

# Street Level Heroin, an Overview on Its Components and Adulterants

Maryam Akhgari<sup>1</sup>, Afshar Etemadi-Aleagha<sup>2</sup>, Farzaneh Jokar<sup>1</sup>

<sup>1</sup>Department of Forensic Toxicology, Legal Medicine Research Center, Legal Medicine Organization, Tehran, Iran; <sup>2</sup>Department of Anesthesiology, Tehran University of Medical Sciences (TUMS), Amir Alam Hospital, Tehran, Iran

## INTRODUCTION

There are many definitions for drug abuse in different societies. Drug or substance use for any reason other than therapeutic purposes to change physical or mental functions (euphoria, sedation, etc.) is termed drug or substance abuse. Substance abuse or illicit drug abuse has negative consequences, which may produce problems for abusers (Shannon et al., 2008). Abused substances are classified into various groups. Opium and its natural, semi-synthetic, and synthetic derivatives constitute a big category of abused substances. Heroin is a semisynthetic derivative of morphine originated from opium. Street heroin contains many adulterants in addition to its main proposed active ingredient (heroin, diacetylmorphine, also known as diamorphine). Some of these adulterants are inert and others have pharmacological action. Adulterants can vary street heroin purity. The occurrence of fatalities with this highly addictive substance can be associated with the effects of adulterants, microbial contamination, and variation in heroin purity (McLauchlin et al., 2002).

This chapter provides an overview of the constituents in street heroin samples. It starts with the categorization of opioids followed by an explanation of the history of heroin production and marketing and finally its pulling out of the drug market. The production process for illicit heroin is explained in Sections A Focus on Heroin Production Process, Definition of Controlled Substances, and Controlled Substances Act Schedules. Then we cover the Controlled Substances Act and Controlled Substances Act Schedules. Opioid pharmacology and the effects of opioids on receptors are reviewed, followed by a discussion of the physical appearance of heroin, routes of heroin administration, and body packers of heroin. Street names or slang terms used for heroin, its combination with other drugs, and the presence of adulterants in heroin samples are discussed in Sections Street Names and Slang Terms for Heroin and Component Analysis of Heroin. The last, important, part of the chapter explains the medical consequences of street heroin abuse.

With the reviews contained in this chapter the reader will have a general knowledge about heroin pharmacology, its manufacturing processes, the adulterants added to it, and finally the health consequences of its use.

## AN OVERVIEW OF OPIATES

Opium is a highly addictive natural and nonsynthetic opioid, which is obtained from the poppy plant, *Papaver somniferum*. Opium is the base substance for the synthesis of various medications.

## Classification of Opioids According to Source

Opioid-derived drugs are categorized into three subgroups:

1. Natural opiates: morphine, codeine, and opium are natural opiates. These are alkaloids found naturally in poppy seeds.
2. Semisynthetic opiates: heroin, oxycodone, oxymorphone, and buprenorphine are half-natural substances. Opium is used as a base for the synthesis of these drugs.
3. Synthetic opiates: fentanyl, pethidine, and dextropropoxyphene are not found naturally and are manufactured in laboratories.

## Classification of Opioids According to Chemical Structure

There are numerous chemical structures for opioids:

1. Phenanthrenes: morphine, codeine, heroin, hydromorphone, and oxycodone.
2. Benzomorphanes: pentazocine and phenazocine
3. Diphenylpropylamines: propoxyphene, methadone, levo- $\alpha$ -acetylmethadol, loperamide
4. Phenylpiperidines: meperidine, also known as pethidine
5. Anilidopiperidines: fentanyl, alfentanil, and sufentanil
6. Oripavine derivatives: etorphine, dihydroetorphine, and buprenorphine
7. Morphinan derivatives: levorphanol and butorphanol
8. Other types of opioids: some types of synthetic opioids do not belong to the mentioned categories. One of these drugs is tramadol, a synthetic analogue of codeine (Stolberg, 2011).

## Classification of Opioids According to Their Effects on Opioid Receptors

The opioid receptors are named  $\mu$ ,  $\kappa$ ,  $\delta$ ,  $\sigma$ , and  $\epsilon$ . Opioids can act as agonists, antagonists, agonists/antagonists, or partial agonists (Contet, Kieffer, & Befort, 2004).

