ejpmr, 2019,6(3), 189-193

SJIF Impact Factor 4.897

EUROPEAN JOURNAL OF PHARMACEUTICAL AND MEDICAL RESEARCH

www.ejpmr.com

Review Article

ISSN 2394-3211

EJPMR

A REVIEW ON USE OF JET INJECTOR AND ITS ADVANTAGES

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Article Received on 25/12/2018 **Article Revised on 15/01/2019** **Article Accepted on 04/02/2019**

ABSTRACT

A personal needle –free system could be of great benefit to the hundreds of thousands of individuals who require daily injections of medications. For instance, those with insulin-dependent diabetes need multiple injections of insulin every day. Unfortunately, this means multiple painful needle sticks. This technique is also useful for obtaining gingival anesthesia before a rubber dam clamp is placed for isolation procedures that otherwise do not require local anesthetic. Similarly, soft-tissue anesthesia may be obtained before band adaptation of partially erupted molars or for the removal of a very loose (soft-tissue–retained) primary tooth. For many developing countries, where inadvertent or intentional reuse of nonsterile needle-syringes is a serious problem, modeling indicated significant cost savings for the use of needle-free JIs compared with needle-syringes, especially when the indirect costs of iatrogenic disease resulting from the latter were included.

KEYWORDS: Needle –free system, Disposable-syringe jet injectors, lipohypertrophy, Lipoatrophy.

The evolution of modern day syringe systems has led to the involvement of medical-grade stainless-steel as hypodermic needles while the body is made of plastic, developing the syringes as a two-part disposable system.[1] However, the technical advancements and bioengineering capabilities have led to the emergence of various "newer" active enhancements, designed so as to circumvent the barrier function of the stratum corneum. Every Year, approximately 16 million injections are administered to patients to deliver vital medications and vaccinations. A personal needle –free system could be of great benefit to the hundreds of thousands of individuals who require daily injections of medications. For instance, those with insulin-dependent diabetes need multiple injections of insulin every day. Unfortunately, this means multiple painful needle sticks. A device of this nature could reduce the pain associated with therapy and improve compliance. Non- adherence to insulin regimens can have serious health consequences.

History and applications

- Jet injectors (JIs) squirt liquid under high pressure to deliver medication without needles into targeted tissues. The technology was invented in France in the 1860s. A patent was filed for in 1936 and it was reintroduced in the 1940s as the Hypo spray for patient self-injection with insulin. In the 1950s, the US military developed a high-speed system which was imitated by others, and the units were once referred to as jet guns for mass vaccination programs. Over the past half-century, JIs have been used to administer hundreds of millions, if not billions, of vaccine doses for mass campaigns in humans against smallpox, measles, polio, meningitis, influenza, yellow fever, cholera and other diseases. During the swine influenza mass campaign of 1976–77 in the United States, a substantial proportion of the approximately 43 million doses administered that season were by JIs (CDC, unpublished data).
- JIs have also been used for a wide variety of therapeutic drugs, including local and pre-general anesthetics, antibiotics, anticoagulants, antivirals, corticosteroids, cytotoxic, immunomodulators, insulin and other hormones, and vitamins. Veterinary models for agricultural use are widespread. In recent years, the devices have been used to administer various antigens to both humans and animal models for a variety of investigational vaccines, including dengue, herpes simplex type 2, HIV/AIDS, Japanese encephalitis, malaria, and melanoma.
- Jet injection produces surface anesthesia instantly and is used instead of topical anesthetics by some dentists. The method is quick and essentially painless, although the abruptness of the injection may produce momentary anxiety in the patient. This technique is also useful for obtaining gingival

anesthesia before a rubber dam clamp is placed for isolation procedures that otherwise do not require local anesthetic. Similarly, soft-tissue anesthesia may be obtained before band adaptation of partially erupted molars or for the removal of a very loose (soft-tissue–retained) primary tooth. O'Toole has reported that the Syrijet may be used instead of needle injections for nasopalatine, anterior palatine, and long buccal nerve blocks.[2]

Occupational and patient safety, economics

Increasing concern for needle-stick injuries and possible transmission of blood borne pathogens to health workers, as well as the more expensive needle-shielding syringes that occupational health regulations now require to reduce the risk of injury, have boosted interest in JIs in developed countries. Another economic factor is the high cost of proper disposal of highly regulated sharps waste, which is not required for used JI syringes (see "Disposable-syringe jet injectors", later). As the latter may be soiled with blood or tissue fluid, they should be discarded with conventional red-bag medical waste, along with used bandages and similar materials.

