from limited to continuously for 3 years.	Minimal EEG abnormality		Convulsive disorder
<b>CHLOROFORM</b>			
<u>Storms, 1973:</u> Case report of a 10-year-old male who participated in a "chloroform party" in which large amounts of chloroform were inhaled.	Coma		Severe hepatic damage

TABLE 1  
SUMMARY OF CLINICAL SYNDROMES OF SELECTED CASES FROM THE LITERATURE (con.)

Chemical Compound/Product	Neurologic - CMS Effects		
	Clinical Effects	Diagnostic/Pathologic Findings	Other Effects
<b>TRICHLOROETHYLENE</b> <u>Mitchell and Parson-Smith, 1959:</u> Case description of 33-year-old male who worked as a metal degreaser in which he lowered a basket containing metal into warm trichloroethylene. <u>Seage and Burns, 1971:</u> Report of male with history of cardiac disease who drank alcohol following inhalation of trichloroethylene. <u>Hayden et al., 1976:</u> The authors cite three sources of inhalation of cleaning fluids which contain trichloroethylene.	Loss of taste, vertigo, analgesia in all divisions of RT. Trigeminal nerve	Neuropathy	Pulmonary edema
<b>TRICHLOROETHANE</b> <u>Travers, 1974:</u> Case report of an 18-year-old male seaman who collapsed on ship; 28 hr later death occurred. Evidence in his bunk indicated he had been sniffing the substance. <u>Guberen et al., 1976:</u> Case report of a 20-year-old mechanic who inhaled trichloroethane in an episode which led to his death. Autopsy showed no anatomical cause of death.	Vertigo, trigeminal analgesic, decreased visual field.  Cerebral edema	Neuropathy	Jaundice, centrilobular necrosis, hepatomegaly, anuria, hematuria, oliguria, proteinuria (tubular necrosis)  Hematuria; ventricular fibrillation, tachycardia, cardiac arrest  Ventricular fibrillation

TABLE 1  
SUMMARY OF CLINICAL SYNDROMES OF SELECTED CASES FROM THE LITERATURE (con.)

Chemical Compound/Product	Neurologic - CMS Effects		
	Clinical Effects	Diagnostic/Pathologic Findings	Other Effects
<b>BENZENE</b> <u>Vigiani and Saita, 1964:</u> A review of the history of benzene exposure resulting in leukemia. Plus 6 case reports from personal observation in which all worked with benzene. <u>Forni and Moreo, 1967:</u> Case report of a 38-year-old female who worked for 22 years as a cable cleaner using solvents containing benzene. <u>Winek and Collom, 1971:</u> Case report of 18-year-old male who died following inhalation of reagent grade benzene. Boy's head was found inside a plastic bag. <u>Aksoy et al., 1972:</u> Four case histories are reported in which shoemakers using benzene-containing adhesives developed acute leukemia. <u>Aksoy et al., 1974:</u> Two case reports of leukemia following exposure to benzene are discussed with particular reference to the familial factors in this case. <u>Hayden et al., 1976:</u> The authors enumerate several sources of principally industrial exposure resulting in hematologic damage.	Cerebral edema	Epistaxis, hemocytoblastic leukemia, mucosanguineous diarrhea  Hyporegenerative anemia, leukemia  Cerebral edema  Pancytopenia; aplastic anemia, acute myeloblastic leukemia, thrombocytopenia  Acute lymphoblastic leukemia, acute myeloblastic leukemia  Erythroleukemia, pancytopenia, thrombocytopenia, myeloid metoplasia, aplastic anemia	

## Aerosols

Abuse of freon-pressurized aerosol products is common. (Not all aerosols contain freons and many contain solvents other than freon.) The great variety of clinical manifestations attributed to these products is not surprising because of the diversity of contents. The consistently recognized syndrome is sudden death associated with vigorous exertion immediately after inhaling freon. Myocardial sensitization to endogenous epinephrine with ventricular fibrillation is one accepted mechanism. A number of case reports and reviews of freon use appear in the current literature (Carlton, 1976; Crawford, 1976; Kamm, 1975; Poklis, 1975; Standefer, 1975; Treffert, 1974; Wenzl et al., 1974; Wilde, 1975).