## HISTORICAL REVIEW OF HEROIN

The word heroin is derived from the German word “heroisch” (heroic) owing to its producing a heroic feeling in users. Heroin was first synthesized by chemist Charles Romley Alder Wright in 1874 in England to find a nonaddictive alternative for morphine (Wright). Twenty-three years later heroin was first marketed by Bayer Pharmaceutical Company in 1897. Heroin was sold as a cough medicine in a variety of dosage forms, tablets, mixed into cough syrups, mixed with glycerin to make an elixir, and as heroin salts mixed with water, and was exported to 23 countries as a cough medicine. As a result of physicians’ reports of their patients’ addiction to this medicine within months of its widespread prescription and use, Bayer pulled its heroin cough medicine from the market in 1913. Heroin was regulated by international authorities to restrict its production, distribution, and use. The ban on heroin production converted it to an illegal drug. Illicit manufacturing and trafficking of this highly addictive substance were started in many countries. The quantity of heroin seizures underwent a tenfold increase from 1970 to 2014 (Heroin Wikipedia, 2014).

## A FOCUS ON THE HEROIN PRODUCTION PROCESS

One of the Asian businesses is illegal cultivation of *P. somniferum*. Western countries such as Mexico and Colombia produce opium poppy. Afghanistan, Pakistan, Turkey, Iran, and India are other countries that produce opium. According to a United Nations Office on Drugs and Crime report Afghanistan is the world’s largest supplier of opium poppy. *P. somniferum* is a flowering plant that is the main source for heroin manufacturing. Flowers of the plant convert to round grayish-green fruits, which develop into capsules also called the seedpod or poppy head. After the pods are fully mature they are ready to be incised by iron or glass blades. Incisions cause a white latex to drip onto the surface of the pods. This white latex oxidizes, darkens, and thickens overnight to produce opium. Opium contains over 40 different alkaloids. Most of these alkaloids are salts of meconic acid. The most important alkaloid of opium is morphine. The *P. somniferum* morphine content is about 9–14%. The next prominent alkaloid is codeine. Other alkaloids of opium include noscapine, papaverine, thebaine, narceine, protopine, laudanine, codamine, and cryptopine, among others. Morphine can be extracted and purified from opium to be a source of illicit heroin production. However, clandestine laboratories are not able to extract and purify morphine ideally and some of the opium alkaloids remain as impurities of origin in illegally synthesized heroin.

Acetylation of morphine converts it to heroin. The most important chemical used in the acetylation process of heroin is acetic anhydride. Morphine is mixed with acetic anhydride and heated. The product is heroin (3,6-diacetylmorphine) with other impurities (Cannabis, Coca & Poppy; Nature’s Addictive Plants, Production & Distribution, 2014; Zerell, Ahrens, & Gerz, 2005).

## DEFINITION OF CONTROLLED SUBSTANCES

The abuse potential of a drug or substance can be estimated by some items; they include:

1. There is evidence that a drug or substance is used in sufficient amounts to become a health hazard for the abuser or other people in the community.
2. The drug was diverted significantly from a legal drug channel or its original purpose to an illegal use.
3. The drug is used by individuals without any medical advice from a practitioner.
4. The drug is new and its action is similar to that of other drugs already listed as having a potential for abuse.

## CONTROLLED SUBSTANCES ACT SCHEDULES

Manufacturing, importation, possession, use, and distribution of certain drugs such as narcotics, stimulants, etc., and other chemicals are regulated by US federal drug policy. All substances that are regulated under federal law have been placed by the Controlled Substances Act into one of five schedules.

### Schedule I

1. Has high abuse potential;
2. Has no accepted medical use in treatment in the United States or its use lacks accepted safety in treatment under medical supervision:
  - Heroin, 3,4-methylenedioxyamphetamine (ecstasy), methaqualone, lysergic acid diethylamide (LSD), marijuana, mescaline, psilocybin, tetrahydrocannabinol

### Schedule II

1. The substance has high abuse potential;
2. The substance has currently accepted medical use in treatment in the United States or severe restrictions needed to be used in treatment;
3. Abuse of the substance induces severe psychological or physical dependence:
  - Cocaine/crack, raw opium, codeine, hydromorphone, morphine, oxycodone (oxycontin), oxymorphone, methadone, pethidine, amphetamine, methamphetamine, phenmetrazine, phencyclidine

### Schedule III

1. The potential for substance abuse is less than for the substances listed in Schedules I and II;
2. The substance has currently accepted medical use in treatment in the United States;
3. Abuse of the substance may induce moderate or low physical dependence or high psychological dependence:
  - Anabolic steroid, ketamine

## Schedule IV

1. The substance has a low potential for abuse in comparison with substances in Schedule III;
2. The substance has currently accepted medical use in treatment in the United States;
3. Abuse of the substance may induce limited physical dependence or psychological dependence in comparison to the substances in Schedule III:
  - Dextropropoxyphene (Darvocet), alprazolam (Xanax), clonazepam (Klonopin), diazepam (Valium), lorazepam (Ativan), pentazocine, phentermine, zolpidem (Ambien)

## Schedule V

1. The substance has low potential for abuse in comparison to the substances in Schedule IV;
2. The substance has currently accepted medical use in treatment in the United States;
3. The substance has limited physical dependence or psychological dependence problems in comparison to the controlled substances in Schedule IV:
  - Cough medicines with codeine

As is seen in this section, heroin is categorized as a Schedule I substance with high potential for abuse ([Controlled Substance Schedules, 2012](#)).

