Volcano

VAPORIZING SYSTEM

Independent Scientific Studies

www.storz-bickel.com

Cannabis vaporizer combines efficient delivery of THC with effective suppression of pyrolytic compounds

Dale Gieringer
Joseph St. Laurent
Scott Goodrich

ABSTRACT. Cannabis vaporization is a technology designed to deliver inhaled cannabinoids while avoiding the respiratory hazards of smoking by heating cannabis to a temperature where therapeutically active cannabinoid vapors are produced, but below the point of combustion where noxious pyrolytic byproducts are formed.

This study was designed to evaluate the efficacy of an herbal vaporizer known as the **Volcano®**, produced by **Storz & Bickel GmbH & Co. KG, Tuttlingen, Germany (http://www.storz-bickel.com)**. Three 200 mg samples of standard NIDA cannabis were vaporized at temperatures of 155°-218°C. For comparison, smoke from combusted samples was also tested.

The study consisted of two phases: (1) a quantitative analysis of the solid phase of the vapor using HPLC-DAD-MS (High Performance Liquid Chromatograph-Diode Array-Mass Spectometry) to determine the amount of cannabinoids delivered; (2) a GC/MS (Gas Chromatograph/Mass Spectrometer) analysis of the gas phase to analyze the vapor for a wide range of toxins, focusing on pyrene and other polynuclear aromatic hydrocarbons (PAHs).

The HPLC analysis of the vapor found that the **Volcano** delivered 36%-61% of the THC in the sample, a delivery efficiency that compares favourably to that of marijuana cigarettes.

The GC/MS analysis showed that the gas phase of the vapor consisted overwhelmingly of cannobinoids, with trace amounts of three other compounds. In contrast, over 111 compounds were identified in the combusted smoke, including several known PAHs.

The results indicate that vaporization can deliver therapeutic doses of cannabinoids with a drastic reduction in pyrolytic smoke compounds. Vaporization therefore appears to be an attractive alternative to smoked marijuana for future medical cannabis studies.

Dale Gieringer is affiliated with California NORML, 2215-R Market Street #278, San Francisco, CA 94114.
Joseph St. Laurent and Scott Goodrich are affiliated with Chemic Labs, 480 Neponset Street, Building #7C, Canton, MA 02021.
The authors offer thanks for insight and technical support to Jeff Jones, Elvy Musikka, Irvin Rosenfeld and Aidan Hampson.
This research was supported by a grant from the Marijuana Policy Project. Additional support provided by the NORML Foundation, the Multidisciplinary Association for Psychedelic Studies and Storz & Bickel GmbH & Co. KG.

Source: Journal of Cannabis Therapeutics, Vol. 4(1) 2004

Vaporization as a smokeless cannabis delivery system: A pilot study

Donald I. Abrams[1], Hecto P. Vizoso[1], Starley B. Shade[1],
Cheryl Jay[1], Mary Ellen Kelly[1], Neal Benowitz[1]

Introduction: The Institute of Medicine report published in 1999 suggested that although marijuana may have potential therapeutic value, smoking was not a desirable delivery system for cannabis. A 6-day "proof of concept" pilot study was proposed to investigate vaporization using the **Volcano** device as an alternative means of delivery of inhaled *Cannabis sativa*, to characterize preliminary pharmacokinetic and pharmacodynamic effects and to determine whether it may be an appropriate system for use in clinical effectiveness studies.

Methods: Eighteen healthy subjects were recruited and admitted to the inpatient ward of the General Clinical Research Center (GCRC) at San Francisco General Hospital to investigate the delivery of cannabinoids by vaporization of marijuana compared to marijuana smoked in a standard cigarette. One dose (1.7, 3.4 or 6.8% tetrahydrocannabinol) and delivery system (smoked marijuana cigarette or vaporization system) was randomly assigned for each of the six study days. The primary endpoint was the comparison of plasma concentrations of delta-9-tetrahydrocannabinol (THC), cannabidiol, cannabinol, and metabolites, including 11-OH-THC resulting from inhalation of cannabis after vaporization vs smoking. Expired carbon monoxide was measured to evaluate whether the vaporizer reduces exposure to gaseous toxins as a secondary endpoint. We also evaluated physiologic and neuropsychologic effects and queried patients for their preference of blinded dose day and delivery method. Adverse events were collected.

Results: 21 participants were enrolled to obtain the 18 who completed the 6-day inpatient study. 15 men and 3 women, mean age 30 years, were included in the final analysis. The plasma THC concentrations are still being determined at this time. Results will be available in September. 14 participants preferred vaporization, 2 smoking and 2 reported no preference. While still blinded with regard to dose, 8 participants selected the day they received 3.4% THC (7 vaporized, 1 smoked) as their most preferred treatment day; 4 selected the day they received 6.8% THC via vaporization and 6 had no treatment day preference. No adverse events were observed.

Conclusion: Vaporization of cannabis is a safe mode of delivery. The determination of plasma THC levels and comparison of clinical effects to smoked cannabis will provide information on the effectiveness of this delivery system. Participants had a clear preference for vaporization over smoking as a delivery system for the cannabis used in this trial.

[1] The University of California San Francisco, San Francisco, California 94110, USA

Optimized administration of THC for clinical use by vaporizing

Arno Hazekamp[2], Renee Ruhaak[1], Lineke Zuurman[3], Joop van Gerven[2], Rob Verpoorte[1]

What is currently needed for optimal use of medicinal cannabinoids is a feasible, non-smoked, rapid-onset delivery system. Smoking of cannabis plant material results in the highest bioavailability and consequently pulmonal administration of cannabinoids is considered to be very effective. The goal of this study was to evaluate the performance of the **Volcano®** vaporizer in terms of reproducible administration of pure THC, without the formation of degradation products. Results were used for designing a clinical trial for administration of THC by vaporizing.

