

# A Review of Medical Cannabis Studies relating to Chemical Compositions and Dosages for Qualifying Medical Conditions

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Minnesota  
Department of Health  
**OFFICE OF MEDICAL CANNABIS**

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## Executive Summary

On May 29, 2014 the Governor of Minnesota signed into law a medical cannabis therapeutic use law: 2014 Minnesota Laws chapter 311. This Act is designed to enable truly sick patients to engage in the therapeutic use of cannabis while preventing it being misused or diverted from its medical purpose. Another purpose of the program is to generate and collect data in a science-based approach, to move the evidence relating to the efficacy of cannabis in treating specified medical conditions from the anecdotal to something more structured.

This report summarizes clinical trials and prospective observational studies in humans, published in peer reviewed journals, which focus on medical cannabis formulations consistent with Minnesota's medical cannabis program. It was produced in fulfillment of Minnesota Statutes 2014, Chapter 311, Section 5, subdivision 2. The report will be updated periodically. Relevant new study publications and newly discovered existing study publications will be included as they come to the attention of the Office of Medical Cannabis.

The medical conditions identified in the statute for inclusion in the medical cannabis program are:

- 1 Cancer, if the underlying condition or treatment produces one or more of the following:
  - a. Severe or chronic pain;
  - b. Nausea or severe vomiting; or
  - c. Cachexia or severe wasting
- 2 Glaucoma
- 3 Human immunodeficiency virus or acquired immune deficiency syndrome
- 4 Tourette's syndrome
- 5 Amyotrophic lateral sclerosis
- 6 Seizures, including those characteristic of epilepsy
- 7 Severe and persistent muscle spasms, including those characteristic of multiple sclerosis
- 8 Crohn's disease
- 9 Terminal illness, with a probable life expectancy of under one year, if the illness or its treatment produces one or more of the following:
  - a. Severe or chronic pain;
  - b. Nausea or severe vomiting; or
  - c. Cachexia or severe wasting

There are relatively few clinical trials, especially large clinical trials that can produce the most definitive results. In recent years the number of such trials has increased to some degree, perhaps reflecting the commercialization of medical cannabis products around the world over the past few decades. Following are summary observations for each section.

## Cancer: pain

Trial results suggest a combination of THC and CBD might be more effective than THC alone and that doses of THC higher than approximately 25 mg, even when divided over the course of a day, might be poorly tolerated by a substantial number of patients.

## Cancer: nausea and vomiting

Several studies of plant-derived THC for chemotherapy-induced nausea and vomiting (CINV) from the late 1970s used 10 to 18 mg THC starting an hour or two before chemotherapy initiation, then repeating the dose every 2 to 4 hours for an additional 2 to 4 doses over 12 to 24 hours. Clinical trials of dronabinol, synthetic delta-9-THC, have used daily doses similar to the trials of plant-derived THC from the 1970s: 30 to 80 mg/day in divided doses. Not everyone can tolerate these doses, and the FDA recommends a lower dronabinol dose for CINV, stating most patients respond to 5 mg three or four times daily.

## Cancer: cachexia/wasting

Some small early trials showed effectiveness with doses of plant-derived THC 10 to 15 mg three to four times daily on days of chemotherapy infusion. Later trials with dronabinol, mostly in cancer patients not receiving chemotherapy, are less encouraging. Using doses of 5.0 to 7.5 mg daily in divided doses there was either modest

effectiveness compared to placebo or inferior effectiveness compared to standard anti-emetic drugs, and a substantial number of patients could not tolerate these doses. A large trial with cannabis extract treatment arms of relatively small doses of THC only (2.5 mg twice daily) or THC + CBD (2.5 mg THC/1.0 mg CBD twice daily) was stopped early for lack of effectiveness, yet dose reductions were necessary in a third of both groups.

## Glaucoma

CBD does not appear to be effective at lowering intraocular pressure (IOP) and might even increase it. There is some evidence that even relatively low (5 mg) single doses of THC significantly reduces IOP for 4 to 5 hours before it returns to baseline, but this isn't a consistent finding across studies. Larger single doses (20 and 25 mg) appear to reduce IOP longer (10 hours), but with a high occurrence of intolerable side effects.

## HIV/AIDS

Each of the studies identified used dronabinol and assessed effect on appetite and weight. Most used 5.0 to 7.5 mg daily in 2 or 3 divided doses, consistent with FDA label recommendations. Though most patients tolerated this dose well, a substantial minority could only tolerate 2.5 mg daily. Results from three trials that enrolled current marijuana users suggest current marijuana users can tolerate higher doses, in the range of 20 to 40 mg daily in divided doses.

## Tourette Syndrome

Two small studies of oral, plant-derived THC (source not specified) in adult TS patients used single daily doses of 2.5 mg to 10 mg. About a third of the patients needed to decrease dose because of unacceptable side effects. Together,

these studies provide modest evidence of effectiveness at reducing tic severity.

## Amyotrophic Lateral Sclerosis

The two small trials in ALS patients that were identified used dronabinol. One was reported in an abstract with few details, but started patients on 2.5 mg daily and titrated up to a maximum daily dose of 10 mg. The second used 10 mg daily in two divided doses. Both studies indicated patients tolerated the dronabinol doses well, but with little clear evidence of effectiveness.

## Seizures

Reported trials that appear to have enrolled mostly adults each used 200 or 300 mg CBD daily with two of the three suggesting evidence of effectiveness at reducing seizure severity. A recent survey of parents of children with epilepsy treated with CBD extract indicates a very wide range of daily dose, but the results are hard to interpret because of lack of standardization of the CBD preparations used. Recent trials mostly or entirely focusing on children have used pure or nearly pure CBD, starting at a dose of 2 to 5 mg/kg/day, titrating up slowly to a goal of 25 to 50 mg/kg/day.

## Muscle spasms

Results of numerous trials focusing on spasticity and muscle spasm have been published, mostly with multiple sclerosis patients, but also some with spinal cord injury patients. Whether in combination with CBD in various ratios or as a single agent (dronabinol), THC has been used in

average dosages of 20 to 25 mg/day in divided doses. Dosages are usually started fairly low and then titrated up to achieve a balance between symptom reduction and appearance of side effects. From the trial experience, it appears that doing this titration over weeks, rather than over days, helps to reduce incidence and severity of side effects. There is some indication that THC is more effective in reducing spasticity and spasm at higher doses and that higher doses are better tolerated when given in conjunction with CBD in a THC:CBD ratio of 1:1 (versus 2:1 or 3:1 or dronabinol). But some patients cannot tolerate even quite low doses of THC. Treatment appears to be effective in only a subset of patients, perhaps around half, and whether or not treatment will be effective can generally be determined within a few weeks.

## Crohn's Disease

At this point there is no clear guidance on composition or dosing. The two trials included in this report both emphasize CBD, with somewhat different approaches: THC:CBD ratio 1:10 (5 mg THC and 50 mg CBD, twice daily) and CBD only (5 mg CBD in olive oil twice daily). The former is a completed trial, but results have not yet been reported. The latter is a trial now recruiting patients.

## Terminal Illness

Relevant studies can be found in other sections of this report, particularly the cancer sections. No published medical cannabis trials were found that specifically targeted patients with short life expectancy, cutting across medical conditions.

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## Introduction

This report summarizes clinical trials and prospective observational studies in humans, published in peer-reviewed journals, that focus on medical cannabis formulations consistent with Minnesota's medical cannabis program. It was produced in fulfillment of Minnesota Statutes 2014, Chapter 311, Section 5, Subdivision 2. The report will be updated periodically. Relevant new study publications and newly discovered existing study publications will be included as they come to the attention of the Office of Medical Cannabis.

To accomplish this review, the National Library of Medicine's MEDLINE database was searched using key words appropriate for each qualifying medical condition in the Minnesota medical cannabis program statute. Articles that appeared to be results of clinical trials or reviews of clinical trials were accessed through the MDH library for examination. References in such articles were studied to identify additional articles that were not found on the initial search. This continued in an iterative fashion until no additional relevant articles were found. Finally, the government maintained web site of registered clinical trials, [clinicaltrials.gov](http://clinicaltrials.gov), was searched to learn about trials currently under way or under development and to check whether additional articles on completed trials could be found.

The body of this report contains a section for each of the nine qualifying medical conditions. At the beginning of each section (or subsection, in the case of cancer) there are comments providing an overview of the scientific articles that follow. Below the citation for each article is a condensed description of the study and its results.

Trials involving non-smokeable medical cannabis usually use either extractions of cannabis, sometimes with processing that enriches specific components of the plant's constituent parts, or synthetic cannabinoids. Cannabinoids are a class of oxygen-containing aromatic hydrocarbons found distinctively in plants from the genus *Cannabis*.

The two cannabinoids typically found in greatest quantity in cannabis plants are delta-9-tetrahydrocannabinol (typically referred to as THC) and cannabidiol (CBD). THC is the cannabinoid usually present in greatest quantity and it is psychoactive, acting as a prominent cause of the euphoria - and sometimes dysphoria, - perceptions of time distortion, and so forth that are well known from recreational use of marijuana. Both THC and CBD have been studied extensively in pre-clinical research, both in basic laboratory studies and in animal models. Both have attributes and effects in animal models that suggest beneficial effects with medical use in humans. CBD is not psychoactive and might attenuate the psychoactive effects of THC in some patients. There are relatively few clinical trials, especially large clinical trials that can produce the most definitive results. In recent years the number of such trials has increased to some degree, perhaps reflecting the commercialization of medical cannabis products around the world over the past few decades.