### Chlorinated Hydrocarbons

Among the chlorinated hydrocarbon solvents there is a potential for injury of various organ systems especially neuropathy and liver and kidney injury. These substances also sensitize the myocardium to epinephrine-induced dysrhythmia.

### SURVEY OF MEDICAL EFFECTS OF INHALANT ABUSE

During the 2 years of existence of the Houston Polydrug Abuse Research and Treatment Program, 22 patients among 241 admissions were identified as having sustained intense and long-term exposure to inhalants. Among these 22 patients, 8 patients were identified as primarily inhalant users with minimal and sporadic involvement with other drugs. The patients were admitted primarily for drug abuse sufficient to be significantly disruptive of their life style and not selected on medical criteria. This population provides an opportunity to assess the health status of heavy and long-term inhalant users.

All patients in this data base had been using inhalants up to and including the day prior to admission. Seven of the eight patients presented with an acute organic brain syndrome as the predominant finding on the day of admission. Several days were required for the acute organic brain syndrome to clear, and it is assumed that this represents the time required to clear accumulated residual lipophilic vapors from fat depots in the body.\* Completion of any examination dependent on subjective data was difficult during the initial 2 to 3 days of admission because of the confusion, disorientation, and general lethargy manifested by the patients. Neurologic examinations during the initial stages of admission also are unreliable, particularly with regard to ataxia and dysmetria, characteristic findings in acute organic brain syndrome which clear after several days of inhalant-free living.

\*Editor's note: Further work needs to be done to assess whether the amount persisting in tissues can cause these symptoms or whether this is a metabolic process of regeneration or reorganization.

## CASE ABSTRACTS

### Patient #9238

The patient is an 18-year-old white male who presently is on probation. Drug history includes marijuana three months and spray paint inhalation for more than 5 years with use occasionally as much as 12 hours per day. The patient dropped out of school after the tenth grade and presently is living with his family. He had been employed intermittently. Psychiatric diagnosis: Acute organic brain syndrome. The patient was released to his parents against medical advice after 5 days in the inpatient treatment program. Past history reveals a suicide attempt with drugs.

### Patient #9258

The patient is a 23-year-old white female with a 10-year history of drug abuse who considers herself to be physically dependent on Plasticoat aerosol spray. Over the past 2 years she has used Plasticoat, plastic enamels, and toluene from paint thinner. She estimates daily use up to 5 hours. The patient completed the twelfth grade. She has made two suicide attempts with drugs. The patient is married but separated from her husband whose location is unknown. The patient's parents are divorced and the patient has lived in at least five households since the divorce. Both parents are alcoholics. The patient has had approximately 30 arrests with charges currently pending for assaulting a police officer. In 1969 she was hospitalized for 5-1/2 months at the Austin State Hospital. Admission diagnosis: Acute organic brain syndrome. The patient was discharged after 16 days on an inpatient program. Her typical pattern of abuse was to inhale the toluene-based acrylic spray paint for up to 5 hours a day. She managed to remain almost continuously intoxicated during this period by saturating a cloth with the spray paint, placing the cloth in her mouth, and inhaling the vapors through her mouth. Routine physical examination revealed no neurological deficit in either motor sensory function; however, the patient complained of continual muscle pain and loss of sensation distally in her extremities. With the exception of a slightly elevated alkaline phosphatase, her laboratory values were all within normal limits. A routine toxicology screen failed to detect the presence of any common drugs of abuse in her blood or urine. Electromyography and nerve conduction tests failed to indicate evidence of

either peripheral neuropathy or myoneural transmission defects; however, borderline myopathic changes consistent with a low-grade myopathy were observed. A deltoid muscle biopsy was performed and microscopic examination of the muscle specimen indicated the presence of minor pathological changes including isolated rare atrophic skeletal muscle cells with increased sarcolemma cell activity. In general, however, there was no evidence of gross changes that would account for the patient's symptomatology.