## HEROIN PHARMACOLOGY

After intravenous (iv) injection, smoking, or snorting, heroin enters the bloodstream and crosses the blood–brain barrier (BBB) rapidly, but in oral administration heroin undergoes extensive first-pass metabolism. Plasma butyrylcholinesterase is the primary enzyme responsible for the activation of heroin ([Qiao, Han, & Zhan, 2013](#)). Hydrolysis converts heroin to its active metabolite, 6-monoacetylmorphine (6-MAM), and its inactive one, 3-MAM, followed by transformation to morphine. Heroin is more lipid soluble, more potent, and 100 times faster acting than morphine. The difference between heroin and morphine lies in the two acetyl groups in heroin's structure, which increase the solubility of heroin in lipid tissues and make for an easy passage through the BBB ([Zovko & Criscuolo, 2009](#)). The affinity of heroin for  $\mu$  opioid receptors is very low ([Selley et al., 2001](#)). Heroin exerts its analgesic effect by two active metabolites, 6-MAM and morphine. These two metabolites have an agonistic effect on  $\mu$  opioid receptors in the brain and spinal cord of the central nervous system (CNS). Also, morphine is a weak agonist at the  $\delta$  and  $\kappa$  opioid receptor subtypes. Morphine binding to  $\delta$  and  $\kappa$  receptors reduces the inhibitory effect of  $\gamma$ -aminobutyric acid (GABA) on dopaminergic neurons by inhibiting the release of GABA from the nerve terminals ([Katzung, 2001](#)).

Morphine (heroin metabolite) is metabolized by conjugation with glucuronic acid and by other minor routes of metabolism, including deamination, to produce normorphine ([Trescott, Datta, Lee, & Hansen, 2008](#)). Conjugation yields two metabolites, morphine-3-glucuronide (M3G) and M6G. M6G has an analgesic effect and respiratory depressant activity ([Peat, Hanna, Woodham, Knibb, & Ponte, 1991](#)). The  $\mu$  opioid receptors mediate some pharmacological actions of heroin, such as respiratory depression, euphoria, and physical dependence ([Hosztafi, 2003](#)).

Street heroin has variable composition and purity and can cause death in heroin abusers through respiratory arrest.

## WHAT DOES HEROIN LOOK LIKE?

Heroin is a fine white powder with a bitter taste in its purest form ([Figure 1](#)) ([What is heroin cut with?, 2014](#)). It contains up to 85–95% diacetylmorphine. Nonpure heroin varies in chemical and physical appearance. It contains additives and adulterants, which influence its appearance. Additives make heroin appear as gray, pink/beige, brown, or black granular lumps or black sticky material (black tar) ([Figures 2 and 3](#)). Asian heroin is a brown coarse powder with poor water solubility ([Ciccarone, 2009](#)).



**FIGURE 1** Heroin is a fine white powder in its purest form.



**FIGURE 2** Additives can make heroin appear as gray, pink/beige, brown, or black granular lumps.



**FIGURE 3** Additives can also make heroin appear as a black sticky material (black tar).



Black tar is a product of postprocessing hydrolysis of heroin. Hydrolysis can be mediated by water or excess acid in heroin samples. 6-MAM content above 10% can be an indicator of post-processing hydrolysis of heroin ([Drugs of abuse, Heroin, 2014](#)).

## ROUTES OF ADMINISTRATION FOR HEROIN

The route of administration is an important factor influencing the onset of heroin effects. Heroin can be nasally insufflated, or “snorted,” smoked, or injected into veins, into muscles, or under the skin. Oral or rectal routes are other ways of using heroin.

Heroin blood concentration rises quickly after iv injection. Using heroin by other routes of administration such as smoking, insertion into the vagina or anus, snorting, and oral routes can produce slower effects in comparison to the iv method ([Klous, Van den Brink, Van Ree, & Beijnen, 2005](#)). For reaching a quick and potent “high,” heroin is most often used by iv injection to easily accessible arm veins or the femoral vein in the groin ([Senbanjo, Tipping, Hunt, & Strang, 2012](#)). As iv injection has the risk of sharing needles and spreading infectious diseases such as human immunodeficiency virus, hepatitis B and C, and other blood-borne diseases, some heroin abusers choose other routes of administrations such as insufflation or snorting ([Clatts, Giang, Goldsamt, & Yi, 2007](#)). In this method heroin is crushed into fine particles. This fine powder can be inhaled through a rolled-up paper into the nose. Liquefied heroin may be sniffed by nasal spray bottles, a practice known as “shabanging” ([A Dictionary of Slang Drug Terms, Trade Names, and Pharmacological Effects and Uses, 1997; Heroin CESAR, 2014](#)). Abusers who have the experience of iv routes do not use other methods of drug administration, because the “rush” encourages them to use the iv route rather than smoking, snorting, or eating ([Hosztafi, 2011](#)). Abusers of heroin experience little to no “rush” after an oral dose, also the first-pass metabolism decreases heroin bioavailability after oral administration ([Klous, Van den Brink, Van Ree, & Beijnen, 2005](#)).