*Cancer, if the underlying condition or treatment produces one or more of the following: severe or chronic pain; nausea or severe vomiting; or cachexia or severe wasting*

## Cancer

### SEVERE OR CHRONIC PAIN

Two early trials studied delta-9-THC sourced from the U.S. government (Noyes J Clin Pharmacol 1975; Noyes Clin Pharmacol Ther 1975) and gave single oral administrations of 5, 10, 15, and 20 mg THC to adult cancer patients. Oral administration of 20 mg was not well-tolerated. Studies where similar daily doses of THC, or larger, divided into smaller dose administrations over the course of the day, would be helpful. But such studies were not found in the published literature and do not appear to be in the planning phases on [clinicaltrials.gov](http://clinicaltrials.gov).

Later, larger trials have studied nabiximols, the US Adopted Name for Sativex. Nabiximols is an oromucosal spray produced through extraction and processing of a strain of *Cannabis sativa* that results in high and stable concentrations of delta-9-THC and CBD and minor amounts of other cannabinoids and terpenes. Each 100 micro-liter actualization (spray) contains 2.7 mg THC and 2.5 mg CBD. The high dose group in Portenoy 2012, at least 11 sprays per day (3 in the AM, 8 in the PM), was not well tolerated. 11 sprays delivers 29.7 mg THC (8.7 mg in the AM, 21.6 mg in the PM) and 25 mg CBD. Patients in Johnson 2010 self-titrated to an average of 8.75 sprays (23.6 mg THC, 21.9 mg CBD), delivered over the course of a day. Patients taking nabiximols in the Johnson 2010 study tolerated it fairly well. The Johnson 2010 study also had a group taking a cannabis extract that had only THC. Patients in this group self-titrated to 8.34 sprays over the course of a day (22.5 mg THC), tolerating it fairly well, with a side effect profile similar to the THC/CBD group. These studies, as a group, suggest the wisdom of dividing a day's total

dose over multiple different administrations to mitigate side effects. The Johnson 2012 extension study lacked large numbers of patients followed long-term on nabiximols, but nevertheless it does provide some evidence of effectiveness over many months with no evidence of need for dose escalation over time.

Three clinical trials of Sativex for adjunct treatment of cancer pain have now been completed. Results have not been published but some information on results is included in press releases issued by the sponsor company, GW Pharmaceuticals. Each of the trials set an upper bound of dosing at 10 sprays per day (27 mg THC and 25 mg CBD). The primary endpoint in each was reduction in patient reported pain on a 0-10 numerical rating scale. None of the three showed a statistically significant difference in pain reduction between Sativex and placebo. However, a pre-specified pooled analysis of patients from US centers from two of the trials, showed better pain control with Sativex that reached statistical significance.

**Johnson JR, Burnell-Nugent M, Lossignol D, Ganac-Motan ED, et al. Multicenter, double-blind, randomized, placebo-controlled, parallel-group study of the efficacy, safety, and tolerability of THC:CBD extract and THC extract in patients with intractable cancer-related pain. J Pain Symptom Manage 2010;39:167-179.**

The effect of two weeks of treatment with nabiximols, THC extract, or placebo was studied in this double-blind, randomized, placebo-controlled, parallel group study involving 177 adult cancer patients from 28 European centers. The patients were required to have advanced cancer with pain not adequately controlled despite optimized opioid management. Patients with chemotherapy within the preceding two weeks were excluded. Patients were randomized to nabiximols, to a cannabis extract containing only THC (2.7 mg per 100 micro-liter spray), or placebo spray. Patients self-titrated with the instruction of increasing the number of sprays each day by a maximum of 50% until they either had satisfactory relief of their symptoms or



developed unwanted side effects. Sprays were to be spread throughout the day, with at least 15 minutes between sprays. Maximum number of sprays allowed within a 3 hour period was 8 and maximum within a 24 hour period was 48. The mean number of sprays in the nabiximols group was 8.75 (23.6 mg THC, 21.9 mg CBD) and the average number of sprays in the THC group was 8.34 (22.5 mg THC). The co-primary end-point was reduction in pain score between baseline and end of study. 43% of patients in the THC/CBD group achieved a 30% or greater reduction in their pain score, twice the number of patients who achieved this response in the THC and placebo groups. A higher percentage of patients experienced somnolence (13%), dizziness (12%), and confusion (7%) in the nabiximols group than in placebo. Incidence of these side effects was similar in the THC/CBD and THC groups. However, 3 episodes of hypotension were seen in the nabiximols group and none was observed in the THC or placebo groups. Side effects leading to study withdrawal occurred in 17%, 12%, and 3%, respectively, for nabiximols, THC extract, and placebo.

**Johnson JR, Lossignol D, Burnell-Nugent M, and Fallon MT. An open-label extension study to investigate the long-term safety and tolerability of THC/CBD oromucosal sprays and oromucosal THC spray in patients with terminal cancer-related pain refractory to strong opioid analgesics. J Pain Symptom Manage 2013;46:207218.**

This open-label extension to the parent study reported in Johnson 2010 enrolled 43 patients: 13 had received nabiximols (THC/CBD) in the parent study, 11 had received THC spray and 19 had received placebo. 39 received nabiximols in the extension study and 4 received THC spray. Though it was conceived as a long-term follow-up study, because of staggered enrollment in the parent study (creating shorter follow-up for more recently-enrolled patients before end of the extension study) and patients who dropped out of the study, median follow-up time for patients receiving nabiximols was 25 days (range 2 to 579 days) and for the four patients receiving THC spray

median follow-up was 152 days (range 4 to 657 days). Patients were instructed to self-titrate dose to reach a balance between effectiveness and side effects and to not exceed 8 sprays in a three hour period or 48 sprays per 24 hours. Actual dose experience of the patients was not reported, except that the authors noted study medication was taken for more than six months by 10% of patients and for more than one year by 5% without resulting in dose escalation. Effectiveness analyses were limited to 5 weeks of observation time, over which a trend of improvement in pain control was noted. A total of 23 patients (59%) receiving nabiximols and one of the 4 receiving THC spray withdrew because of side effects. Of these, 12 patients taking nabiximols had been in the placebo group during the parent study. Improvements over time were observed for insomnia and fatigue and worsening of nausea and vomiting was observed over time.

**Lynch ME, Cesar-Rittenberg P, Hohmann AG. A double-blind, placebo-controlled, crossover pilot trial with extension using an oral mucosal cannabinoid extract for treatment of chemotherapy-induced neuropathic pain. J Pain and Symptom Manage 2014;47:166-173.**

Randomized, placebo-controlled crossover pilot study of nabiximols vs placebo in 16 patients with chemotherapy-induced neuropathic pain. Inclusion criteria included neuropathic pain persisting for three months after completing chemotherapy with paclitaxel, vincristine, or cisplatin, average seven day intensity of pain  $\geq 4$  on an 11-point scale, and concurrent analgesics stable for 14 days before entry into the trial. Participants had a wide variety of cancers. Average chemotherapy cycle number when pain started was 2.8; average duration of pain was 17 months. The trial started with a one-week baseline pain assessment period, then up to two weeks of titration of medication upwards, four weeks at stable medication dose, up to two week period titrating dose down, then a two week wash-out period before a second round using the other agent. Dosing started with one spray and

participants were instructed to increase the study medication by one to two sprays per day until they reached a dose that helped their pain, up to a maximum of 12 sprays per day, stopping increases if unacceptable side effects developed. The primary outcome was change in 11-point rating scale of pain over the past seven days. Secondary measures included SF-36 quality of life survey and QST sensory testing. 18 patients started the study and two dropped out for unspecified reasons. Mean dose used during active treatment was 8 sprays per day (range 3-12) and 11 sprays during placebo treatment. Mean baseline NRS score was 6.75. During active treatment, participants experienced 11.1% reduction in NRS score at week 4; during placebo treatment the reduction was 5.2% (difference not statistically significant). Five participants were reported as having a two point or greater decrease in NRS score during active treatment. Among these 5, called "responders," the mean baseline NRS scores were 6.0. During active treatment, these participants experienced 43.3% reduction in NRS score; during placebo treatment the reduction was 10.0% (difference statistically significant). Most patients reported side effects during active treatment and only two reported side effects during placebo treatment. Most common side effects during active treatment were fatigue (n=7), dizziness (6), nausea (6), and dry mouth (5). Authors report there were no serious medication-related adverse events and that no patient discontinued medication or withdrew from the study because of side effects.

**Noyes R Jr, Brunk SF, Baram DA, and Canter A. Analgesic effect of delta-9-tetrahydrocannabinol. J Clin Pharmacol 1975;15:139-143.**

Ten adults with advanced cancer and continuous moderate pain were recruited for a double-blind trial testing the effect of single administrations of delta-9-THC at different dosages. The THC was sourced from the U.S. government and oral dosages tested were 5 mg, 10 mg, 15 mg, and 20 mg. Over 5 days patients received each of these

dosages or placebo in random order. The patients remained on their usual pain medications (none on "large doses of narcotics") until 4 AM each day and the study medication was administered at 8:30 AM and pain assessments done before administration and hourly thereafter for six hours. Measures of pain reduction and pain relief increased with larger doses. Analgesic effect increased over time, peaking at 3 hours for the lower doses and at 5 hours for the 20 mg dose. Interestingly, in all groups a secondary peak can be seen at 5 hours – perhaps the result of THC's mobilization from the gall bladder and reabsorption following food ingestion. The most prominent side effect was dose-dependent drowsiness and slurred speech.