Patient #9279

The patient is a 15-year-old Mexican-American male who has used clear plastic acrylic sprays, Texas Shoeshine, and other aerosols three times a week for approximately 1 year. The patient completed the ninth grade and is not in school presently. There were several suspensions for fighting and he has been arrested more than ten times having spent 7 months in Gatesville Prison for automobile theft. The patient's father is an alcoholic who is frequently drunk and belligerent. The patient has never been employed. Psychiatric diagnosis: Acute organic brain syndrome. The patient remained 13 days in the inpatient treatment program.

Patient #9281

The patient is a 21-year-old white male who has been using inhalants for 4 years and now considers himself to be psychologically dependent. Substances used include Texas Shoeshine, clear acrylic spray, and toluene. The patient completed the twelfth grade and currently is on probation by both the county and the state. There have been six arrests with a total of 67 days in Harris County jail. The patient entered the program as an alternative to incarceration. Family background reveals parents divorced and the parents state that they have "given up on him." The patient has had four jobs with 4 months being the longest at any one job. He states his present occupation is "getting high." There have been two previous psychiatric admissions with a tentative diagnosis of paranoid schizophrenia. Psychiatric diagnosis: Acute organic brain syndrome. Duration of hospital stay was 17 days.

Patient #9285

The patient is a 13-year-old Mexican-American male who has been using gold spray paint and Texas Shoeshine every other day for approximately 4 months. The patient was abandoned at birth and reared in foster

homes. Presently he is in the seventh grade and has been suspended from school for disciplinary problems and truancy. There have been two drug-related arrests. Psychiatric diagnosis: Adolescent adjustment reaction and depression neurosis. The patient remained in the inpatient treatment program for 22 days.

Patient #9289

The patient is a 21-year-old Mexican-American male with a history of using glue, paint thinner, and Texas Shoeshine over the past 11 years, three or more times daily. The patient states that he is dependent upon these substances. The patient completed the seventh grade of school and was suspended and has not returned to school. Presently he is unemployed but has been employed intermittently over the past 4 years. The patient has had nine juvenile arrests and four adult arrests with no charges pending currently. Parents are separated. Psychiatric diagnosis: Acute organic brain syndrome with mild retardation. The patient remained in the treatment program for 16 days.

Patient #9308

The patient is a 16-year-old white male who has been using paint thinner and clear acrylic plastic sprays on a daily basis for 2 years. The patient completed the ninth grade and was suspended for poor attendance, inattentiveness, and truancy. The patient has held one job for 14 months and has no arrest record. Both natural parents are dead. Presently being reared by a stepmother and maternal grandparents. Psychiatric diagnosis: Organic brain syndrome. Patient remained in the program 14 days.

Patient #9312

The patient is a 17-year-old white male who has been using clear acrylic paints several times a week for 3 years. The patient completed the eleventh grade and dropped out of school. He has been arrested twice for driving while under the influence of drugs and currently has charges pending for the possession of marijuana. The patient has been in jail on three different occasions. Both parents are alive. Mother is an alcoholic who has had psychiatric hospitalization twice. Father is an epileptic with asthma. Psychiatric diagnosis: Acute organic brain syndrome. Patient remained in the treatment program 14 days.

## DATA SUMMARY

Table 2 summarizes the history of inhalant use for these patients. Table 3 presents positive responses to questions in the review of systems for six of these primary inhalant-using patients. (Case #9238 was excluded because of other drug involvement; data for case #9279 are missing.) Their responses are compared with those of 95 non-inhalant polydrug abuse patients admitted to the Houston Polydrug Abuse Research and Treatment Program. Serum chemistries included: total protein, albumen, calcium, cholesterol, glucose, blood urea nitrogen, uric acid, creatinine, total bilirubin, alkaline phosphatase, lactic dehydrogenase, glutamyl-oxaloacetic transaminase, and glutamic-pyruvic transaminase. These were found to be within normal limits. Other admission evaluation included physical examination, EKG, chest X-ray, complete blood count, and urinalysis. None of these procedures yielded clinically significant findings.

