Attenuation of Heroin Withdrawal Syndrome by the Administration of High-Dose Vitamin C

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Abstract *Heroin addiction is a serious health and social problem that afflicts societies around the world. Its addicting characteristics have been known for thousands of years. Derived from opium, obtained from the opium poppy (*Papaver somniferum*), heroin is highly addictive. Conventional approaches to heroin withdrawal involve the use of synthetic or semi-synthetic opioids, with or without concomitant behavioral therapy. A study conducted in New York City in the 1960s, demonstrated that by giving increasing doses of vitamin C (ascorbic acid) salts administered orally in water or juice during withdrawal, vitamin C blocked opioid receptors in the brain, and attenuated withdrawal symptoms, encouraging heroin addicts to end their dependence on heroin. A 1978 field visit to Seattle, Washington, by officials of the National Institute for Drug Abuse and Alcoholism (NIDAA) at the U.S. National Institutes for Health (NIH), confirmed its effectiveness, yet the agency to date has failed to provide funding to support further research on this promising treatment modality. Despite serious reported side effects, pharmacotherapeutic approaches in the treatment of heroin-dependence prevail with support by NIDAA, while nutrient-based therapies, that could help break the cycle of addiction, are disregarded.*

Introduction

A search of the literature in the medical school library of the University of New Mexico over forty years ago suggested that vitamin C (ascorbic acid) might block the neuromodulatory response of opioid receptors to opioids such as heroin, a highly addictive narcotic drug. This suggested the possibility that vitamin C therapy might be a novel approach able to help heroin addicts withdraw from narcotic dependence.

I grew up in a crime-ridden neighborhood on the upper west side of Manhattan, a borough of New York City, which at the time had the highest per capita use of heroin in the United States. The junior high school I attended was only three blocks from notorious "Needle Park," where one could observe an endless progression of drug transactions night and day. And it spilled over into our neighborhood. It was not uncommon to watch classmates inject themselves with heroin in bathrooms, stairwells, or the playground. After giving themselves a "fix" they entered a state of euphoria that made them oblivious to the opportunity education afforded them to get out of the "Airtight Cage" and find relief from whatever familial, societal, or genetic factors, inspired them to use heroin two or three times a day, day after day.

The "Airtight Cage" that Joseph P. Lyford described in his study of New York's West Side, funded by the Center for the Study of Democratic Institutions, eloquently described the despair and suffering experienced by those living within the boundaries of its gang riddled, corrupt, and crime-infested streets.[1] Lyford had grown up in the lower East Side section of Manhattan, a neighborhood given the notorious name, "Hell's Kitchen," that harbored generations of immigrants to "the promised land." Yet,

when he moved into The Cage to watch over a tenement building he had purchased, he found it difficult to block out the sirens and sounds that instilled fear and resentment. It did not take him long to realize that this was a different community, a far more insidiously dangerous neighborhood riddled by tragic episodes of crime and violence nestled among decomposing tenement buildings occupied by broken spirits seeking escape from hopelessness and despair.

Having witnessed first-hand the destruction that heroin wages on the minds and bodies of peers, it seemed that destiny might give me an opportunity to find a way to break the powerful life-destroying shackle of heroin addiction. A former heroin addict described how it is able to take over one's life with these words: "The first time you inject it, it is as if you are kissing the creator… It is safe to say that you will NEVER feel that way again, although you will certainly try–to the point of losing everything–maybe even your life." What makes heroin so addictive is eloquently explained as follows:

> "It's like warm golden sunshine flowing through your veins. It makes everything ok, and it makes everything beautiful, and it makes anything seem within your reach. Then you come down. And need more. And will do anything to get it. It's your best friend at first, and when you still can quit, you'd never dream of it. Then at some point that is indefinable and inevitable, it turns on you. It grows fangs and claws, and it wants your soul. It lies to you and tells you that you aren't doing anything wrong. It makes you feel like you would rather die than spend another second without it. Then before you know it, your days are consumed with waking up dry heaving and so sick you want to die (provided you could sleep at all, which is dependent upon whether or not you had a shot before bed). Once you finally get a first hit of the day, then it's time to start really looking for something to get you by. You lie, scam, break the law, and sell your soul to get just barely enough to keep you out of bed. You take that last shot of the day, and become filled with dread and exhaustion thinking how you'll manage it tomorrow. Then you go to bed, only to wake up a few hours later because your muscles are twitching and cramping. You fight with yourself for ten minutes about whether or not to take that small hit you saved for morning, inevitably take it, and then wake up a few hours later, only to start all over again. And you'd rather die than live any other way."

Heroin

For at least 6,000 years, opium poppies have been cultivated to produce a crude opium base used to relieve pain, treat chronic coughs, as an anti-diarrhoeal, or to induce a mind state of temporary euphoria.

Heroin (diacetylmorphine) is derived from the seedpod of the poppy plant (*Papaver somniferum*). The Latin name for the species means "that which induces sleep," while *Papaver* has its origin in the Greek word for sap. *P. somniferum* is as a controlled substance since it contains addictive benzylisoquinoline alkaloids. In the United States, heroin is listed as Schedule I under the Controlled Substances Act; no prescriptions may be written for heroin as it has a high potential for abuse and there is no accepted medical use for it. Since it is twice as potent by weight as morphine, some European countries allow its use to relieve pain in terminal cancer patients. In Switzerland, heroin is prescribed in cases where heroin addicts have not responded to other forms of substance abuse treatment.

Heroin, morphine, codeine, and thebaine (paramorphine), are all derived from the sap of *P. somniferum*. This sap is extracted from the egg-shaped seedpod of the plant by slitting the pod vertically in parallel strokes. As the sap oozes out of the pod it forms a golden to dark brown gum that is collected and bundled into cakes or balls. These bundles are then transported for refinement into drugs such as morphine.

In 1847, C.R. Wright, a British scientist, synthesized heroin by boiling acetic anhydride with morphine for several hours. More recent methods of production and pu-

rification use a relatively easy process used around the world capable of producing tons of heroin annually. For instance, 10 tons of cheap opium can be processed into one ton of heroin. In the late 1990s a kilo of heroin cost between $100,000 and $120,000. Of the 430 tons of heroin produced globally in 1996, half found its way into the United States to be sold illegally to heroin addicts.[2] Heroin is typically diluted to reduce its potency and to increase profits by adding such substances as powdered milk, quinine, or sugar.

Most heroin sold in the streets of New York during the 1950s to 1970's had been repeatedly adulterated, or "cut" to the point that the purity sold was in the range of 2% to 10%, yet potent enough to produce a rush followed by a temporary state of euphoria. As the amount of heroin entering the United States increased in the 1980s, heroin's purity rose to 20-30%. Some addicts became so addicted to the drug that they spent one or two thousand dollars a day getting high. As the flood of heroin produced in Central America, South America, and the Middle East, particularly Afghanistan, and smuggled into the United States increased, the street price for a fix dropped to $5 (a "nickel bag") while purity increased up to 80 or 90%.

The most common way heroin is used is by cooking it in a spoon until it turns into a liquid. This fluid is then drawn into a syringe. After locating a vein, usually somewhere on the arm, it is injected into the vein and enters the blood stream. The "rush" addicts experience by this route of administration is almost instantaneous. If administered intramuscularly, the rush may take 6 to 8 minutes. Some addicts prefer to snort the drug or smoke it, which delays the rush by as much as 15 minutes. Regardless of the route of administration, heroin use can be highly addictive.