**Noyes R Jr, Brunk SF, Avery DA, and Canter AC. The analgesic properties of delta-9-tetrahydrocannabinol and codeine. Clin Pharmacol Ther 1975;18:84-89.**

This randomized, double-blinded trial followed the preliminary trial reported in Noyes J Clin Pharmacol 1975. It randomized 36 advanced cancer patients with continuous moderate pain to a morning administration of either placebo, 10 mg THC (sourced from the U.S. government), 60 mg codeine, 20 mg THC, or 120 mg codeine, in random order, on five successive days. Their usual analgesic medications ("none were receiving large doses of narcotics") were continued until 4 AM and study medication administered at 8:30 AM. Information on pain and other symptoms was collected just before medication administration and hourly for seven hours thereafter. 10 mg THC showed improved pain control compared with placebo over 7 hours, but the difference was not statistically significant. The larger reduction in pain with 20 mg THC was a statistically significant difference from placebo but caused substantial cognitive impairments and drowsiness. Side effects were much milder and shorter lasting with 10 mg THC. The authors noted that evaluating pain relief was especially difficult in patients after receiving THC because in many instances the patients appeared exceptionally peaceful while reporting little pain relief. And, in other instances, they claimed that

though the pain was unchanged, it bothered them less.

**Portenoy RK, Ganae-Motan ED, Allende S, Yanagihara R, et al. Nabiximols for opioid-treated cancer patients with poorly-controlled chronic pain: a randomized, placebo-controlled, graded-dose trial. J Pain 2012;13:438-449.**

This was a randomized, placebo-controlled graded dose study of patients with advanced cancer and pain despite optimized opioid therapy from 84 centers in North America, Europe, South America and South Africa. Patients who had received or planned to receive chemotherapy or other treatments expected to change pain were excluded. Baseline pain had to be between 4 and 8 on an 11-point scale at baseline and stable for three consecutive days during a qualifying period when opioid management was optimized. Study treatment was nabiximols. Patients were randomized to one of three dose titration regimens and then half of each group was randomized to nabiximols and half to placebo. Patients randomized to the Low Dose group were instructed to titrate the study medication to between 1 and 4 sprays per day. Those assigned to Medium Dose group titrated the number of sprays to between 6 and 10 sprays per day, and those assigned to the High Dose group titrated to between 11 and 16 sprays per day. Daily dosage was split between morning and evening administration. All three groups were given a titration schedule that increased total dose over 7 days (3 days for the low dose group). Patients were told to increase to the maximum dose for their group unless intolerable side effects prevented further dose escalation. After the week of dose titration patients continued on stable dosing for four weeks. Daily assessments included average pain, worst pain, and sleep disruption. There were also baseline and study-end pain questionnaires and quality of life surveys. The primary end-point was 30% or greater reduction of pain from baseline. Results showed no statistically significant difference among treatment groups, compared to placebo. However, when the full

distribution of percentage of pain relief is compared among the groups, the two lower dose groups showed an improvement in pain relief, compared to placebo, that was statistically significant. Similar results were seen when “worst pain” and “disrupted sleep” scores were analyzed, where the largest improvement over placebo – and the only statistically significant differences – were seen in the group that administered 1 to 4 sprays per day. Neither the use of regularly scheduled opioids nor the number of opioid doses taken as needed for breakthrough pain varied significantly between treatment groups. Not only did the high dose group not show effectiveness in pain relief, but the high doses were not well tolerated. Only 66% could continue at the lowest dose (11 sprays) to the end of the study.

#### NAUSEA OR SEVERE VOMITING

Nausea and vomiting are common side effects of cancer and – especially - its treatment. There are multiple drug therapies for nausea and vomiting, but not all are effective for all patients and some patients cannot tolerate the side effects. There has been substantial study of cannabinoids for treatment of chemotherapy-induced nausea and vomiting (CINV). Most published trials have studied three synthetic versions of THC or THC analogs: dronabinol, nabilone, and levonantradol. Dronabinol, a synthetically produced delta-9-THC, and nabilone, a synthetic derivative of delta-9-THC, are both approved by the FDA for treatment of nausea and vomiting associated with cancer chemotherapy in patients who have failed to respond to conventional antiemetic therapy. Levonantradol is a synthetic analog of dronabinol that is much more potent than THC and remains an investigational drug. Of these three drugs, dronabinol is the one directly relevant to the Minnesota medical cannabis program.

A systematic review and meta-analysis of trials of dronabinol, nabilone and levonantradol for CINV, some comparing them to placebo and some comparing them to other antiemetic drugs, covered 30 studies (Machado Rocha 2008).

Limitations of sample sizes and study designs prevented firm conclusions, but the authors' general conclusion was there was evidence that dronabinol had better acute anti-emetic efficiency than the conventional anti-emetic drug comparitors. Doses of dronabinol ranged generally from 30mg/day to 80 mg/day in divided doses. The FDA label for dronabinol emphasizes the need for dosage individualization, but for use as an antiemetic, notes that most patients respond to 5 mg three or four times daily and that use of dronabinol with phenothiazines has resulted in improved efficacy as compared to either drug alone, without additional toxicity.

Two early trials of oral THC (with, in some cases, the addition of smoked marijuana) for reduction of chemotherapy-induced nausea and vomiting had mixed results. In both trials, the majority of patients were experienced marijuana smokers. The same protocol was used in both trials, administering five oral doses of approximately 18 mg delta-9-THC from one hour prior to 11 hours after time of chemotherapy infusion. Significant reduction in nausea and vomiting occurred during the trial with methotrexate therapy (Chang 1979), but no difference from placebo was observed in the trial with Adriamycin and Cytosin chemotherapy (Chang 1981). Two additional trials of THC for CINV from the same late-1970s era used similar dosing: 10 to 15 mg five times over 24 hours (Ekert 1979) and 10 to 15 mg 3 times over 12 hours (Sallan 1980).

A small randomized, double-blind trial studied nabiximols treatment as an adjunct to standard anti-emetic therapy for chemotherapy-induced nausea and vomiting (Duran 2010). On the day of chemotherapy treatment three sprays of nabiximols were delivered and the patient was instructed to increase the number of sprays throughout the day, up to a limit of 8 sprays within any 4 hour period. The mean number of daily sprays taken during the four days after chemotherapy was 4.8 in the active treatment group (range 2.7-5.0), representing a daily THC dose of 13.0 mg of THC per day (range 7.3 mg to

13.5 mg). One patient withdrew from active treatment because of adverse effects. A higher proportion of patients in the active treatment group (5/7) had complete response, compared to the placebo group (2/9). Complete response was defined by no vomiting and a specified score on a self-assessed nausea rating scale.

**Chang AE, Shiling DJ, Stillman RC, Goldberg NH, Seipp CA, Barofsky I, Simon RM, Rosenberg SA. Delta-9-tetrahydrocannabinol as an antiemetic in cancer patients receiving high-dose methotrexate. A prospective, randomized evaluation. Ann Intern Med 1970;91:819-824.**

Fifteen patients, age 15 to 49, with osteogenic sarcoma and receiving high dose methotrexate chemotherapy were studied. Eleven of the 15 were experienced users of marijuana. In this randomized, double-blind, placebo-controlled trial patients served as their own control. One hour prior to each instance of chemotherapy infusion the patient received a capsule containing either 10 mg/m<sup>2</sup> THC or placebo, with additional doses every three hours for a total of five doses. Based on a body surface area of 1.75 m<sup>2</sup>, the oral THC dose was 17.5 mg every 3 hours for five doses. If vomiting occurred during the treatment, patients received a marijuana cigarette instead of a capsule for the remaining doses. Results showed THC was significantly more effective than placebo in reducing the number of vomiting and retching episodes, degree of nausea, duration of nausea and volume of emesis.

**Chang AE, Shiling DJ, Stillman RC, Goldberg NH, Seipp CA, Barofsky I, Rosenberg S. A prospective evaluation of delta-9-tetrahydrocannabinol as an antiemetic in patients receiving Adriamycin and Cytosin chemotherapy. Cancer 1981;47:1746-1751.**

Eight patients, age 17 to 58, with soft tissue sarcomas and receiving Adriamycin and Cytosin chemotherapy were studied. Seven of the eight were experienced users of marijuana. In this randomized, double-blind, placebo-controlled trial patients served as their own control. One hour

prior to each instance of chemotherapy infusion the patient received a capsule containing either 10 mg/m<sup>2</sup> THC or placebo, with additional doses every three hours for a total of five doses. Based on a body surface area of 1.75 m<sup>2</sup>, the oral THC dose was 17.5 mg every 3 hours for five doses. If vomiting occurred during the treatment, patients received a marijuana cigarette instead of a capsule for the remaining doses. Results showed no effect of THC on nausea or vomiting in these chemotherapy patients.

**Ekert H, Waters KD, Jurk IH, Mobilia J, et al. Amelioration of cancer chemotherapy-induced nausea and vomiting by delta-9tetrahydrocannabinol. Med J Aust 1979;2:657659.**

This short article reports on two studies – or perhaps three. It is somewhat confusing. One study was a double-blind test of delta-9-THC and meloclopramide on children with cancer requiring chemotherapy. Source of the THC is not described. An oral dose of 10 mg/m<sup>2</sup> (with maximum of 15 mg) was administered four hours before chemotherapy and at 4, 8, 16, and 24 hours after the first dose. Incidence of nausea, vomiting, and anorexia was less than half in the patients taking THC, compared to those taking meloclopramide, with the differences achieving statistical significance. The side effect reported, drowsiness, was not common and was similar in both groups.