Methods: Using the **Volcano®**cannabis vaporizer, THC and its acidic analogue THCA were tested for delivery of THC into the balloon of the **Volcano** device. The efficiency of vaporizing of these samples was compared with cannabis plant material. Analyses were performed using HPLC and quantitive ^{1}H-NMR. After determination of the dynamics of heating up, and accuracy and stability of vaporizing temperatures of the **Volcano**, the temperature setting and balloon volume were systematically optimized for maximum evaporation of THC. Factors contributing to loss of THC were evaluated. Several **Volcano** set-ups were tested to determine variability. After validation, the **Volcano** was used in a methodology study to determine the effects of pulmonary administration of a rising dose of THC in twelve healthy volunteers, who were subjected to an array of physiological and psychological tests after each administration.

Results: Under optimized conditions the **Volcano** was found to deliver about 54% of the loaded sample in a reproducible way into the vapor phase without formation of degradation products like delta-8-THC or CBN. In the range of 2 to 8 mg of THC the delivery was found to be linear with the amount of THC loaded onto the vaporizer. Prolonged storage of the balloon before inhalation resulted in an increasing loss of THC by condensation. No significant differences in THC delivery were found between four devices tested. Full results of this phase I clinical trial are not presented here, but a clear dose-dependent effect was found in several of the used tests. During these inhalation studies the fraction of exhaled THC was found to be around 34%. Improvements in the original design of the **Volcano** were made based on these results for further optimization of the **Volcano** for administration of pure cannabinoids in a clinical setting.

Conclusions: Using the **Volcano** for pulmonal administration of THC, a delivery is reached that is comparable to smoking, without the presence of degradation products or harmful byproducts in significant amounts. This study confirms that the pulmonary administration of cannabinoids by evaporation certainly has a clinical potential. With the **Volcano** a safe and effective cannabinoid delivery system seems to be available to patients. Although our current study has concentrated on the delivery of THC it should be noted that other cannabinoids might also have a role to play for some indications.

[2] Division of Pharmacognosy, Institute of Biology, Leiden University, The Netherlands
[3] Centre for Human Drug Research, Leiden, The Netherlands,

Effect of the THC administration in humans: Methodology study for further pharmacodynamic studies with cannabinoid agonist or antagonist

L. Zuurman[4], C. Roy[5], A. Hazekamp[6], R. Schoemaker[1], J. den Hartigh[7], J.C.M.E. Bender[8], R. Verpoorte[3], J.L. Pinquier[2], A.F. Cohen[1], J.M.A. van Gerven[1]

Introduction: Cannabinoid receptor I agonists and antagonists are in development for neurological, metabolic and psychiatric disorders. The effects of cannabinoid antagonists in healthy volunteers are mostly unknown, hampering the design and interpretation of early pharmacology studies in humans with these compounds. Cannabinoid antagonist activity can be demonstrated, by showing inhibitory activity on the effects of the cannabinoid receptor I agonist tetrahydrocannabinol (THC). This study addresses the dose-response-relationships for THC. This information can be used as the basis for pharmacological proof-of-mechanism studies of cannabinoid antagonists (counteraction studies) and agonists (as a positive control). The study was also set up to identify by which pharmacodynamic parameters the effects of THC are most accurately quantified.

Methods: THC was purified from *Cannabis sativa* according to GMP-compliant procedures (Farmalyse BV, Zaandam, The Netherlands). Twelve healthy males (average 23.3 years, range 21-27) with a history of mild cannabis use for at least one year were included in the study. On one study day, rising doses of THC (2, 4, 6 and 8 mg) were administered by inhalation at 90-minute intervals using a **Volcano® vaporizer (Storz & Bickel GmbH & Co. KG, Tuttlingen, Germany)**. On a separate, randomised occasion, vehicle was administered in the same way, as double-blinded placebo. Pharmacodynamic measurements were obtained frequently after each consecutive dose, including, visual analogue scales (VAS) according to Bond & Lader, psychotomimetic VAS according to Bowdle, Saccadic Eye Movements, Smooth Pursuit Eye Movements, Pupil size, Body Sway, Adaptive Tracking, Pharmaco-EEG and Heart Rate. Bloodsamples were taken to measure plasma THC concentrations.

Results: Analysis was performed using mixed model ANOVA with baseline values as covariate. After THC administration, significant dose-related changes compared to placebo were seen in Body Sway (58.9%: 95% CI 33, 89.7) and VAS alertness (-33.6%: 95% CI -41.6, -25.7). Significant dose-related changes were also seen in pharmaco-EEG, in which Pz-Oz delta- and beta activity decreased (-12.0%: 95% CI -19.1%, -4.4% and -8.0%: 95% CI -13.8%, -1.8% resp.). Heart rate increased significantly compared to placebo with a maximum of 24 beats per minute (19.4%: 95% CI 13.3, 25.5). Plasma THC concentrations showed little inter-individual variation. The average initial plasma half life was 4 minutes and the terminal half life was 70 minutes.

Conclusion: This study provides a model for pharmacological proof-of-mechanism studies of cannabinoid antagonists (inhibitory activity) and agonists (positive control).

[4] Centre for Human Drug Research, Leiden, The Netherlands,
[5] Aventis-Pharma Recherche-Développement, Paris, France
[6] Department of Pharmacognosy of Leiden University, Leiden, The Netherlands
[7] Hospital Pharmacy Leiden University Medical Center, Leiden, The Netherlands
[8] Farmalyse BV, Zaandam, The Netherlands