## DISCUSSION

The clinical assessment of the eight inhalant-abusing patients on whom data are presented was not designed prospectively specifically for evaluation of inhalant users, but was the routine clinical assessment performed on all Polydrug patients. The data illustrate that no abnormalities of clinical significance were detected by the approaches used for medical assessment. The only exception is the acute organic brain syndrome which was manifest on their admission to the unit. This was manifest by varying degrees of ataxia, lethargy, irritability, confusion, and in some cases disorientation and impaired short-term memory. The acute organic brain syndrome characteristically disappeared in a time frame consistent with the metabolism and/or excretion of accumulated lipid soluble psychoactive volatiles.

These data are remarkable for the absence of abnormalities. In this population selected for heavy and prolonged inhalant use, there was no evidence of neuropathies, liver injury, kidney injury, anatomical lung changes, or hematopoietic abnormalities. The opinion that frequent and prolonged inhalant use does not commonly result in significant tissue injury is supported by this investigation. These data do not address the issue of more subtle abnormalities detectable by neuropsychological testing and their etiology. Neither do they address the problem of delayed increase in incidence of neoplastic disease requiring 10 to 30 years to be manifest. They also comprise a small sample and may not be very representative of the inhalant population.

## MEDICAL EVALUATION OF INHALANT USERS

Medical evaluation of inhalant users may have to be performed in several stages or repeated several days after the patients have

TABLE 2  
INHALANT USE HISTORY OF SELECTED CASES\*

Case No.	Age, Ethnicity and Sex	Substance	Duration	Frequency
9238	18 WM	Spray paint	> 5 yr	Daily up to 12 hr
9258	23 WF	Acrylic spray Enamel spray Toluene	2 yr	Daily X3 up to 5 hr
9279	15 M-AM	Acrylic spray Texaco Shoe Shine	1 yr	Weekly X3
9281	21 WM	Acrylic spray Lacquer Toluene	4 yr	Daily X3
9285	13 M-AM	Gold spray paint Texaco Shoe Shine	4 mo	Weekly X 3-4
9289	21 M-AM	Glue Paint thinner Texaco Shoe Shine	11 yr	Daily X3+
9308	16 WM	Acrylic spray Paint thinner	2 yr	Daily
9312	17 WM	Acrylic spray	3 yr	Weekly

\*Age, ethnicity, sex, substances used, duration of use, and frequency of use for eight patients (selected from 241 polydrug admissions) for primary solvent abuse without significant simultaneous abuse of other substances.

WF = White female.

WM = White male.

M-AM = Mexican-American male.

TABLE 3  
REVIEW OF SYSTEMS OF SELECTED CASES\*

	9256	9281	9285	9289	9308	9312	No. Positive	% Positive	95 Drug abuse admissions, % positive	
Ear disease										20
Nose, sinus, throat	+				+		2	33		49
Fainting spells										27
Loss consciousness										32
Convulsions										17
Paralysis										5
Dizziness	+						1	16		63
Frequent severe headaches	+	+		+			4	66		66
Depression, anxiety	+	+		+			3	50		76
Difficulty concentrating	+	+		+			2	33		46
Memory problems	+	+		+			2	33		69
Enlarged glands										16
Skin disease										10
Chronic or frequent cough	+	+		+			4	66		29
Chest pain or angina	+	+		+			3	50		29
Cough blood	+	+		+			3	50		20
Night sweats					+		1	16		37
Shortness of breath	+	+					2	33		55
Palpitations, heart fluttering										26
Swelling hands or feet										27
Back, arm, or leg problems										23
Varicose veins										8
Extreme tiredness or weakness	+	+		+			3	50		57
Kidney disease										22
Bladder disease										4
Urine albumin, sugar										2
Urine pus or blood										4
Difficulty urinating					+		2	33		19
Abnormal thirst	+			+			1	16		27
Stomach trouble, ulcer	+			+			2	33		38
Indigestion										42
Appendicitis										15
Liver-gall bladder disease										5
Colitis or bowel disease										7
Hemorrhoids-rectal bleeding										18
Constipation or diarrhea	+									42