**Duran M, Preliminary efficacy and safety of an oromucosal standardized cannabis extract in chemotherapy-induced nausea and vomiting. Br J Clin Pharmacol 2010;70(4):656-663.**

Small randomized, double-blind trial of nabiximols treatment as an adjunct to standard anti-emetic therapy for chemotherapy-induced nausea and vomiting. 16 patients suffering from CINV despite prophylaxis with standard anti-emetic treatment were randomized to placebo (n=9) or nabiximols (n=7), to be taken in conjunction with standard anti-emetic treatment. Nabiximols (Sativex) is an oromucosal cannabis extract spray developed by

GW Pharmaceuticals. The whole plant extract is highly standardized, produced from cloned cannabis chemovars grown under controlled conditions. Each 100 µliter actuation (spray) yields 2.7 mg delta-9-THC and 2.5 mg of CBD with these two cannabinoids constituting at least 90% of cannabinoid content. On the day of chemotherapy treatment three sprays of nabiximols were delivered and the patient was instructed to increase home-dose for four days, up to 8 sprays within any 4 hour period. The mean number of daily sprays taken during the four days after chemotherapy was 4.8 in the active treatment group (range 2.7-5.0), representing a daily THC dose of 13.0 mg of THC per day (range 7.3 mg to 13.5 mg). One patient withdrew from active treatment because of adverse effects. A higher proportion of patients in the active treatment group (5/7) had complete response, compared to the placebo group (2/9). Complete response was defined by no vomiting and a specified score on a self-assessed nausea rating scale.

**Machado Rocha FC, Stefano SC, DeCassia HR, Rosa Oliveira LM, et al. Therapeutic use of Cannabis sativa on chemotherapy-induced nausea and vomiting among cancer patients: systematic review and meta-analysis. Eur J Cancer Care (Engl) 2008;17:431-443.**

A systematic review and meta-analysis of trials of dronabinol and nabilone for chemotherapy-induced nausea and vomiting, some comparing them to placebo and some comparing them to other antiemetic drugs.

**Sallan SE, Cronin C, Zelen M, and Zinberg NE. Antiemetics in patients receiving chemotherapy for cancer: a randomized comparison of delta-9tetrahydrocannabinol and prochlorperazine. N Engl J Med 1980;302:135-138.**

This was a study of delta-9-THC and prochlorperazine as antiemetics in cancer patients receiving chemotherapy resulting in nausea and vomiting inadequately controlled by conventional antiemetics, including phenothiazines. It was carried out in the late 1970s using delta-9-THC

sourced from the National Institute on Drug Abuse. 84 patients were randomized to receive three double-blind single-day courses of drug on days of chemotherapy. The trial was structured so patients received different orderings of two kinds

of one drug and one kind of the other (to address potential order effect). When the course was THC, the patient received 15 mg THC (or, in a few cases of small persons, 10 mg) an hour before start of chemotherapy and the same dose 4 and 8 hours later. "Complete response" was defined as no nausea or vomiting after chemotherapy. Regardless of the emetic activity of the chemotherapeutic agents, there were more complete responses to THC courses (36 of 79 courses) than to prochlorperazine (16 of 78 courses). Increased food intake occurred more frequently with THC. Side effects were not recorded, other than comments on proportions of patients who "got high." Of 36 THC courses resulting in complete response, 32 were associated with a high.

#### CACHEXIA OR SEVERE WASTING

Results of trials on effectiveness of cannabis formulations for increasing appetite in cancer patients are mixed and not particularly encouraging. Two early trials that used delta-9-THC derived from cannabis plants reported positive results in patients receiving chemotherapy. Maximum daily dose in the trial with plant-derived THC was up to 75 mg in five divided doses in children (Ekert 1979) and 30 to 45 mg in 3 divided doses in adults (Sallan 1980).

Three more recent trials used dronabinol, synthetic delta-9-THC. In one study with positive results cancer patients (not necessarily on chemotherapy) took 5 mg or 7.5 mg daily in divided doses with minimal side effects (Brisbois 2011). Another trial with modestly positive results used 7.5 mg/day in three divided doses, resulting in intolerable side effects for 20% of patients (Nelson 1994). A large trial that compared dronabinol and megestrol used 5 mg dronabinol daily in two divided doses. The modest improvement in weight seen with

dronabinol was inferior to that seen with megestrol; patients tolerated the dronabinol well (Jatoi 2002).

A large clinical trial comparing THC:CBD extract, THC-only extract and placebo was stopped early because of lack of effectiveness (Strasser 2006). Patients in the THC:CBD arm received 5.0 mg THC and 2.0 mg CBD daily in two divided doses; patients in the THC-only arm received 5.0 mg THC daily in two divided doses. Temporary or permanent dose reductions were necessary in approximately a third of both groups.

**Brisbois TD, de Kock IH, Watanabe SM, Mirhosseini M, et al. Delta-9-tetrahydrocannabinol may palliate altered chemosensory perception in cancer patients: results of a randomized, double-blind, placebocontrolled pilot trial. Ann Oncol 2011;2086-2093.**

This was a randomized, double-blind placebo controlled pilot study of effectiveness of dronabinol (synthetic delta-9-THC) in improving taste and smell (chemosensory) perception as well as appetite, weight, and quality of life in cancer patients with chemosensory alterations. 46 adult cancer patients with poor appetite and chemosensory alterations were recruited from two Canadian centers and randomized to dronabinol or placebo for 18 days. A third of the patients were receiving chemotherapy at the time of data collection, but all patients had previously been on multiple rounds of chemotherapy. Patients were started on one capsule (2.5 mg dronabinol) daily for three days then increased to two capsules daily (5 mg dronabinol/day). Patients had the option of increasing dose to a maximum of 8 capsules (20 mg dronabinol/day). 21 patients completed the study: 11 on dronabinol and 10 on placebo. Eight of the dronabinol patients took two capsules per day (5 mg/day in 2 divided doses) and 3 patients increased dose to 3 capsules (7.5 mg/day in 3 divided doses). Most patients receiving dronabinol had increased appetite at the end of the study (7), 3 had no change and one had incomplete data. Among patients receiving placebo half had

decreased appetite (5) and two showed no change (status of the remaining 3 not reported, but could be either increased appetite or incomplete data). Compared with placebo, dronabinol-treated patients increased their protein intake as a proportion of total energy and reported better sleep. Increase in caloric intake and in quality of life scores was similar in the two groups. No differences in number of adverse events or serious adverse events between active treatment and placebo groups were reported.

**Ekert H, Waters KD, Jurk IH, Mobilia J, et al. Amelioration of cancer chemotherapy-induced nausea and vomiting by delta-9-tetrahydrocannabinol. Med J Aust 1979;2:657-659.**

This short article reports on two studies – or perhaps three. It is somewhat confusing. One study was a double-blind test of delta-9-THC and meloclopramide on children with cancer requiring chemotherapy. Source of the THC is not described. An oral dose of 10 mg/m<sup>2</sup> (with maximum of 15 mg) was administered four hours before chemotherapy and at 4, 8, 16, and 24 hours after the first dose. Incidence of nausea, vomiting, and anorexia was less than half in the patients taking THC, compared to those taking meloclopramide, with the differences achieving statistical significance. The side effect reported, drowsiness, was not common and was similar in both groups.

**Jatoi A, Windschitl HE, Loprinzi CL, Sloan JA, et al. Dronabinol versus megestrol acetate versus combination therapy for cancer-associated anorexia: a North Central Cancer Treatment Group study. J Clin Oncol 2002;20:567-573.**

Jatoi et al studied the effect of megestrol acetate, dronabinol (synthetic delta-9-THC) and combination therapy on 469 patients with incurable cancer on no appetite stimulating drugs. All patients reported loss of 5 pounds or more over two months or caloric intake of less than 20 calories/kg of body weight. Patients were randomized to (1) megestrol acetate liquid suspension 800 mg orally daily plus capsule

placebo; (2) dronabinol capsules 2.5 mg orally twice a day plus liquid placebo; or (3) both medications. Patients were continued on treatment for as long as the health care provider thought it beneficial or until toxic side effects prompted study withdrawal. The North Central Cancer Treatment Group questionnaires for appetite and weight were used at baseline, weekly for a month, and monthly thereafter. Duration of observation was similar among the groups (megestrol=80 days, dronabinol=57 days, combination=74 days). A greater proportion of patients taking megestrol (11%) gained more than 10% of baseline weight, by home weight measurements, than patients taking dronabinol (3%) or both drugs (8%). And a greater percentage of patients taking megestrol reported improved appetite (75%), than patients taking dronabinol (49%) or both drugs (66%). Side effects were similar across the treatment groups, except for impotence, which was reported by 18 men taking megestrol, 4 men taking dronabinol, and 14 men taking both.