Heroin may be used as suppository (anal insertion) or pessary (vaginal insertion) by pushing dissolved heroin in a water base into the anus or vagina ([Heroin Abuse and Suppositories, 2014](#)).

## BODY PACKING OF HEROIN

Internal concealment of wrapped packets of illicit drugs (heroin, amphetamines, marijuana, and other substances) in the body to transport them is called body packing. These packets can either be swallowed or inserted into the rectum or vagina. Accidental deaths due to the rupture of drug packs have been reported in some studies ([Njau, Raikos, Spagou, Tzikas, & Tsoukali, 2010](#)). [Figure 4](#) shows street heroin packets extracted from the stomach of a body packer. As is shown, one packet was punctured.

## STREET NAMES AND SLANG TERMS FOR HEROIN

### Definition of Street Drug Names

Street drugs or illegal substances often have slang names. These names are chosen by abusers to describe the drug or its action on the body or to confuse police agents who are looking for heroin suppliers. Many geographic areas have their specific slang names



**FIGURE 4** Street heroin packets extracted from the stomach of a body packer. As is shown, one packet was punctured.

for illicit drugs; also, in police stations and courtrooms they are called by their own selected names. Another reason for using slang names is to disguise the activity of abusers.

## Common Street Names for Heroin

Heroin has many common street names, for example, brown sugar, boy, black, black tar, black pearl, black stuff, black eagle, brown, brown crystal, brown tape, brown Rhine, big bag, blue bag, blue star, brick gum, China white, chiba or chiva, dope, dragon, H, Iranian crack, junk, Mexican brown, Mexican mud, Mexican horse, mud, Number 3, Number 4, Number 8, skag, smack, snow, snowball, scat, sack, skunk, tar, white, white nurse, white lady, white horse, white girl, white boy, white stuff.

## Street Names for “Mixed” Drugs

Sometimes heroin is mixed with other drugs to obtain a certain pharmacologic effect. Slang terms for these mixtures are shown in [Table 1](#) ([Akhgari, Jokar, Bahmanabadi, & Etemadi-Aleagha, 2012; Casa Palmera Staff, 2010; Kazemifar, Solhi, & Badakhshan, 2011](#)).

## COMPONENT ANALYSIS OF HEROIN

Why is it important to analyze the components of heroin?

Analysis of seized street heroin is important for legal purposes. Analysis of heroin shows that two or more samples are linked to one another (i.e., they came from an identical source, from one batch or from the same clandestine laboratory, characterized by inert and life-threatening adulterants ([Lurie, Driscoll, Cathapermal, & Panicker, 2013](#))).

## Adulterants and Diluents in Street Heroin

The terms adulterant and diluent are used for substances added to illicitly distributed controlled drugs in addition to the active ingredients. Adulterants may have mild to serious health consequences and sometimes be fatal in abusers. While “adulterants” and “diluents” have differences, they share a common characteristic in that they refer to all additional substances added to illicit drugs

**TABLE 1** Street Names for Drug Combinations with Street Heroin

Active Ingredients	Street Name
Heroin and marijuana	Atom bomb, canade, woola, woolie, woo-woo
Heroin and cold medicine	Cheese
Heroin and ecstasy	Chocolate chip cookies, H bomb
Heroin and alprazolam	Bars
Heroin and Ritalin	Pineapple
Heroin and cocaine	Belushi, boy-girl, he-she, dynamite, goofball, H&C, primo, snowball, Murder 1
Heroin and LSD	Beast, LBJ, neon nod
Heroin and crack cocaine	Eightball
Heroin and crack	Dragon rock, moon rock
Heroin, cocaine, marijuana, and PCP	El diablito
Heroin and cocaine	Goofball
Heroin and cocaine	H & C
Ecstasy and heroin	H-bomb
Heroin, phenobarbital, and methaqualone	Karachi
Heroin plus LSD and PCP	LBJ
Methamphetamine and heroin mixed in one syringe	Methball
Crack and heroin	Moonrock
Heroin and cocaine	Murder one
LSD and heroin	Neon Nod
Ecstasy particles added to a bag of heroin	On the ball
Heroin and dimenhydrinate	Polo
Heroin plus PCP	Poro
Heroin, sleeping pills, strychnine, and caffeine	Red rock opium/redrum
Two layers of cocaine with a layer of heroin in the middle	Sandwich
Low-purity heroin plus crack cocaine	Scramble
Heroin and methamphetamine	Screwball

This table shows the slang names for drugs mixed with heroin. These mixtures are produced to obtain a certain “high.”

intentionally or synthesized during manufacturing, distribution, or storage steps.