When addicts share hypodermic needles, they risk contracting hepatitis B or C and HIV. According to the Centers for Disease Control and Prevention, 32% of females and 24% of males with AIDS acquired the disease by injection drug use.[3] The risk of overdose, heart disease, particularly heart failure and pulmonary complications, along with kidney disease, are just some of the consequences associated with heroin addiction. Since heroin affects the immune system, and the body's ability to fight infections, diseases such as tuberculosis, and pneumonia, are not uncommon. Immune reactions to adulterants added to heroin to reduce potency have been correlated with the onset of osteoarthritis and rheumatoid arthritis.

Whether injected or inhaled, heroin crosses the blood-brain barrier, where it is converted to morphine and binds to opioid receptors. How strong the "rush" is experienced depends on the amount of heroin administered and the speed with which it alters neural pathways and affects opioid receptors.

Any disruption in use of the drug once addicted can lead to symptoms of withdrawal within hours after taking the last dose. This creates a craving for the drug to avoid withdrawal symptoms. If the drug is stopped for too long a period, severe muscle and bone pains, diarrhoea, vomiting, constant restlessness, insomnia, involuntary arm and leg movements, will occur. In addition, sudden feelings of hypothermia associated with goose bumps are experienced. When this happens the skin looks very much like that seen on the skin of a frozen turkey. This is where the term "cold turkey" comes from, as every addict goes through periods of needing blankets to avoid the acute onset of chills they experience from time to time as they go through withdrawal.

By the 1950s and 60s, going "cold turkey" was the only choice heroin addicts had if they chose not to use certain drugs to try and block withdrawal symptoms. Some of these drugs simply replaced one addiction for another. This led to methadone becoming a drug of abuse that was also sold on the streets, given its addictive properties.

Many risk factors increase the likelihood that the addict will return to their addiction. So it is not unusual to have an addict go through withdrawal numerous times.

Heroin Addiction

Recent studies suggest that complex factors involving genetic and psychosocial fac-

tors contribute to substance abuse. Genetic studies have reported that genetic variants may account for up to 60% of the risk associated with developing opioid dependence.[4-6]

Of particular interest, is the effect of heroin abuse upon the body's redox state. A study of 137 heroin addicts found they experienced damaging oxidative injury due to oxidation, peroxidation, and lipoperoxidation, compared to that of 100 healthy volunteers.[7] To understand why this occurred, addicts and healthy volunteers volunteered to have plasma levels of nitric oxide, vitamin C, vitamin E, beta-carotene, lipoperoxides and erythrocyte activities of superoxide dismutase, catalase, glutathione peroxidase, and erythrocyte lipoperoxides determined. It was found that in addicts the balance between the production of oxidation products and antioxidant activity was gravely imbalanced, with the lack of sufficient exogenous vitamin C, vitamin E, as well as endogenous nitric oxide production, closely correlated with and contributing to the damage to DNA and cells during chronic states of oxidative stress. In another study of 114 heroin abusers and 100 healthy volunteers it was found that the longer the duration of heroin abuse the more injury occurred from oxidative stress, which correlated with decreased levels of antioxidant vitamins C and E, and beta-carotene, along with diminished values for several endogenous antioxidants, including: superoxide dismutase, catalase, and glutathione peroxidase.[8] The authors concluded that it was necessary "in abstaining from heroin dependence" that the heroin abuser "acquire sufficient quantities of antioxidants such as vitamin C, vitamin E, and beta-carotene."

None of this was known in 1969, when the author organized a clinical trial to see if high dose vitamin C would be of any benefit to heroin addicts wishing to break their dependency during "cold turkey" withdrawal.

While attending the City University of New York, in 1969, a clinical trial was conducted to test the theory that vitamin C (as sodium ascorbate) might block opiate receptors in the brain of heroin addicts and block or diminish the "rush" and subsequent euphoria experienced following intravenous injection of the drug.

The hypothesis was based on a series of experiments performed by this author at the University of New Mexico, based on the premise that opioids bind to specific opioid receptors, as originally proposed in 1954 by Beckett and Casy,[9,10] and that vitamin C can occupy those receptors, thereby blocking the neuromodulatory effect of the opioid.