**Nelson K, Walsh D, Deeter P, and Sheehan F. A phase II study of delta-9-tetrahydrocannabinol for appetite stimulation in cancer-associated anorexia. J Palliat Care 1994;10:14-18.**

Nineteen adult patients with advanced cancer were recruited into an open-label (unmasked) four week trial of dronabinol (synthetic delta-9-THC) on appetite. Some patients were receiving chemotherapy and some were not. Patients were excluded if they were taking other drugs known to affect appetite. Each was started on 2.5 mg dronabinol three times per day (patients over the age of 65 were started on 2.5 mg twice /day for three days and then increased to three times/day). Four patients reported side effects and three dropped out because of them: one for slurred speech and two for nausea. A fourth patient experienced severe nausea but continued in the study. At four weeks 13 of 18 reported their appetite was at least slightly improved, compared with baseline (10 “slight improvement” and 3 “major improvement”).

**Sallan SE, Cronin C, Zelen M, and Zinberg NE. Antiemetics in patients receiving chemotherapy for cancer: a randomized comparison of delta-9-tetrahydrocannabinol and prochlorperazine. N Engl J Med 1980;302:135-138.**

This was a study of delta-9-THC and prochlorperazine as antiemetics in cancer patients receiving chemotherapy resulting in nausea and vomiting inadequately controlled by conventional antiemetics, including phenothiazines. It was carried out in the late 1970s using delta-9-THC sourced from the National Institute on Drug Abuse. 84 patients were randomized to receive three double-blind single-day courses of drug on days of chemotherapy. The trial was structured so patients received different orderings of two kinds of one drug and one kind of the other (to address potential order effect). When the course was THC, the patient received 15 mg THC (or, in a few cases of small persons, 10 mg) an hour before start of chemotherapy and the same dose 4 and 8 hours later. "Complete response" was defined as no nausea or vomiting after chemotherapy. Regardless of the emetic activity of the chemotherapeutic agents, there were more complete responses to THC courses (36 of 79 courses) than to prochlorperazine (16 of 78 courses). Increased food intake occurred more frequently with THC. Side effects were not recorded, other than comments on proportions of patients who "got high." Of 36 THC courses resulting in complete response, 32 were associated with a high.

**Strasser F, Luftner D, Possinger K, Ernst G, et al. Comparison of orally administered cannabis extract and delta-9-tetrahydrocannabinol in treating patients with cancer-related anorexia cachexia syndrome: a multicenter, phase III, randomized, double-blind, placebo-controlled clinical trial from the Cannabis-in-Cachexia-StudyGroup. J Clin Oncol 2006;24:3394-3400.**

A trial comparing effectiveness of cannabis extract capsules containing 2.5 mg THC and 1.0 mg CBD twice daily, cannabis extract capsules containing only 2.5 mg THC twice daily and placebo on

increasing appetite and quality of life in terminal cancer patients was stopped early because of lack of effectiveness. Before the study was stopped 243 patients with at least 5% weight loss over the past 6 months, from 30 European centers, were randomly assigned to the three treatment arms for six weeks of treatment. Many patients dropped out of the study – most because they withdrew consent and 164 completed the study (CBD/THC: 66/95, THC: 65/100, placebo:33/48) Primary outcome was improvement of appetite as measured by visual analog scale. Secondary outcome measures included a cancer-specific quality of life survey. After 6 weeks THC/CBD and placebo patients showed similar improvement in appetite; THC patients showed little improvement. Mean quality of life measures showed no significant change in any of the three groups. Side effects were common, with temporary or permanent dose reductions necessary in 78 patients (CBD/THC=34, THC=30, placebo=14). Side effects that appeared to be more common in the active treatment groups included nausea, fatigue, pain, diarrhea, and obstipation

## Glaucoma

Glaucoma is a multi-factorial disease characterized by the progressive degeneration of the optic nerve and the death of retinal ganglion cells, ultimately leading to irreversible blindness. Increased intraocular pressure (IOP) has been implicated in the pathophysiology of glaucoma; however, inadequate blood supply to the optic nerve, oxidative damage, and apoptosis (programmed death) of the retinal ganglion cells are also thought to play a role in the disease. Aside from lowering IOP, cannabinoids such as delta-9-THC and CBD may also have neuroprotective effects which could be useful in the management of glaucoma. Published trails to date have focused on reduction of IOP.

The few published clinical trials of medical cannabis for glaucoma are quite small with mixed evidence of temporary reduction in IOC. An early



open-label (uncontrolled) trial of single-dose administrations of dronabinol (synthetic delta-9-THC) found 20 mg and 25 mg were equally effective in reducing IOP for at least 10 hours, but side effects at these dosages were intolerable (Merritt 1980). In a second, small, double-blinded study reported in the same article, effects of single administrations of 5 mg and 10 mg synthetic delta-9-THC were compared with placebo. No difference in IOP reduction was seen between active drug and placebo patients.

In a small prospective observational study patients were started on 2.5 mg THC four times per day and instructed to titrate dose up, balancing effectiveness of IOP reduction with appearance of side effects. During the course of the trial 2 patients received a maximum dose of 7.5 mg 4x/day, 3 pts 5.0 mg 4x/day, and 3 did not increase from 2.5 mg 4x/day. Side effects were common and severe enough in four patients to cause withdrawal from the study. This occurred at a wide range of doses. IOP reduction was inconsistent across patient weekly assessments, with only two of nine participants having reduced IOP during the majority of assessments (Flach 2002).

A well-controlled pilot study of six patients with ocular hypertension or early primary open-angle glaucoma reported that single sub-lingual doses of 5 mg delta-9-THC (applied by means of an oromucosal spray) significantly but temporarily reduced IOP 2 hours after administration. After the four hour measurement IOP had returned to normal (Tomida 2006). A single sub-lingual dose of 20 mg cannabidiol (CBD) (containing around 1 mg delta-9-THC) had no effect while a single sub-lingual dose 40 mg of CBD (containing around 2 mg of delta-9-THC) caused a significant transient increase in IOP 4 hours after administration. There were no serious or severe adverse events and all but 2 (nausea and hypertension after administration of 5 mg delta-9-THC, rated moderate) were rated mild.

**Flach AJ. Delta-9-tetrahydrocannabinol (THC) in the treatment of end-stage open-angle glaucoma. *Trans Am Ophthalmol Soc* 2002;100:215-224.**

Nonrandomized, uncontrolled prospective observational study of nine California adults with primary open angle glaucoma on maximally tolerated medical therapy available in the mid-1980s. Oral capsules with 2.5 mg or 5 mg THC dissolved in sesame oil were used in the study. Initial dosage for each patient was 2.5 mg or 5 mg given each 4 hours (four times daily) while awake. The dose was increased or decreased by 2.5 mg increments as needed to obtain a greater effect or less toxicity with a maximum permitted dose of 20 mg four times daily. After initiation of THC, IOP was measured weekly until satisfactory control of IOP was achieved for 2 consecutive weeks with examinations monthly thereafter. Maximum allowed dose was 15 mg THC four times daily (60 mg daily). During the course of the trial 2 patients received a maximum dose of 7.5 mg 4x/day (30 mg daily), 3 pts 5.0 mg 4x/day (20 mg daily), and 3 did not increase from 2.5 mg 4x/day (10 mg daily). All patients withdrew from the study, for a variety of reasons, between months 1 and 9. Four withdrew because of side effects (3 weeks – taking 2.5 mg 4x/day, 8 weeks – 7.5 mg 4x/day, 20 weeks – 5 mg/day, 20 weeks – 15 mg/day, ) such as distortion of perception, confusion, anxiety, depression, and severe dizziness. The dizziness and lightheadedness reported by subjects in the study were never associated with systemic hypotension. All patients were observed to have at least an initial improvement in IOP. An improvement was noted during more than 50% of the office visits in two of the nine subjects. One subject was considered improved on all visits during a 36 month treatment period (withdrew from study because of cataract surgery).

**Merritt, JC, McKinnon S, Armstrong JR, Hatem G, Reid LA. Oral delta 9-Tetrahydrocannabinol in Heterogenous Glaucomas. *Ann Ophthalmol* 1980;12:947-950.**

The study report contains results from two small observational trials of different designs at different US institutions. Group A was seven glaucoma patients treated with 20 mg or 25 mg synthetic delta-9-THC capsules obtained from the National Institute on Drug Abuse. The dose was given in the morning. IOP was decreased 7.8 +/- 1.7 mm Hg at 5 hours. Doses of 20 mg and 25 mg were found equally effective in lowering IOP for at least 10 hours. But adverse effects (depersonalization, acute panic reactions, and paranoia) occurred with such frequency, in the opinion of the authors (frequency not reported) as to preclude further testing at these dosages. Accordingly, Group B was administered 5 mg or 10 mg synthetic delta-9-THC or placebo in a randomized, double-masked study with 10 subjects. Gradual decreases in IOP occurred with both cannabinoid and placebo therapies for up to 5 hours. But cannabinoid therapy produced no greater IOP reduction than placebo. One subject who took 5 mg delta 9-THC experienced tachycardia, severe postural hypotension and severe anxiety and depersonalization reactions.

**Tomida I, Azuara-Blanco A, House H, Flint M, Pertwee R, Robson P. Effect of sublingual application of cannabinoids on intraocular pressure: a pilot study. J Glaucoma 2006;15(5):349-353.**

A randomized, double-masked, placebo-controlled, 4 way crossover study at a single institution. Six subjects with either ocular hypertension or primary open-angle glaucoma discontinued their topical glaucoma medication (three had none) for 4 to 6 weeks before receiving the test medication. Subjects were administered oromucosal spray preparations under the tongue. The preparations delivered 5 mg delta-9-THC, 20 mg CBD, 40 mg CBD, or placebo. The CBD preparations contained a small amount of delta-9-THC: 1 mg delta-9-THC for every 21 mg CBD. Intraocular pressure was measured at hours 0, 1, 2, 3, 4, 6, and 12. Two hours after sublingual administration of 5 mg delta 9-THC, the IOP was significantly lower than with placebo (23.5 mm Hg vs. 27.3 mm Hg, P=0.026).