Some of the reasons for adding adulterants to street drugs are:

1. Dilution or bulking of the substance of abuse (sugar);
2. Enhancing or mimicking the pharmacological effects of the active ingredient (fentanyl in heroin);
3. Facilitating the administration of the substance of abuse (caffeine in heroin).

There are many studies from various countries indicating the presence of adulterants in multiple samples of illicit drugs (Behrman, 2008; Chaudron-Thozet, Girard, & David, 1992; Cole et al., 2010; Janhunen & Cole, 1999; O’Neal, Poklis, & Lichtman, 2001; Wong, Curtis, & Wingert, 2008). A summary of the published studies on drug adulterants found in illicit heroin, the potential reason for their presence, and their neurological effects and neuropathy is provided in Table 2. As is shown in Table 2, acetylcodeine is one of the most notable impurities of origin in most heroin products as a result of the failure to remove codeine during the purification process of morphine. One of the key markers in signature analysis of street heroin is acetylcodeine because the ratio of heroin/acetylcodeine varies between sources. Acetylcodeine is a toxic by-product and potentiates the convulsant effect of diacetylmorphine (Johnston & King, 1998). Unreacted morphine and codeine are other components of street heroin and account for some adverse reactions in iv heroin abusers. Noscapine and papaverine are found in smaller amounts but have pharmacologic effects in street heroin. MAM is found in illicitly produced heroin as an impurity; this derivative could be a result of heroin hydrolysis and spontaneous deacetylation under humid conditions (Atasoy, Biçer, Açıkkol, & Bilgiç, 1988; Gomez & Rodriguez, 1989).

## Microbial Contamination of Heroin

Street heroin can cause bacterial infections. Bacterial infections are common in iv heroin abusers. As a result of poor or unsterile manufacturing techniques, nonstandard packaging, and distribution and storage conditions, bacteria, fungi, and viruses can contaminate street heroin. There are many reports demonstrating microbial contamination of street heroin. McLauchlin et al. (2002) studied 58 heroin samples and identified 17 species of bacteria in these samples. Brett, Hood, Brazier, Duerden, and Hahné (2005) showed that there was a dramatic increase in soft-tissue infections with spore-forming bacteria (*Clostridium* and *Bacillus* spp.) in injecting drug users. Dancer, McNair, Finn, and Kolsto (2002) studied a case of cellulitis. Aspirate samples from tissue and the patient’s own heroin were positive for *Bacillus cereus*. Kalka-Moll, Aurbach, Schaumann, Schwarz, and Seifert (2007) recognized 12 clinical cases of iv drug abusers with abscess in various parts of the body in the metropolitan area of Cologne, Germany. Abscess samples of a number of cases showed positive results for botulinum toxin.

## Adulteration of Heroin with Heavy Metals

One of the heavy metals detected in street heroin is lead. Parras, Patier, and Ezpeleta (1987) reported one case of lead poisoning from using lead-adulterated heroin. This heavy metal can be added to street drugs intentionally to increase weight. Another source of lead in heroin samples is lead pots used in the illicit manufacturing of street drugs (Zerell et al., 2005).