Pilot Animal Studies

Guinea pigs share with humans an inability to synthesize vitamin C, based on mutations in the L-gulono-gamma-lactone oxidase (GLO) gene which codes for the enzyme responsible for catalyzing the last step in the biosynthesis of vitamin C.[11] This is why humans can get scurvy from a deficiency of vitamin C in the diet.

An exploratory study injected guinea pigs with 5% pharmaceutical pure heroin in sterile water daily until dependency was established. Thereafter, the solution was administered twice daily for one week. When administration was withdrawn, the response resulted in significant behavioral and locomotor changes, somewhat similar to the withdrawal syndrome seen in humans.

In the second experiment, guinea pigs were injected with the same dose after being pretreated for four days with vitamin C. It was observed that vitamin C attenuated some of the withdrawal symptoms seen in the first study, compared to controls.

Additional experiments were performed, each of which demonstrated the ability of vitamin C to diminish withdrawal symptoms.

These encouraging results suggested that an open label pilot study of the effect of high dose oral vitamin C in humans was warranted. With the assistance of the City University of New York, the study was approved in 1969, and a site selected.

Titration Protocol

Six volunteers who had been addicts for at least five years, who had experienced "cold turkey" withdrawals at least three times, agreed to participate in the trial, following

written consent. The study was conducted at an addiction treatment center in Harlem, a community within the Borough of Manhattan, New York, known for a high per capita rate of heroin addicts. Five or more times a day each volunteer drank a 6-ounce glass of diluted orange juice or apple juice containing various amounts of vitamin C (as sodium ascorbate)

Initially, compliance was poor, as the juice had an unpleasant salty taste. It was explained to the volunteers that the reason for the salty taste was that the vitamin C was bound to a salt which tasted salty but also was non-acidic (as sodium ascorbate has a neutral pH). The ratio of fruit juice to water was 50:50. Addicts were told that they might experience diarrhoea. Volunteers were instructed to report any symptoms to the nursing staff by phone or in person, and could terminate participation in the study at any time. Participants were paid $5 a week to participate in the two-week study. They were also informed that the principal investigator (the author) wanted to determine if vitamin C could reduce any side effects experienced during withdrawal.

Participants reported that the primary reason for participating in the study was to get their addiction under control by eliminating dependence on the drug. Fearful of going through withdrawal by "cold turkey," they were willing to see if the vitamin could reduce the symptoms during withdrawal. Records were kept on 20 addicts who volunteered and who met exclusion and inclusion criteria to participate in the study.

The question of how much vitamin C an addict could tolerate before reaching "bowel tolerance" turned out to vary. (When diarrhoea occurred, the amount of vitamin C was decreased to a lower dose.) Over time it was observed that addicts heavily addicted to heroin could tolerate considerable amounts of vitamin C before reaching bowel tolerance.

The first step in the protocol is to go through vitamin C loading for at least three days before going through withdrawal. This titration phase is critical. This would allow the dose of vitamin C to gradually increase to an amount of the vitamin that could be frequently administered every few hours once withdrawal symptoms were anticipated Nurses adjusted the dose of sodium ascorbate in juice depending on the participant's body weight, medical history, and frequency of daily heroin use. The protocol for an addict who met inclusion criteria might be as follows:

* Day-One (three days prior to day of withdrawal): Drink six ounces diluted fruit juice (DFJ) containing 500-1000 mg of sodium ascorbate (SA) every two hours until bedtime.
* Day-Two: Drink DFJ with 1,000-2,500 mg of SA every two hours until bedtime.
* Day-Three: Drink DFJ with 5,000-7,500 mg SA every three hours until bedtime. Begin withdrawal at bedtime. If withdrawal symptoms occur during the night, DFJ with 5000-7500 mg SA, administered when awake, and taken every two hours until symptoms abate.
* Day-Four: DFJ with 2,500-5,000 mg SA every two hours until bedtime. If symptoms occur during the night, DFJ with 2500-5000 mg SA, administered when awake, and taken every two hours until symptoms abate.
* Day-Five: DFJ with 1,000-2,500 mg SA every two hours until bedtime. If symptoms occur during the night, DFJ with 1,000-2,500 mg SA, administered when awake, and taken every two hours until symptoms abate.
* Day-Six: DFJ with 1,000 mg SA every two hours until bedtime. If symptoms occur during the night, DFJ with 1,000 mg SA, administered when awake, and taken every two hours until symptoms abate.