The IOP returned to baseline level after the 4-hour IOP measurement. CBD administration did not reduce the IOP at any time. However, the higher dose of CBD (40 mg) produced a transient elevation of IOP at 4 hours after administration, from 23.2 to 25.9 mm Hg (P=0.028). One patient experienced a transient and mild panic-like reaction after delta 9-THC administration.

## Human immunodeficiency virus or acquired immune deficiency syndrome

Each of the relevant published trials identified used dronabinol, synthetic delta-9-THC, and most studied its effectiveness on improving appetite and increasing weight in HIV-positive patients.

Dronabinol is approved by the FDA for anorexia associated with weight loss in patients with AIDS (and for nausea and vomiting associated with cancer chemotherapy in patients who have failed to respond adequately to conventional antiemetic treatments). The FDA label acknowledges the wide range of dosages of dronabinol used in clinical trials and that the pharmacologic effects of the drug have wide inter-individual variability. For appetite stimulation, the label recommends, for adults, to start with 2.5 mg before lunch and 2.5 mg before supper. It goes on to recommend when adverse events are absent or minimal and further therapeutic effect is desired, to increase the dose to 2.5 mg before lunch and 5 mg before supper or 5 and 5 mg. It notes that 10 mg twice daily has been tolerated in about half of the patients in appetite stimulation studies. Those recommendations are broadly consistent with the findings of the studies below (Abrams 2003, Beal 1995, Beal 1997), with the exception of trials that recruited regular marijuana users. In this patient group it appears that larger doses of dronabinol are well tolerated (Bedi 2010, Haney 2005, Haney

2007). But even at these relatively high dosages of dronabinol, its effectiveness at improving appetite and weight gain are mixed. A study of the effect of dronabinol and smoked marijuana on viral load in HIV-infected patients taking antiretroviral protease inhibitor drugs gives some assurance that THC treatment in this patient group is not unsafe (Abrams 2003)

**Abrams DI, Hilton JF, Leiser RJ, Shade SB, Elbeik TA, et al. Short-term effects of cannabinoids in patients with HIV-1 infection. *Ann Intern Med* 2003;139:258-266.**

A total of 67 HIV-positive patients participated in this randomized, placebo-controlled trial over 25 days (4 days lead-in and 21 days inpatient treatment) whose primary objective was to determine the short-term effect of cannabis on the viral load in HIV-infected patients. Participants were at least 18 years old, experienced marijuana users, and were on stable antiretroviral protease inhibitor regimens with indinavir or nelfinavir. None of them smoked marijuana or ingested cannabinoids within 30 days of enrollment. Patients taking nelfinavir and indinavir were stratified and allocated into 3 different groups: marijuana, dronabinol, and placebo. The marijuana group (n = 22) smoked up to three 3.95% THC marijuana cigarettes 1 hour before meals daily, as tolerated. Dronabinol (n = 20) and placebo (n = 20) groups received either 2.5 mg dronabinol or placebo capsules 3 times daily before meals. HIV RNA level was monitored at baseline, days 2, 5, 8, 11, 14, 17, 19, and 21. CD4+ and CD8+ cell counts were collected at baseline and every 7 days. Five patients left the study prior to day 14 and 14 completed the trial. Results showed no significant impact from cannabinoids on HIV RNA level. Both cannabinoid groups had increased CD4+ and CD8+ cell counts, compared with placebo group, indicating benefit rather than harm. Pharmacokinetics of both protease inhibitors were also unaffected by cannabinoid exposures. Significant increases in weight gain

occurred in both the dronabinol (median = 3.2 kg; range -1.4 to 7.6 kg) and marijuana (median = 3.0 kg; range -0.75 to 8.6 kg) groups.

**Beal JE, Olson R, Laubenstein L, Morales JO, et al. Dronabinol as a treatment for anorexia associated with weight loss in patients with AIDS. *J Pain Symptom Manage* 1995;10:89-97.**

139 patients at advanced stages of HIV with AIDS-related anorexia were included in this multi-center, randomized, double-blind, placebo-controlled, parallel-group trial over 6 weeks. All participants were marijuana free for at least 30 days before the trial. The trial had two treatment arms: dronabinol and placebo. Patients were randomized to each group and received capsules with either placebo or 2.5 mg dronabinol and received instruction to take one capsule twice a day. The dose was reduced to one capsule per day if intolerable side effects developed (n = 17 in dronabinol group). At baseline and three times weekly patients used a 100-mm visual analog scale (VAS) to rate their mood, appetite, and nausea on a scale from 0 to 100 with 0 being no appetite, no nausea, and terrible mood, and 100 representing respective opposites. Subjects were also evaluated biweekly on weight, physical exam and Karnofsky score – a performance assessment with a score of 100 representing normal activity, 50 as need for frequent assistance and medical care, and 0 representing death. Of the 139 patients, 51 were not evaluable due to protocol violation or noncompletion of study treatment. Evaluable patients' outcomes showed statistically significant improvements in appetite, mood, decreased nausea, and stabilized weight from dronabinol use compared with placebo. No significant difference was seen in the Karnofsky score between the two groups. Overall, dronabinol was well tolerated, with central nervous system disturbances such as dizziness, euphoria, thinking abnormalities, and somnolence being the most commonly reported treatment-related side effects. Only 16 patients (8.3%) receiving dronabinol and 3 (4.5%) receiving placebo discontinued treatment due to side effects. No significant interaction occurred

between dronabinol and opioid analgesics or benzodiazepines in terms of adverse events. This trial was an important part of the evidence that led the FDA to approve dronabinol as a treatment for anorexia associated with weight loss in patients with AIDS.

**Beal JE, Olson R, Lefkowitz L, Laubenstein L, et al. Long-term efficacy and safety of dronabinol for acquired immunodeficiency syndrome-associated anorexia. *J Pain Symptom Manage* 1997;14:7-14.**

This was a follow-up study on participants from the Dronabinol as a Treatment of Anorexia Associated with Weight Loss in Patients with AIDS trial (Beal 1995) with a duration of 12 months. Ninety-four late-stage AIDS patients from the parent trial enrolled in this multi-center, open-label study. Of these, 46 received dronabinol and 48 received placebo during the parent trial. Treatment initiated at 2.5 mg dronabinol twice daily for 90% and 2.5 g daily for 10% (patients who could tolerate only 2.5 mg daily in the parent trial). Dose titration and adjustments were made according to each patient's response and side effects. Dose increases were limited to 5 mg/day every 2 weeks. Dose was decreased to 2.5 mg/day in 19% of patients and increased to 7.5 mg/day or higher (2 patients 10 mg/day, 1 patient 20 mg/day) in 19%. Only 22 patients (24%) completed the 12 month study. Side effects were the reason for discontinuation for 14 patients. The most common reason for drop-outs was intercurrent illness (n = 25). Patients treated with dronabinol in the parent trial continued to show improvements in appetite. Patients treated with placebo in the parent trial showed substantial improvement in appetite, especially during the first 4 months of dronabinol therapy. Patient weight tended to remain stable for the first 5 months and then showed modest decline. Treatment-related adverse events were reported in 44% of patients, with 2% having an adverse event considered severe (nature of events not specified). The most common side effects were anxiety, confusion, depersonalization, dizziness, euphoria, somnolence, and abnormal thinking.

**Bedi G, Foltin RW, Gunderson EW, Rabkin J, Hart CL, Comer SD, Vosburg SK, Haney M. Efficacy and tolerability of high-dose dronabinol maintenance in HIV-positive marijuana smokers: A controlled laboratory study. *Psychopharmacol (Berl)* 2010;212:675-686.**

Seven HIV-positive adults age 21-50 on at least two antiretroviral medications and who use marijuana at least twice per week were recruited for this within-subjects, double-blind, placebo-controlled study. During one of two 16-day inpatient stays subjects received 10 mg dronabinol (synthetic delta-9-THC) 4 times per day; during the other 16 day stay they received placebo capsules. The two stays were separated by a 5 to 15 day outpatient period for study of medication clearance. Despite sustained increases in self-reported food cravings, dronabinol only increased caloric intake in the initial eight days of dosing. During the initial eight days there was an average weight gain of 1 kg (not statistically significant) and no weight gain in the second eight days of dronabinol treatment. Similarly, sleep quality was improved only during the first 8 days of dosing. Mood was enhanced for the duration of dronabinol use. These relatively high dronabinol doses in habitual marijuana users were well tolerated with few negative subjective effects. There were minor effects of dronabinol on aspects of cognitive testing performance.