\*Review of systems on six primary solvent abuse patients showing number and percent of positive responses; percent of positive responses on 95 drug abuse patients not primarily solvent users (Case 9238 was excluded because of other drug involvement; data for case 9279 are missing).

been free of inhalant use. This is necessary in order to differentiate effects due to the influence of volatile substances in the body in contrast with residual effects present after the substances have been cleared from the body. Aspects of the examination which require responsiveness from the patient or subjective assessment may vary substantially from the first day of admission to a drug-free program as compared with similar assessment after 3 to 4 days.

#### Clinical Assessment

#### Chief Complaints

The chief complaint should review in brief form the principle immediate health concerns of the patient along with a statement of the duration of each health concern. For example, a usual complaint would be headache. A brief simple statement should indicate the location, the quality, the frequency, and duration of headaches experienced by the patient. Other chief complaints may be dizziness, loss of memory, inability to think, cough, easy bruising or easy bleeding, abdominal pains, menstrual disorders, urinary pain, muscle cramps, weakness in extremities, numbness or tingling in the extremities, or spotty paralysis. These are examples of typical chief complaints and not an exhaustive enumeration. Each statement of a chief complaint should give the location, the duration, the frequency, and the quality of the health concern involved.

A patient experiencing an acute organic brain syndrome secondary to the immediate effects of inhaled substances may not have a chief complaint upon his admission to a treating program. Several days may be required before the confusion clears.

#### Present Illness

The present illness consists of a careful, detailed chronological development of circumstances leading to the illness enumerated in the present illness. In the case of inhalant users, the present illness should include a statement as to first involvement with inhalants, the types of inhalants used and the manner in which they were used; for example, head in a plastic bag, inhaled through a saturated cloth, inhalation from a rigid container. A description of the present illness may well be developed from exploring with the patient the most recent time that he felt himself to be normal or well. The time of onset of all symptoms should be recorded and the chronological development of symptoms explored. The present illness should include detailed description of therapeutic intervention undertaken during the course of the present illness. This should include doctors or other health care persons visited and nature of therapy undertaken, particularly the use of prescription drugs. Attempts at self-treatment should be explored and enumerated, especially with reference to use of

over-the-counter drugs or use of other home remedies. The present illness should consist of the patient's description of the chronological development of his current clinical status. Examiner should avoid extensive probing in a manner such as to be suggestive of manifestations which the observer injects into the patient's account of his illness. When a patient complains of such symptoms as chills, fever, headache, gastrointestinal disturbances, cough, regional pain, or any other general or local symptoms, then these should be documented with respect to their time of first onset and changes in the quality and duration of these symptoms as the present illness has progressed. The relationship of any complaint to the pattern of use of inhalants should be documented since the use of inhalants is intermittent and cyclic. Some disabilities may occur only while under the influence of volatile substances while others persist through the non-use period.

#### Review of Systems

In order to determine the presence or absence of specific significant manifestations, a review of systems as detailed in any standard text on internal medicine should be documented.

#### Past Medical History

Inquiry into past medical history should include documentation of physician visits wherever possible, with identification of the name and address of the physician to facilitate obtaining past records. Any hospitalization should be identified as to date, duration, principle reason for admission, and name of the attending physician so as to facilitate obtaining hospital records. Consent forms for obtaining past medical records should be signed by the patient at this time. Inquiry should be made as to childhood diseases, acute or chronic infections with description as to nature, duration, treatment, and complications. Any injuries sustained should be documented, described, and resulting disabilities enumerated.