**TABLE 2** Typical Adulterants Used to Cut Street Heroin

Adulterant	Licit Pharmacological Effect	Potential Reason for the Presence of Adulterant	Neurological Effects and Neuropathology	References
Procaine	Local anesthetic	Facilitate smoking Anesthetic property relieves pain of injection	Ischemic nerve injury	Atasoy, Biçer, Açikkol, and Bilgiç (1988), Cole et al. (2011), and Kalichman and Lalonde (1991)
Fentanyl	Potent synthetic opioid analgesic	Produces more powerful opiate effect	Bradykinesia	Wong et al. (2008) and Zesiewicz et al. (2009)
Clenbuterol	β <sub>2</sub> -Adrenergic agonist	Unknown	Tremor, agitation	Behrman et al. (2008) and Brett, Dawson, and Brown (2014)
Diphenhydramine	Antihistamine	Relieves symptoms of allergy	Hallucinatory psychosis, encephalitis	Behrman et al. (2008) and Jones, Dougherty, and Cannon (1986)
Acetaminophen	Over-the-counter pain reliever	Disguises poor-quality heroin with its bitter taste	Oxidative stress, neurotoxicity	Ghanizadeh et al. (2012) and Chaudron-Thozet et al. (1992)
Acetylcodeine	Synthetic by-product	Impurity of origin	Convulsion	Soltaninejad, Faryadi, Akhgari, and Bahmanabadi (2007)
6-Monoacetylmorphine	Degradation or synthetic by-product	Impurity of origin	CNS depression	Johnston and King (1998) and Hosztafi (2003)
Caffeine		Causes heroin to vaporize at a lower temperature	Neurodegenerative disease	Chaudron-Thozet et al. (1992) and Luong and Nguyen (2015)
Papaverine	Opium alkaloid	Impurity of origin	CNS depression	Johnston and King (1998)
Noscapine	Opium alkaloid	Impurity of origin	Hallucination	Johnston and King (1998)
Dextromethorphan	Antitussive	Induces “high” effect	CNS depression	Barbera, Busardò, Indorato, and Romano (2013)
Codeine	Opium alkaloid	Impurity of origin	CNS depression	Akhgari, Jokar, Bahmanabadi, and Etemadi -Aleagha (2012)
Morphine	Opium alkaloid	Impurity of origin	Neurodegeneration	Cunha-Oliveira, et al. (2007)
Phenobarbital	Anticonvulsant	Has sedative and hypnotic effects and facilitates heroin smoking	Impaired cognition	Akhgari et al. (2012) and Hong (2011)
Acetylthebaol	Synthetic by-product	Impurity of origin		Akhgari et al. (2012)
Diazepam	Antianxiety	Probably used for its antianxiety and sedative effects	CNS depression	Akhgari et al. (2012)
Chloroquine	Antimalarial and amebicidal drug	With no effect but widespread availability, low price, and color and crystalline structure that can be used to bulk heroin	Coma, convulsion	Messant, Jérémie, Lenfant, and Freysz (2004)
Tramadol	Synthetic opioid drug	Shares many effects with heroin	Seizure, serotonin syndrome	Randall et al. (2014)
Sugars (sucrose, lactose)	Sugars	Used to bulk and dilute heroin		Chaudron-Thozet et al. (1992)
Quinine	Antimalarial drug	Disguises poor-quality heroin with its bitter taste, provides a “rush feeling”	Brown-Séquard syndrome	Cole et al. (2010) and Krause (1983)
Lead	Metal	Increases weight	Peripheral neuropathy	Parras et al. (1987) and Krigman (1978)

Adulterants found in street heroin samples, their accepted medical use, the reason for their use as cutting agent, and their neurological effects are shown in Table 2.

## Diluents or Bulking Agents Added to Heroin

Sugars (sucrose, fructose, glucose) are common cutting agents in heroin samples. Other diluents for cutting heroin samples are chalk, brick dust, powdered milk, and starch, which do not have any pharmacological effects and are benign substances but can cause health consequences (Coomber, 1997a, 1997b).

## MEDICAL CONSEQUENCES OF STREET HEROIN ABUSE

Chronic consumption of street drugs can lead to altered mental status, damage to various organs in the body, and finally multiple organ failure. Adulterated street heroin contains other drugs in addition to heroin that cannot be detected by laboratory screening tests, but they can cause health problems (Radovanović, Milovanović, Ignjatović-Ristić, & Radovanović, 2012).

## Neurological Effects and Neuropathology of Adulterants and Diluents in Street Heroin

A broad spectrum of morphofunctional and neuropathologic changes has been reported in the brain of heroin abusers (Neri et al., 2013). These lesions are caused by the active ingredient, heroin, and other substances added as adulterants (Büttner, Mall, Penning, & Weis, 2000). Postmortem investigations on the brains of drug-addicted individuals show biochemical and ultrastructural abnormalities. Neuropathologic changes in the brain can be precipitated by direct effects of heroin such as respiratory depression or by other reasons (infections and adulterants) (Büttner et al., 2000).

Cerebral edema with increased brain weight, decreased neuronal densities in the globus pallidus, bilateral and symmetric ischemic lesions, and hypodensities in the basal ganglia are caused by hypoxia related to heroin abuse (Andersen & Skullerud, 1999). As indicated by Niehaus and Meyer (1998) heroin abuse has caused focal neurological deficits and stroke. Flaccid paraparesis and paraplegia along with sensory loss in the legs are clinical presentations of heroin addiction-induced myelopathy. Neurotoxic effects of heroin and its adulterants, allergic reaction to “cutting agents,” and adulterants, and embolism are some causes of myelopathy in heroin abusers (Büttner et al., 2000). Inhalation of preheated heroin can cause spongiform leukoencephalopathy due to a lipophilic toxin-induced process by contaminants or cerebral hypoxia (Büttner et al., 2000).