Upon learning of the study's success, Linus Pauling, PhD, informed Vic Pawlek, the Director of a drug treatment center in Phoenix, Arizona, about the study. In 1972, Pawlek reported favorable results.[12] The center created a cocktail that included vitamin C (as an ascorbate) and niacin, the addition of which was suggested by Abram Hoffer, MD, PhD, who felt the addition of niacin would be beneficial.[13]

Jordan Scher, MD, an addiction specialist and psychiatrist who worked at the National Council on Drug Abuse and Methadone Maintenance Institute in Chicago, Illinois, reported that large doses of vitamin C significantly reduced withdrawal symptoms

when co-administered with methadone.[14]

Despite these promising observations in several states, advocacy for the use of vitamin C during withdrawal failed to gain ground within the substance abuse field, partially due to criticism and concerns about the use of "megavitamins." The use of drugs was heavily favoured over dietary supplementation at the time, combined with the belief that taking more vitamins or minerals only produced "expensive urine," a belief some critics continue to espouse to this day.

In 1979, I gave a presentation on a quasi-experimental study we had conducted in King and Pierce County, Washington, at a medical conference held in SeaTac, Washington. During the presentation the subject of vitamin C came up during which I mentioned the observations made on using vitamin C in New York a decade earlier. I pointed out that among the 20 addicts that complied with the protocol each one reported very few symptoms commonly experienced during heroin withdrawal. Attending the conference and in the audience was Dr. Janice Keller-Phelps, MD, the medical director of the King County Center for Addiction Services (which includes the city of Seattle). Dr. Keller-Phelps is a substance abuse specialist, with considerable experience treating addicts. She had been a medical director in Maryland's correction system, and participated in studies funded by the National Institute for Drug Abuse and Alcoholism (NIDAA) at the National Institutes for Health (NIH).

After completing the presentation the moderator asked the audience if anyone had any questions or comments. She grabbed the microphone and insisted that the suggestion vitamin C could help heroin addicts during withdrawal was "total nonsense." In response I challenged her to try treatment for one month with any of the hard-core addicts in her programme. I also pointed out that she had no proof it did not work. During a sidebar conversation at the end of the session, I provided her information on programs using vitamin C on the west coast of the United States that she could visit to see how the vitamin is used. She accepted the challenge.

Her first trip took her to Oakland, California, where she visited an addiction treatment clinic that has been using vitamin C. She also met with Michael Lesser, MD, in Berkeley, California, a psychiatrist. Dr. Lesser described the work of Dr. Irwin Stone and his theory as to why primates could not synthesize vitamin C, and explained his "hypoascorbemia hypothesis."[15-16] She then traveled to the other side of the Bay, not far from Stanford, and met Dr. Stone. He shared with her his collaboration with Alfred Libby, PhD, using vitamin C. Dr. Stone also mentioned the pioneering work of Frederick R. Klenner, MD, who in the 1940s began experimenting with megadoses of sodium ascorbate up to 350 to 700 mg/kg of body weight each day in the treatment of a wide range of diseases. Drs. Libby and Stone published a paper in 1978 that described a pilot study they conducted using sodium ascorbate in the treatment of drug addiction.[17] She also spoke with Bernard Rimland, PhD, a Navy psychologist in San Diego, who had taken an interest in the use of megadoses of nutrients in the treatment of neurological disorders, including autism.