For many developing countries, where inadvertent or intentional reuse of nonsterile needle-syringes is a serious problem, modeling indicated significant cost savings for the use of needle-free JIs compared with needle-syringes, especially when the indirect costs of iatrogenic disease resulting from the latter were included.[3]

Jet injection device for diabetes

Insulin jet injectors can allow people with diabetes to inject insulin without using a needle. However, many people shy away from these small devices because they can be expensive and complex to use. These are expensive but good for people who cannot perform the injection for themselves. The device holds a large quantity of insulin to be used for multiple treatments. After dialing up the amount of insulin to be delivered, the device is held against the skin and, on pressing a button, a jet of air forces the insulin through the skin into the tissue underneath. The device is occasionally leaky, with insulin staying above the skin; others report that the injection can be painful.

Traditionally patients are advised to rotate the location of their injection sites; this helps to avoid local reactions to insulin, which are, principally:

- **Allergy:** Local allergic reactions are uncommon with modern insulin preparations; reactions to diluents or preservatives are sometimes thought to be of relevance; a change of brand may help, but many cases resolve spontaneously. Transient tender nodules developing at the injection site are suggestive; generalized allergic reactions are exceedingly uncommon. Testing kits are available from insulin manufacturers. Major insulin resistance due to high titres of anti-insulin antibodies that cause antigen–antibody complexes is very uncommon; corticosteroids may be useful.
- **Lipohypertrophy:** Localized areas of lipohypertrophy, although comfortable to inject into, are thought to cause erratic absorption of insulin from the site. The hypertrophy is attributed to the trophic effects of insulin on fat metabolism. Avoidance of the area may lead to regression; liposuction has been used.
- **Lipoatrophy:** This has become rare since the introduction of highly purified, and more recently human sequence, insulins. It may be improved by the injection of highly purified soluble insulin around the edge of the lesion. Patients occasionally complain of recurrent minor local bleeding or bruising, which rarely presents any real cause for concern.

Advantages

Jet injection involves the use of a needle-free device that delivers a prescribed drug, vaccine, or compound intradermally, subcutaneously, or intramuscularly via high pressure produced by either a carbon-dioxide-filled or nitrogen-filled cartridge or a spring. During that procedure, the injector is held at an angle against the patient's skin, and a very fine stream of liquid medication is forced through a tiny orifice in the device, penetrates the skin in a selected volume ranging from 0.05 mL to 1.0 mL, and is deposited in the underlying tissue. When compared with methods of injection that require a needle, jet injection offers multiple benefits.

It can be less painful for the patient, and it enhances compliance, reduces risks such as needlestick injuries and cross-contamination, eliminates the need for "sharps" disposal, and enables (with minimal training) the reliable, reproducible, and accurate delivery of medication.

Patient convenience is also a factor

- Jet injectors are designed for self-medication as well as professional use.
- It must be remembered, however, that treatment via jet injection is not always painless.
- Because of their formulations, some medications and vaccines produce a burning or stinging sensation, whether they are administered with a jet injector or a needle.
- Some compounded preparations, like the formulations included in this article, can be administered by jet injection; a practice that we suggest will increase in popularity as more drugs are prescribed for administration in the home setting.
- Because changes in drug concentration may be required to affect the transfer of an agent or ensure the accurate reconstitution of a lyophilized drug administered with a jet injector, the skill of a compounding pharmacist will be essential in preparing customized injectates.

Types

A jet injector, also known as a jet gun injector, air gun, or pneumatic injector, is a medical instrument that uses a high-pressure jet of liquid medicament to penetrate the skin and deliver and deposit medicament under the skin, without a needle. Jet injectors can be single-dose or multi-dose jet injectors.

Throughout the years jet injectors have been redesigned to overcome the risk of carrying contamination to subsequent subjects.

To try to stop the risk, researchers placed a single-use protective cap over the reusable nozzle. The protective cap was intended to act as a shield between the reusable nozzle and the patient's skin. After each injection the cap would be discarded and replaced with a sterile one. These devices were known as protector cap needle-free injectors or PCNFI.[4]

However, a safety-test by Kelly and colleagues (2008)[5] found a PCNFI device failed to prevent contamination. After administering injections to Hepatitis Bpatients, researchers found Hepatitis B had penetrated the protective cap and contaminated the internal components of the jet injector, showing that the internal fluid pathway and patient contacting parts cannot safely be reused.