**Haney M, Rabkin J, Gunderson E, and Foltin RW. Dronabinol and marijuana in HIV(+) marijuana smokers: acute effects on caloric intake and mood. *Psychopharmacology (Berl)* 2005;181:170178**

Thirty HIV-positive marijuana-using patients were recruited; 15 with and 15 without clinically significant muscle wasting, for testing the effect of single administrations of dronabinol and marijuana. At eight 7-hour testing sessions spread out over 4 weeks, participants took capsules and then one hour afterward took three puffs of a marijuana cigarette. The capsules contained 0, 10, 20, or 30 mg of dronabinol and the cigarettes were 0.0, 1.8, 2.8, or 3.9 % THC. In any one session only

one dose form was active. Mood, physical symptoms, food intake, cardiovascular data, and cognitive task performance were measured before and repeatedly during each session. Caloric intake was significantly increased for the patients with muscle wasting with each of the dose forms, but not for patients without muscle wasting (who had a higher baseline caloric intake). The 10 mg and 20 mg of dronabinol were well tolerated in this study's cohort of marijuana users. The 30 mg dronabinol administration produced at least one adverse event (headache, vomiting, "uncomfortable level of intoxication") in 20% of participants. Drug effects on cognitive performance were minor.

**Haney M, Gunderson E, Rabkin J, Hart C>, et al. Dronabinol and marijuana in HIV-positive marijuana smokers. Caloric intake, mood, and sleep. J Acquir Immune Defic Syndr 2007;45:545-554.**

Ten HIV-positive experienced marijuana smokers with an average age of 40 years were included in this research. Subjects took capsules and smoked marijuana cigarettes four times per day over sequential four day periods, with each four day period separated by a four day wash-out period. Two dosages of capsules were used, dronabinol 5 mg and 10 mg and marijuana cigarettes with two strengths of delta-9-THC were used, 2.0% and 3.6%. During any given four day treatment period, only one dose form was active. The courses of treatment were done in an inpatient setting with extensive patient assessments and testing, including a cognitive testing battery, hunger-satiety questionnaire, food intake, and subjective experience surveys. Results showed that dronabinol and smoked marijuana had similar dose-dependent improvements in total daily caloric intake and frequency of eating as compared to placebo. The higher doses of both also resulted in significant increase in weight within 4 days. Compared with placebo, neither dronabinol nor smoked marijuana significantly altered performance on any of the cognitive performance tests (e.g. measures of learning, memory, vigilance,

psychomotor ability). This study suggests that higher doses of dronabinol (40 mg per day in 4 divided doses; 8 times the standard dosing) could be used safely and effectively in HIV-positive marijuana smokers.

**Timpone JG, Wright DJ, Li N, Egorin MJ, et al. The safety and pharmacokinetics of single-agent and combination therapy with megestrol acetate and dronabinol for the treatment of HIV wasting syndrome. The DATRI 004 Study Group. Division of AIDS Treatment Research Initiative. AIDS Res Hum Retroviruses 1997;13:305-315.**

A total of 52 patients with HIV wasting syndrome were enrolled into this multi-center, randomized, open-label 12-week trial. The average age was 39 years. Marijuana use in the past month was an exclusion criterion. Patients were randomized into 4 treatment arms: dronabinol 2.5 mg twice daily (D; n = 12); megestrol acetate 750 mg daily (M750; n = 12); megestrol acetate 750 mg daily + dronabinol 2.5 mg twice daily (M750 +D; n = 13); and megestrol acetate 250 mg/day; dronabinol 2.5 mg twice daily (M250+D; n = 13). The study was performed in an outpatient setting over 12 weeks. Dronabinol doses were taken 1 hour before meals at lunch and dinner. Megestrol was taken 1 hour before lunch. Subjects completed 4 different self-reported questionnaires for this study: visual analog scale for hunger (VASH) was taken 3 times daily before meals; visual analog scale for nausea (VASN), and visual analog for mood (VASM) were both taken at noon; and functional assessment for HIV (FAHI) questionnaire was completed in clinic. VASH scale ranged from 0 (extremely hungry) to 330 (not hungry at all). No information was provided on VASN and VASM's scoring methods. All VAS's were taken at baseline and throughout the outpatient phase on 2 weekdays and 1 weekend day. FAHI, a questionnaire with subscale and perception scores in 6 categories (physical wellbeing, social/family well-being, relationship with doctor, emotional well-being, fulfillment/contentment, and additional concerns), was also completed at baseline and every 4 weeks along with chemistry profile, physical examination,

CD4+ cell count. One patient from the M750 arm was erroneously switched into M250 + D during the study. An average weight gain of 11% from baseline was seen in both M750 and M750 + D arms, and was most rapid during the first 6 weeks. No weight gain was seen in D and M250 + D arms. Data from Karnofsky score, FAHI, and VAS questionnaire revealed no statistically significant change from the baseline or difference among treatment arms. No significant changes or differences were seen in CD4+ cell counts from baseline among all. Pharmacokinetics profiles of M750 and M750+D showed no statistically significant differences, suggesting that dronabinol has no impact on the metabolism or exposure to megestrol acetate.

Regarding adverse events, no statistically significant differences were observed among the treatment arms for nausea, vomiting, diarrhea, headache, total neurological events, and total adverse events. For central nervous system side effects, D arm reported confusion and emotional lability, hallucinations and somnolence; M750 arm had psychosis; M250 had euphoria; and M750+D had seizure, and amblyopia. Megestrol was also associated with hypertension, deep vein thrombosis (DVT), dyspnea, and edema.

## Tourette Syndrome

Tourette syndrome is a complex neurobehavioral disorder characterized by motor and vocal tics that typically has its onset during childhood.

Antipsychotics and other classes of drugs are used to attempt control of TS symptoms, but they are not uniformly effective and many have undesirable side effects. There are two clinical trials of medical cannabis in

Tourette Syndrome patients – both small and 8 of 12 participants from the first were recruited into the second, raising some concerns about the validity of the results. Both used single daily dosages of delta-9-THC, ranging from 2.5 mg to 10 mg. The first tested the effect of single doses of

delta-9-THC (Muller-Vahl 2002). The THC dose differed based on gender, age, and prior cannabis experience, ranging from 5.0 mg to 10.0 mg. Five of the 12 subjects experienced mild side effects after THC administration and the results suggested effectiveness of THC at reducing tic severity. The second was a randomized double-blinded six week trial of delta-9-THC on 24 subjects (Muller-Vahl *J Clin Psychiatry* 2003). The daily dose started at 2.5 mg/day and was increased by 2.5 mg/day every four days to a maximum of 10 mg/day or less if intolerable side effects developed. One of the patients receiving THC dropped out because of side effects, six ended the study taking the daily maximum of 10.0 mg/day, two were taking 7.5 mg/day and one could only tolerate 2.5 mg/day. Results suggested some reduction in tic severity. A companion paper reported on measurement of cognitive function during the trial (Muller-Vahl *Neuropsychopharmacology* 2003). It found no differences in cognitive testing results between the active treatment and placebo groups.

**Muller-Vahl KR, Schneider U, Koblenz A, Jodges M. Treatment of Tourette's syndrome with Delta 9-tetrahydrocannabinol (THC): a randomized crossover trial. *Pharmacopsychiatry* 2002;35(2):57-61.**

A small randomized, double-blind, cross-over study of the effect of a single dose of delta-9-THC on adult patients with Tourette Syndrome. The THC dose differed based on gender, age, and prior cannabis experience. Females without prior use of marijuana and body weight  $\leq 60$  kg or age  $\geq 50$  years received 5.0 mg, otherwise 7.5 mg; men without prior use of marijuana and body weight  $\leq 70$  kg or age  $\geq 50$  years received 5.0 mg; men who used marijuana regularly, body weight  $> 70$  kg and age  $< 50$  years received 10 mg.; all other men received 7.5 mg. Source of the delta-9-THC was not specified. Multiple measures of TS symptoms were done just before and 3 to 4 hours after administration. After a four week washout period subjects who received placebo at the outset received active treatment and vice-versa. Statistically significant improvements in tic severity

were observed following THC treatment, as well as small benefits in some, but not all, additional measures of TS symptoms. After statistical adjustment for multiple comparisons, beneficial effects were no longer significant. No serious adverse effects occurred. Five patients experienced mild transient adverse reactions lasting between 1 and 6 hours.

**Muller-Vahl KR, Schneider U, Prevedel H. Delta 9tetrahydrocannabinol (THC) is effective in the treatment of tics in Tourette syndrome: a 6-week randomized trial. *J Clin Psychiatry* 2003;64:459465.**

A small randomized, double-blind, placebo controlled six-week trial of the effectiveness of delta-9-THC at controlling TS symptoms. The 24 subjects had an average age of 33 (range=18-68 years). Fifteen patients were unmedicated for at least 6 months prior to the study and 9 were taking medications for the treatment of TS. Half the patients were randomly assigned to the THC group and half to placebo. THC was administered in gelatin capsules with a starting dose of 2.5 mg/day. Source of THC was not specified. Dose was titrated up by increasing dose 2.5 mg/day every four days. Target maximum dose was 10 mg/day. Patients were instructed to take the pills once a day with breakfast. If a subject could not tolerate the maximum dose, an adjustment could be made by decreasing study medications up to 5.0 mg until a tolerated dose was achieved. The same dosing schedule was used to reduce medication at the end of the treatment period. Patients were examined at baseline and days 9, 20-22, 30-31, one or two days after medication stopped, and 6 weeks after medication stopped. At each visit tic severity was measured using multiple clinician-rated measurement tools. The authors report seven patients dropped out of the study or had to be excluded afterward. One patient receiving THC dropped out because of side effects (anxiety and restlessness). A companion paper for this study (Muller-Vahl *Neuropsychopharmacology* 2003) notes THC dose at end of study was 10.0 mg/day for 6 patients, 7.5 mg/day for 2 patients, and 2.5

mg/day for one. Most rating scales demonstrated marked tic reduction at visits 2, 3, and 4. However, statistical adjustment for multiple measures eliminated the statistically significant observations, except for those at visit 4. No serious adverse reactions occurred. Five of the patients in the THC group reported mild side effects (tiredness, dry mouth, dizziness), however none of these patients reduced study medication below 7.5 mg due to these side effects because none felt seriously impaired.