#### Employment History

Any jobs held by the patient should be documented as to time the job began, duration of employment, nature of work with special regard to potential for exposure to occupationally related toxic substances, especially solvents and metals. Reasons for discontinuing each job should be documented.

#### Personal and Social History

A complete social and personal history should be documented.

#### General

At this point in the clinical assessment, there is a 70 to 80 percent chance of identifying probable areas of disability associated with inhalant use. The remainder of the examination should be guided by the findings evoked in the preceding assessment. The remainder of the examination is predominantly confirmatory although an additional 20 percent of existing disability may remain to be discovered by subsequent procedures.

#### Physical Examination

Physical examination must be performed by meticulous, consistent adherence to predetermined protocol. The general physical examination may lead to areas of special concern requiring more elaborate diagnostic procedures to investigate variation from normal. Physical examinations must be performed in a compassionate and considerate manner; a cursory 10-minute physical examination is totally unsatisfactory. Although reasonable consideration of the patient's modesty must be observed, a complete physical examination cannot be performed on a partially clothed patient. The physical examination should be quantitative not qualitative; for example, descent of the liver edge below the costal margin should be stated in centimeters not finger breadths. Identified masses should be measured rather than described in qualitative terms. Pupillary size should be measured in millimeters. Data recovered from physical examination should be objective and stated without interpretation. For example, the identification of the left upper quadrant mass should be indicated as to size, consistency, mobility, and not necessarily construed as splenomegaly, since it may well be another abnormal intra-abdominal mass. Assessment of liver size must not be performed exclusively on the basis of palpation of the liver edge below the costal margin since a patient with chronic emphysema may have enlarged chest capacity, depressed diaphragm, and abnormal liver position rather than an actually increased liver size. The physical examination, however, must not be rigid to the extent of exclusion of diversion for more comprehensive assessment of particular findings. The alert physician will pursue, in depth, abnormalities presented in the routine physical examination. For example, discovery of a dusky or bluish discoloration of the skin and nails may lead to a false assumption of representing hypoxemia secondary to lung pathology, whereas in fact the discoloration may be secondary to methemoglobinemia induced by inhalation of aromatic substances in patients with a glucose-6-phosphate dehydrogenase deficiency which impairs ability to correct methemoglobinemia. The discovery of an abnormal heart sound should lead to examination at rest, after exercise, and in varying positions in order to complete its assessment.

Before the performance of hands-on examinations, basic data on the patient should be obtained by observation of his activity.

The patient is asked to stand, to walk toward and away from the observer and to sit on the edge of the examining table. This permits recognition of characteristic abnormalities in body posture, gait, associated movement, ataxia, gross defects in motor neurologic control, gross limitations of motion as well as assessment of the patient's mood and cooperativeness, and assists in development of initial rapport with the physician. A hasty, inconsiderate attitude on the part of the physician will lead to an irritable, uncooperative patient preventing the performance of an effective, maximally informative physical examination.

Neurological examination. The neurological examination of the inhalant-abusing patient is probably the most difficult part of the physical examination. If performed in a cursory manner, many abnormalities will be missed. Because of the frequency with which subtle neurological abnormalities are associated with the commonly inhaled substances, neurologic assessment must be comprehensive. Suitable outlines for further neurologic examination occur in most text books of neurology. The neurologic assessment of these patients is addressed in the following chapter of this volume.

Genetic defects. Certain preexisting genetic defects are known to influence response to toxic substances, many of which appear among the volatiles to which inhalant abusers are exposed. The best example is the occurrence of a glucose-6-phosphate dehydrogenase deficiency, especially common among the non-Caucasian races. The presence of this deficiency increases the sensitivity to lead poisoning, increases sensitivity to intravascular hemolysis induced by aromatic solvents in drugs and increases sensitivity to methemoglobinemia induced by a number of toxic substances. Other genetic abnormalities influencing response to toxic substances include the hemoglobinopathies. Presence of sickle cell and thalassemia hemoglobin may significantly influence response to commonly inhaled vapors (Powers, 1965). The area of genetic predisposition to toxicologic injury is still in an investigational stage and future research is sure to yield additional examples.