Researchers developed a new jet injection design by combining the drug reservoir, plunger and nozzle into a single-use disposable cartridge. The cartridge is placed onto the tip of the jet injector and when activated a rod pushes the plunger forward. These devices are known as disposable-cartridge jet injectors or DCJI.[4]

The International Standards Organization recommended abandoning the use of the name "jet injector" which is associated with carrying a risk of cross-contamination and rather refer to newer devices as "needle-free injectors."[6]

Modern needle-free injector brands

The Biojector 2000 is a maker of gas-cartridge-powered jet injector. It is claimed by its manufacturer that it can deliver intramuscular injections and subcutaneous injections up to 1 milliliter. The part which touches the patient's skin is single-use and can be replaced easily. It can be powered from a big compressed gas cylinder instead of gas cartridges. It is made by Bioject.[7]

The Vision (MJ7) is a compact, spring-powered jet injector. It can deliver up to 1.6ml in 0.03ml increments, and is designed to last 3000 injections. The medication travels through a hole in the needle-free syringe that is about half the diameter of a 30 gauge syringe. The part which touches the patient's skin can be used for a week. The device was designed by Antares Pharma (formerly Medi-Jector).[8]

The PharmaJet Needle-Free Injector delivers vaccines either intramuscularly or subcutaneously by means of a narrow, precise fluid stream syringe that delivers the medicine or vaccine through the skin in one-tenth of a second.[9]

Diabetics have been using jet injectors in the United States for at least 20 years. These devices have all been spring loaded. At their peak, jet injectors accounted for only 7% of the injector market. Currently, the only model available in the United States is the Injex 23. In the United Kingdom, the Insujet has recently entered the market. As of June 2015, the Insujet is available in the UK and a few select countries.

The J-Tip is a single-use, sterile, completely needle free jet injector that administers lidocaine subcutaneously prior to routine needle procedures such as IV starts and blood draws. The J-Tip is being used as a pre number for needle procedures by giving an anesthetic effect within 1-2 minutes. It is being used in hospitals across the United States.[10]

There are three types of inherent problems with jet injectors

Splash-back

Splash-back refers to the jet stream penetrating the outer skin at a high velocity causing the jet stream to ricochet backwards and contaminate the nozzle.[11]

Instances of splash-back have been published by several researchers. Samir Mitragrotri visually captured splash-back after discharging a multi-use nozzle jet injector using high-speed micro cinematography.[12] Hoffman and colleagues (2001) also observed the nozzle and internal fluid pathway of the jet injector becoming contaminated.[13]

Fluid suck-back

Fluid suck-back occurs when blood left on the nozzle of the jet injector is sucked back into the injector orifice, contaminating the next dose to be fired.[14]

The CDC has acknowledged that the most widely used jet injector in the world, the Ped-O-Jet, sucked fluid back into the gun. "After injections, they CDC observed fluid remaining on the Ped-O-Jet nozzle being sucked back into the device upon its cocking and refilling for the next injection (beyond the reach of alcohol swabbing or acetone swabbing)," stated Dr. Bruce Weniger.[15]

Retrograde flow

Retrograde flow happens after the jet stream penetrates the skin and creates a hole, if the pressure of the jet stream causes the spray, after mixing with tissue fluids and blood, to rebound back out of the hole, against the incoming jet stream and back into the nozzle orifice.[16]

Hepatitis B can be transmitted by less than one millionth of a milliliter[17] so makers of injectors must ensure there

is no cross-contamination between applications. The World Health Organization no longer recommends jet injectors for vaccination due to risks of disease transmission.[18]

Numerous studies have found cross-infection of diseases from jet injections. An experiment using mice, published in 1985, showed that jet injectors would frequently transmit the viral infection LDV from one mouse to another.[19] Another study used the device on a calf, then tested the fluid remaining in the injector for blood. Every injector they tested had detectable blood in a quantity sufficient to pass on a virus such as hepatitis B.[20]

From 1984–1985 a weight-loss clinic in Los Angeles, California administered human chorionic gonadotropin with a Med-E-Jet injector. CDC investigation found 57 out of 239 people who had received the jet injection tested positive for hepatitis B.[21]

In addition to transmission between patients, jet injectors have been found to inoculate bacteria from the environment into users. In 1988 a podiatry clinic used a jet injector to deliver local anaesthetic into patients' toes. Eight of these patients developed infections caused by Mycobacterium chelonae. The injector was stored in a container of water and disinfectant between uses, but the organism grew in the container.[22] this species of bacteria is sometimes found in tap water, and had been previously associated with infections from jet injectors.[23]

(Weniger 2004).

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