Bacterial infections are a common problem among injecting drug users (Cole et al., 2010). Unsterile preparation and distribution processes in combination with poor health conditions and use of contaminated injection equipment contribute to inducing bacterial, fungal, and viral infections (McLauchlin et al., 2002). Septic foci in the brain can be produced as a result of bacterial or fungal endocarditis. Other studies have described intracranial mycotic aneurysms and development of subarachnoid hemorrhage in drug abusers with endocarditis (Gilroy, Andaya, & Thomas, 1973).

Direct toxic effects of heroin together with the action of adulterants have been hypothesized in the production of neurologic complications in drug abusers. Embolism from heroin adulterants has been proposed in some studies (Büttner et al., 2000).

There is a case report concerning Brown–Séguard syndrome, characterized by right-sided hemiparalysis with a contralateral sensory loss of touch and pain and vasculitis in the cervical region following quinine-adulterated heroin ingestion. Toxic effects of heroin and quinine caused vasculitis, cellulitis, and arachnoiditis in this heroin abuser (Krause, 1983).

Some lesions in the peripheral nervous system have been attributed to heavy metal adulterants such as lead in heroin. These include polyradiculopathy, brachial and lumbosacral plexitis, Guillain–Barré syndrome, and mononeuropathy (Antonini, Palmieri, Spagnoli, & Millefiorini, 1989).

## Side Effects on Kidney

A broad spectrum of pathologic changes in kidney was reported in previous studies (Buettner et al., 2014; Milroy & Parai, 2011). A traumatic rhabdomyolysis, acute renal failure, and electrolytic disorders are reported in iv heroin abusers. The reason for this problem could be the drugs and toxins in injected street drugs, immune system disorders, muscle ischemia, and other causes. Signs of glomerular ischemia, interstitial inflammation, and arteriosclerosis were seen in postmortem studies on the kidneys of chronic drug abusers (Buettner et al., 2014; Radovanovic et al., 2012).

## Side Effects on Liver

Liver diseases are common in iv drug abusers but usually unrecognized. Hepatitis C virus infection can be acquired by iv drug abusers and subsequently cause liver fibrosis. Liver autopsy samples of iv heroin addicts have shown fat changes, chronic hepatitis, cirrhosis, and Kupffer cell hypertrophy (Ilic, Karadzic, Kostic-Banovic, Stojanovic, & Antovic, 2010).

## Side Effects on Lungs

Adulterants in street heroin enter the bloodstream as small particles. These particles can clog blood vessels in the lungs, liver, kidneys, and brain (Wilson et al., 2006). Lung diseases such as abscesses, pneumonia, and tuberculosis are usual among heroin abusers (Hind, 1990). Inhalation of low concentrations of talc dust for a long period of time or acute exposure to high concentrations of talc powder can produce talcosis or talc pneumoconiosis (Davis, 1983).

Arterial obstruction of the lung was reported to be due to the injection of drugs containing talc (Arnett, Battle, Russo, & Roberts, 1976). Talc is a general filler for producing tablets in the pharmaceutical industry. Talc serves as a foreign body and can produce arterial obstruction after injection of water-dissolved tablets intended for oral use. Ischemic necrosis in some parts of the distal extremities is produced by injection of drugs containing talc (Arnett et al., 1976).

## Side Effects on Heart

Bacteria and other microorganisms are usual components of street heroin. These microorganisms have various sources; they can come from unsterile needles, be incorporated into heroin samples for dividing or distribution processes, or appear after filtering heroin



for injection using unsterile cotton. However, from any source, these microorganisms attack many organs in the body. Endocarditis is one of the complications in iv heroin abusers (Panduranga, Al-Abri, & Al-Lawati, 2013). Particulate matters in street drugs such as talc can produce tricuspid valve damage (Frontera & Gradon, 2000). Infective endocarditis may be the result of contaminated drugs with large bacterial load. Bacteria can be introduced into the body of iv drug abusers through injection of drugs with unsterile or shared syringes (Frontera & Gradon, 2000).

## CONCLUDING REMARKS

Heroin is one of the illicit drugs that are banned by international drug control treaties. Illicit use of street heroin is a significant cause of social problems, economic costs, and premature mortality from drug overdose, violence, and infectious diseases, especially in young age groups. There are some interventions for preventing the use of street heroin. Controlling the source countries of street heroin supply; legal prohibition by the criminal justice system and police force of manufacturing, possession, and use of opioids; and finally educational programs are methods for controlling street drug abuse.