Extended clinical examinations. The medical workup of inhalant abusing patients should include chest X-ray, EKG, EEG, and EMG. A screening electromyographic assessment, particularly in the lower extremities, should be an essential component of all clinical assessment of inhalant-abusing patients. It is equally as important to document normal nerve conduction and normal EMG as it is to document an abnormal result. Data are not sufficient at this time to permit a logical decision upon which to base the need for electromyographic assessment. If in the course of physical examination obvious abnormalities in motor function, deep tendon reflexes, or peripheral sensory perception are identified, there is no doubt that an EMG should follow. However, accumulated clinical experience is not yet sufficient to determine whether electromyographic abnormalities might be present in the absence of clinically detectable abnormalities.

Laboratory examinations. Clinical laboratory examination of the inhalant-abusing patient should include a CBC, serum iron, iron binding capacity, and a bone marrow in the event peripheral hematologic abnormalities are identified. A routine urinalysis is required and this examination should include a careful microscopic assessment of sediment performed within a few hours of collection in order to assure reliable identification of formed elements in the sediment. Serum chemistry should include the usual SMA 12 battery on serum collected while the patient is in the fasting state, and minimally should include a total protein, albumin, cholesterol, glucose, blood urea nitrogen (BUN), uric acid, creatinine, bilirubin, alkaline phosphatase, lactic dehydrogenase (LDH), glutamic-oxaloacetic transaminase (SGOT), glutamic pyruvic transaminase (SGPT), and should be supplemented with creatinine phosphokinase. A glucose-6-phosphate dehydrogenase activity of red blood cells should be determined on non-Caucasian patients minimally. Laboratory assessment also is valuable to determine the chemical nature of the substances the patient has been using. In order to achieve this, exhaled air, blood, or urine is suitable for examination of particular substances. Almost all commonly used inhalants can be identified by one or more of these specimens if they are collected within 24 hours of the last inhaling episode. In some instances volatiles may be identified as long as a week or more after their last use.

#### CONCLUSIONS

The literature documents numerous episodes of individual and/or sporadic outbreaks of significant injury associated with the abuse of inhalant substances. Clinical assessment of chronic inhalant users, not presenting with primary medical complaints has revealed remarkably little in the way of objectively documentable impairment. The overall health significance of inhalant abuse can be assessed only by elaborate and detailed examination of a cross section of long-term inhalant users. Only this type of research will determine whether inhalant abuse constitutes a general hazard to health as opposed to sporadic outbreaks of significant injury secondary to an unusually toxic component in a particular product.

#### REFERENCES

- Ackerly, W., and G. Gibson. Lighter fluid "sniffing." Psychiatry, 120:1056-61, 1964.
- Aksoy, M., K. Dincol, S. Erdem, and G. Dincol. Acute leukemia due to chronic exposure to benzene. Am J Med, 52:160-5, 1972.
- Aksoy, M., S. Erdem, G. Erdogan, and G. Dincol. Acute leukemia in two generations following chronic exposure to benzene. Hum Hered, 24:70-4, 1974.

Knox, J., and J. Nelson. Permanent encephalopathy from toluene inhalation. N Engl J Med, 275:1494-6, 1966.

Korobkin, R., A. Asbury, A. Sumner, and S. Nielsen. Glue-sniffing neuropathy. Arch Neurol, 32:158-62, 1975.

Kramer, N. Availability of volatile nitrites. JAMA, 237:1693, 1977.

Law, W., and E. Nelson. Gasoline-sniffing by an adult. JAMA, 204:1002-4, 1968.

Massengale, O., H. Glaser, R. LeLievre, J. Dodds, and M. Klock. Physical and psychologic factors in glue sniffing. N Engl J Med, 269:1340-4, 1963.