Nevertheless cautious, Dr. Keller-Phelps continued to contact other practitioners who had used vitamin C in their practice, while also reading such works as Dr. Stone's classic work on the vitamin, *The Healing Factor: Vitamin C Against Disease*.[18]

Soon after her return to Seattle, Dr. Keller-Phelps began using sodium ascorbate at the addiction treatment facility in King County, Washington. By August of 1979 she reported "dramatic" success in attenuating the symptoms of heroin addicts, some of whom had been addicted to the drug and gone through multiple withdrawals for more than 25 years. Her opinion was that it was like "a cure to cancer" for addicts. I urged her to temper her enthusiasm by reminding her that addiction was complex and due to multiple factors, as she herself had pointed out at the conference.

After treating 30 hard-core addicts with sodium ascorbate, and convinced of its

benefit, she contacted officials of NIDAA in Washington, DC. At the time, I was Research Director of the Institute for Biosocial Research at City University of Seattle, in University Place, Washington. Dr. Keller-Phelps persuaded NIDAA to send a fact-finding team to Seattle to verify and confirm her observations. Her request was approved. Upon arrival in Seattle, the team of three officials spent four days conducting interviews with addicts who had gone through the vitamin C withdrawal program. By the third day they had interviewed over two-dozen addicts who had successfully gone through withdrawal using the vitamin C protocol Dr. Keller-Phelps had adopted. On the last day of their visit, one of the officials told executives of the university, including Clifford Simonsen, PhD, dean of the graduate school, and a noted professor of criminology, that what they learned and observed seemed "irrefutable," and worthy of NIDAA's support.

Several months passed as we waited for NIDAA's report. Finally, Dr. Simonsen called NIDAA to speak with the officials who came to Seattle. They informed everyone listening to the call on the speakerphone that regrettably the agency could not endorse the treatment. It would be an understatement to say that we were dismayed and in a state of disbelief. How could this be? Why would the agency not fund independent controlled studies of this seemingly effective and safe treatment modality?

Confirmatory Studies

In 1992, a paper was published in Neuroscience Letters that reported chronic treatment with vitamin C (1 g/L, in drinking water for three days, or 200 mg/kg subcutaneously three times daily for 3 days) inhibits morphine withdrawal symptoms in guinea pigs.[19] The authors determined that chronic, but not acute administration of vitamin C blocked opiate withdrawal symptoms.

In 2000, a paper was published by the University of Ioannina in Greece, reporting on the results of a study they conducted on the effect of oral administration of high dose vitamin C during heroin withdrawal.[20] In the study, heroin abusers were given 5 mg/kg of body weight each day of vitamins C and E for at least four weeks. A control group of addicts were administered conventional medication consisting of diazepam and an analgesic each day during the same time period. Whereas 57% of the vitamin C- and E-treated subjects experienced a significant reduction in symptoms during withdrawal, only 7% of the control group experienced a reduction in symptoms. The authors of the study concluded that: "The results indicate that high doses of ascorbic acid administered orally may ameliorate the withdrawal syndrome of heroin addicts. Further studies are needed in order to estimate the dose- and time-dependent effects of ascorbic acid treatment, and to clarify its mechanisms of action in the withdrawal syndrome."

As a footnote, eleven years after meeting Dr. Keller-Phelps, she authored a book that discussed her experience using vitamin C and other nutrients in the treatment and amelioration of substance abuse.[21]

NIDAA Priority: Pharmacotherapeutics

At the same time NIDAA's fact-finding team was visiting Seattle in 1969, the agency was studying a semi-synthetic opioid, buprenorphine, which binds to morphine receptors, in the treatment of heroin withdrawal. NIDAA also promoted the use of methadone (Eli Lilly), a synthetic acyclic analog of morphine and heroin, for use by patients with opioid dependency, at risk of opioid withdrawal syndrome.