## APPLICATION TO OTHER ADDICTIONS AND SUBSTANCE MISUSE

Street heroin abuse neuropathology extends to addiction to other drugs and substances as well. There are reports that heroin elevates dopamine (DA) level. Oxidative metabolism of DA leads to the formation of reactive oxygen species (ROS). Carbohydrate, amino acid, phospholipid, and nucleic acid damage cause neuronal cell injury and neurodegeneration. The brain is the organ most sensitive to the oxidative stress induced by heroin (Xu et al., 2006).

The effect of heroin on ROS-induced neurotoxicity is the same as for amphetamine-type stimulants and ethanol.

Amphetamines are members of the phenylethylamine chemical structure family with psychoactive properties. It is known that amphetamines cause structural and functional alterations in the brain. They can easily diffuse through cellular membranes, especially in the brain, and interact with monoamine transporter sites. In animal models amphetamines show major neurotoxic action such as long-term deficits in dopaminergic and serotonergic systems, depletion of monoamine brain level, degeneration of neuronal fibers, and neuronal death. Some of the mechanisms for methamphetamine-induced neurotoxicity are DA release and subsequent autoxidation and enzymatic oxidation of DA. Also aberrant release of DA can induce oxidative stress (Davidson, Gow, Lee, & Ellinwood, 2001).

It is supposed that the first oxidative metabolite of ethanol, acetaldehyde, induces its neurotoxic effects via the formation of adducts with brain macromolecules such as proteins. Also ethanol can be metabolized by cytochrome P450 2E1 in the brain and produce ROS, thus contributing to neurodegeneration (Brocardo, Gil-Mohapel, & Christie, 2011).

The effects of drug abuse on the brain, however, are crucial for CNS toxicity. Several studies support a role for ROS in the neurotoxicity and neurodegeneration induced by many drugs of abuse in various organs, especially brain.

## KEY FACTS

### Key Facts of Street Heroin

- Heroin was first synthesized as a nonaddictive alternative for morphine.
- Owing to heroin's high addictive property, it is classified as a Schedule I drug under the Controlled Substances Act of 1970.
- Manufacturing, possession, distribution, and selling of heroin are illegal in many countries.
- Heroin can be diluted at each stage of the chain of distribution with pharmaceutical and nonpharmaceutical additives.
- Street heroin is used as a recreational drug on the black market.
- Street heroin is not a pure substance at all and it may contain many adulterants, which can have health consequences to abusers, their families, and the community.
- Heroin and its adulterants exert various neuropathologic changes and neurotoxic effects on the brain.
- Some neurotoxicology and neuropathology features associated with street heroin abuse are gray matter loss, neuronal apoptosis, oxidative cell damage, neurodegeneration, myelopathy, spongiform leukoencephalopathy, cerebral edema, ischemia, and stroke.

### Key Points of the Personality Profile of Persons Vulnerable to Developing Addiction

- Clients with *paranoid personality disorder* can be attracted to the dominance drugs (alcohol, cocaine, and amphetamines), because they enhance the need for control that is central to the disorder (Benjamin, 1993). These drugs allow individuals with this personality to feel more powerful in a world that seems dangerous and hostile.
- Clients with *schizoid personality disorder* may be attracted to psychedelic drugs and become addicted to the state of arousal and satisfaction involved in facilitated fantasy (Milkman & Sunderwirth, 1987).
- Drugs such as marijuana and LSD may replicate the digressive, tangential quality of thought patterns already present in individuals with *schizotypal personality disorder*, and mere drug use can be enough to precipitate a psychiatric crisis. Psychoeducation is vital with these clients (Ekleberry, 1996).
- Clients with *antisocial personality disorders*, perhaps due to low neurological arousal, often seek thrills and are likely to be most attracted to stimulants. Their use of alcohol and drugs bothers them only in terms of the pressure they receive from employers, family, or the criminal justice system (Ekleberry, 1996).
- Clients with *borderline personality disorder* are the best candidates of all those with personality disorders for developing addictive disorders; they will use almost any drug of choice to worst advantage.
- Clients with *histrionic personality disorder* may value drugs and alcohol or compulsive behaviors for social enhancement. Antianxiety drugs are often sought; but stimulants provide them with dramatic mood boosts.



- Clients with *avoidant personality disorder* (AvPD) are vulnerable to substance use that can reduce interpersonal vulnerability or ease social paralysis. Drugs that will make a difference include sedative–hypnotics that calm anxiety and stimulants that provide a sense of strength or reduced vulnerability. Mild hallucinogens facilitate escape into fantasy and distract the AvPD client from the pain of his or her own self-absorption (Stone, 1993).
- Clients with *dependent personality disorder* may use alcohol and other substances as a passive way to escape from problems (Beck, 1993).

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