Merry, J., and N. Zachariadis. Addiction to glue sniffing. Br J Med, 2:1448, 1962.

Mitchell, A., and P. Parsons-Smith. Trichloroethylene neuropathy. Br Med J, 1:122-3, 1969.

O'Brien, E., W. Yocoman, and J. Hobby. Hepatorenal damage from toluene in a "glue-sniffer." Br Med J, 2:20-30, 1971.

Oh, S., and J. Kim. Giant axonal swelling in "huffer's" neuropathy. Arch Neurol, 33:583-6, 1976.

Paulson, G., and G. Waylonis. Polynuropathy due to n-hexane. Arch Intern Med, 136:880-2, 1976.

Poklis, A. Determination of fluorocarbon II and fluorocarbon 12 in post mortem tissues: A case report. Forensic Sci, 5:53-9, 1975.

Powers, D. Aplastic anemia secondary to glue sniffing. N Engl J Med, 273:700-2, 1965.

Prockop, L., M. Alt, and J. Tison. "Huffer's" neuropathy. JAMA, 229:1083-4, 1974.

Satran, R., and V. Dodson. Toluene habituation. N Engl J Med, 268:719-21, 1963.

Seage, A., and M. Burns. Pulmonary oedema following exposure to trichloroethylene. Med J Aust, 2:484-6, 1971.

Shirabe, T., T. Tsuda, A. Terao, and S. Araki. Toxic polynuropathy due to glue-sniffing. J Neurol Sci, 21:101-13, 1974.

Standefer, J. Death associated with fluorocarbon inhalation. Report of a case. J Forensic Sci, 20(3):548-51, July 1975.

Bass, M. Sudden sniffing death. JAMA, 212:2075-9, June 1970.

Carlton, R. Fluorocarbon toxicity: Aerosol deaths and anaesthetic reactions. Ann Clin Lab Sci, 6:411-4, September-October 1976.

Carroll, H., and G. Abel. Chronic gasoline inhalation. South Med J, 66:1429-30, 1973.

Crawford, W. Death due to fluorocarbon inhalation. South Med J, 69:506-7, April 1976.

Easson, W. Gasoline addiction in children. Pediatrics, 29:250-4, 1962.

Forni, A., and L. Moreo. Cytogenetic studies in a case of benzene leukaemia. Eur J Cancer, 3:251-5, 1967.

Glaser, H., and O. Massengale. Glue sniffing in children. JAMA, 181:300-3, 1962.

Gonzalez, E., and J. Downey. Polynuropathy in a glue-sniffer. Arch Phys Med Rehabil, 53:333-7, 1972.

Goto, I., M. Matsumura, N. Inoue, Y. Murai, K. Shida, T. Santa, and Y. Kuroiwa. Toxic polynuropathy due to glue sniffing. J Neurol Neurosurg Psychiatry, 37:848-53, 1974.

Grabski, D. Toluene sniffing producing cerebellar degeneration. Am J Psychiatry, 118:461-2, 1961.

Gubéran, E., O. Fryo, and M. Robert. Sudden death from ventricular fibrillation after voluntary inhalation of chloroethene in a mechanics apprentice. Schweiz Med Wochenschr, 106:119-21, January 1976.

Hayden, J., E. Comstock, and B. Comstock. The clinical toxicology of solvent abuse. Clinical Toxicology, 9:169-84, 1976.

Herskowitz, A., N. Ishii and H. Schaumburg. n-Hexane neuropathy. New Engl J Med, 285:82-5, 1971.

Kamm, R. Fatal arrhythmia following deodorant inhalation: Case report. Forensic Sci, 5:91-3, 1975.

Karani, V. Peripheral neuritis after addiction to petrol. Br Med J, 2:216, 1966.

Kelly, T. Prolonged cerebellar dysfunction associated with paint-sniffing. Pediatrics, 56:605-6, 1975.