Interestingly, in 1990, NIDAA created the Medications Development Division, to focus on developing drug treatments for addiction. Four years later, in 1994, NIDAA formed an agreement with the original developer of buprenorphine to bring the drug to market.[22] Buprenorphine was subsequently approved by the FDA for use in the treatment of addiction, in 2002, and continues to be used for this purpose to this day.

NIDAA also advocates the use of other drugs to reduce the severity of withdrawal symptoms. Among the drugs given research

support are: clonidine and lofexidine, both centrally acting alpha-2 adrenergic agonist, the first of which was launched in 1992 for symptomatic relief in patients undergoing opiate withdrawal, and later naltrexone, an opioid receptor antagonist, primarily used in the management of alcohol and opioid dependence. These pharmacotherapies, along with buprenorphine, naloxone, methadone and its analogues, dipipanone and dextromoramide, continue to be commonly prescribed drugs used in the treatment of narcotic addiction withdrawal.

These drugs are also known to cause serious adverse events. A 1997 study of naltrexone-treated opioid addicts by UCLA and the Matrix Center and Los Angeles Addiction Treatment Center, found that 13 of 81 subjects overdosed within a 12-month period, of which four died. Among the nine non-fatal overdoses, four involved suicide attempts. These serious adverse events were described by the authors of the study as "characteristic of subjects" taking naltrexone.[23] By contrast, in a 1997 paper in JAMA evaluating the safety of naltrexone in a heterogeneous population of persons treated for alcoholism, noted "no new safety concerns," or deaths identified among the 865 patients enrolled in the programme they studied.[24]

The side effects reported by UCLA associated with naltrexone aren't limited to its use during treatment, but can also result in serious adverse events following withdrawal. The Australian National Evaluation of Pharmacotherapies for Opioid Dependence (NEPOD) study analyzed the results of 12 trials of pharmacotherapies for opioid dependence, and found serious adverse events and deaths associated with the use of these drugs. They found that "individuals who leave pharmacotherapies for opioid dependence experience higher overdose and death rates."[25]

Conclusion

Opioid dependence is a serious social and health problem. According to the Centers for Disease Control and Prevention, National Center for Health Statistics, from 2004 to 2008, the estimated rate of emergency visits involving nonmedical use of opioid analgesics doubled from 49 per 100,000 to 101 per 100,000.[26]

Treating opioid dependence requires a multidimensional approach that involves extinguishing dependency, withdrawal (detox), and relapse prevention. Vitamin C therapy may be an effective modality to help patients withdraw from heroin addiction, and improve retention in treatment programs designed to break the cycle of addiction. Combining high-dose vitamin C therapy with other nutrient-based therapies should be considered.

NIDAA and similar agencies concerned with substance abuse need to provide funding and support studies of nutrient-based therapies to determine what their place should be in the armamentarium of treatment modalities used in helping patients recover from the addiction. Research should also focus on whether subclinical deficiencies of nutrients, such as vitamin C combined with genetic factors, increase the risk that someone exposed to addictive drugs such as heroin may develop an addiction.[27] Until such funding and support becomes available, it is encouraging to learn that others are studying whether vitamin C holds promise in treating other substances of abuse such as crack cocaine.[28]

Recent studies have examined the role of non-coding microRNA in understanding the molecular mechanism behind the debilitating effects of addiction. Morphine has been a target for such investigations. Studies reported on the regulation of miR-133b by morphine and its involvement in morphine addiction, along with the role of microRNA let-[7,29] in the regulation of morphine receptors involved in the development of opioid tolerance,[30] are two examples of such investigations. The role microRNAs, such as miR-133b and other non-coding RNAs, play in leading to addiction either by direct opioid regulation or by controlling neuropathways, as affected by vitamin C, would be an example of the kind of research NIDAA could fund in helping us to understand its mechanisms of action in attenuating heroin withdrawal syndrome without pharmacological intervention.

Competing Interests

The author declares that he has no competing interests.

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