**Muller-Vahl K. Treatment of Tourette syndrome with delata-9-tetrahydrocannabinol (delta 9THC): no influence on neuropsychological performance. *Neuropsychopharmacology* 2003;28:384-388.**

This article reports on study of cognitive function during the placebo-controlled trial described above (Muller-Vahl *J Clin Psychiatry* 2003). Five tests of cognitive function were done. No significant differences in cognitive function between the two groups were seen. Though the target dose was 10.0 mg/day, only 6 of the 9 in the placebo group titrated their dose up to that level. The reason why is not stated, but presumably it was due to unpleasant side effects. THC dose at end of study was 10.0 mg/day for 6 patients, 7.5 mg/day for two patients and 2.5 mg/day for one. One patient receiving THC dropped out of the study because of side effects (restlessness and anxiety). No serious adverse events occurred.

## Amyotrophic Lateral Sclerosis

Only two published clinical trials of cannabis for the treatment of symptoms associated with ALS were found, both using dronabinol (synthetic delta-9THC). The effectiveness results of the studies are mixed, but both agree dronabinol, in the tested doses, is well tolerated with few side effects (dizziness). In one open-label crossover pilot study of 20 ALS patients, escalating doses starting at 2.5 mg/day (max 10 mg/day) of

dronabinol for 3 months were associated with improvement in sleep, appetite, and spasticity, but few details are provided (Gelinas 2002). In contrast, a small crossover study using a shorter two-week treatment period reported no improvement in cramp intensity, number of cramps, fasciculation intensity, sleep, appetite, depression, or quality of life measure (Weber 2010). This study used 5 mg dronabinol (in sesame oil drops) twice daily.

**Gelinas, D. F, Miller, R. G, and Abood, M. (2002). Pilot study of safety and tolerability of delta 9-THC (Marinol) treatment for ALS. Amyotroph Lateral Scler Other Motor Neuron Disord 3: 23-24 (an abstract)**

In this open-label (uncontrolled) cross-over study 20 patients with ALS were recruited for a study of the effects of dronabinol (synthetic delta-9-THC) therapy. Subjects were split into two groups, with the first group receiving dronabinol for three months, followed by a month of drug wash-out and then three months of no treatment. The other group was treated with dronabinol in months 5 to 7. The dronabinol dose was started at 2.5 mg/day and then increased to a maximum of 10 mg/day. Details were not provided on achieved dose or pace of escalation. Dronabinol at these doses was reported as tolerated well with no treatment-related adverse events. Symptomatic benefits were reported to have been seen in the areas of insomnia, appetite, and spasticity (no further details provided).

**Weber, M., Goldman, B., and Truniger. Tetrahydrocannabinol (THC) for cramps in amyotrophic lateral sclerosis: a randomized, double-blind crossover trial. J.Neurol.Neurosurg.Psychiatry 2010;81:1135-1140.**

This trial compared 10 mg dronabinol (synthetic delta-9-THC) in two divided doses to placebo as treatment for moderate to severe daily cramps in ALS patients. The 27 patients were allowed to take any medications for ALS or its symptoms but were asked not to change this medication during the study period. Cramp intensity was rated daily by

the patient using a visual analog scale. In this randomized, double-blinded, placebo-controlled crossover trial patients received dronabinol in either the first two or last two weeks of the five week study period, with week 3 serving as the runin/wash-out period. Complete data were available from 22 patients. There were no treatment related serious adverse effects and the only side effect was mild dizziness experienced by one patient during dronabinol treatment. There was no evidence for a treatment effect on cramp intensity, number of cramps, fasciculation intensity or any of the other secondary outcome measures.

## Seizures, including those characteristic of epilepsy

Clinical trial data for effectiveness of cannabis on seizures is scant. Reported trials from the 1970s and 1980s, as outlined below are small and some have design problems and are incompletely described. These trials generally used 200 mg to 300 mg cannabidiol (CBD) daily. These doses were very well tolerated with few side effects reported. Results show mixed evidence of effectiveness.

Additional trials are now underway or recently completed. Geoffrey 2015 describes a trial designed to assess interaction between CBD and the anti-epileptic drug clobazam, but it also describes CBD dosing and seizure outcomes. Devinski 2015 reports on a set of Investigational New Drug studies of a CBD liquid produced by BW Pharmaceuticals (brand name Epidiolex) carried out in cohorts of approximately 25 patients age one to 18 by multiple U>S. physician investigators.

The web site, [www.clinicaltrials.gov](http://www.clinicaltrials.gov), describes several clinical trials under way or being planned using the 99% CBD extraction product Epidiolex, produced by GW Pharmaceuticals. Age of participants varies across the studies; some are limited to children and some are not. Not all describe specific dosing, but those that do start



with a dose of 2-5 mg/kg/day and increase dosing at intervals of a few days to a target of 25 mg/kg/day or 50 mg/kg/day. Additional studies listed on [www.clinicaltrials.gov](http://www.clinicaltrials.gov) describe trials using a synthetic CBD produced by INSYS Therapeutics, Inc. Little information is provided on dosing with the exception of 3 of them noting the maximum dose will be 40 mg/kg/day. Finally, the U of Colorado is organizing a study that will analyze genetic differences between patients with Dravet syndrome (ages one to 50 years) who do and those who do not have a complete response (seizure free 3 months) to a proprietary CBD extract that is 98% CBD and has no THC. Anticipated completion date for this study is February, 2016 per [clinicaltrials.gov](http://clinicaltrials.gov) (<http://clinicaltrials.gov/ct2/show/NCT02229032?term=%22epilepsy%22+AND+%22cannabis%22&rank=1>).

Though not a clinical trial, the parent survey reported by Porter and Jacobson provides information on dosages of CBD used. Given the paucity of clinical trial data, this article is included here. The parents of children age 2 to 16 with treatment-resistant epilepsy reported a wide range of doses: from 0.5 mg/kg/day to 28.6 mg/kg/day. The treatments were well tolerated, with drowsiness and fatigue the most common side effects.

**Ames FR, Cridland S. Anticonvulsant effect of cannabidiol. South African Medical Journal 1986;69:14.**

Twelve patients (ages not given) living in an institution due to mental retardation and with uncontrolled seizures were randomly assigned to receive 300 mg CBD orally or placebo for one week. During weeks two and three the number of capsules was decreased so that CBD patients were receiving 200 mg CBD. Seizure experience was recorded daily. Results showed no statistically significant difference in seizure frequency between the active treatment and placebo groups. The

abstract reported the only side effect was mild drowsiness.

**Cunha JM, Carlini EA, Pereira AE, Ramos OL, Pimentoel C, Gagliardi R, Sanvito WL, Lander N, Mechoulam R. Chronic administration of cannabidiol to healthy volunteers and epileptic patients. Pharmacology 1980;21:175-185.**

15 patients with temporal lobe epilepsy and secondarily generalized seizures, age 14-49 years, were enrolled in this double-blind trial. Each was instructed to add 2 to 3 capsules per day to their standard anti-epileptic regimen. Capsules of the 7 patients randomized to cannabidiol received 100 mg capsules of CBD, so they took 200 or 300 mg CBD daily. Treatment lasted at least 8 weeks and as long as 18 weeks. Weekly patient evaluations included a four-point patient assessment of degree of improvement in seizure activity: 3 = no improvement, 2 = small improvement, 1 = partial improvement, 0 = complete improvement. At baseline all patients were scored 3 and at the end of the trial 7 of 8 placebo patients experienced no improvement while all but one of the CBD patients experienced at least some improvement and four were "almost free of convulsive crisis" for the entire study period. The patients tolerated CBD without toxicity.

**Devinsky O, Sullivan J, Friedman D, et al. Epidiolex (cannabidiol) in treatment resistant epilepsy. Presented at the annual meeting of the American Academy of Neurology, Washington DC, April 18-24, 2015. Abstract and poster presentation.**

Data from ten centers with independent FDA approved open-label Expanded Access Programs for treating children (> age 1) and young adults with treatment-resistant epilepsies with pure CBD. Inclusion criteria included up to 4 concomitant anti-epilepsy drugs; average number of concomitant AEDs was 3. CBD, supplied by GW Pharma, was given as a liquid and daily dose was started at 2-5 mg/kg/day and increased weekly by 2-5 mg/kg increments until intolerance or 25

mg/kg/day. Parents/caregivers kept seizure diaries noting all countable motor seizures during a four week baseline period and during the treatment period. Efficacy results are reported for the 137 patients who received at least 12 weeks of treatment and safety results are reported for the 213 patients who received any treatment. Etiologies included Dravet and Lennox-Gastaut syndromes as well as over 10 other conditions. Total convulsive and non-convulsive seizures showed a median percent reduction from baseline of 46% at week 12. Serious adverse events were reported in 52 patients, including 2 deaths; neither were deemed related to CBD. 22 patients had SAEs which were deemed possibly related to treatment, including status epilepticus (10), diarrhea (3), weight loss (2), pneumonia (2), lethargy (1), and hepatotoxicity (1). Adverse events >10% included somnolence (21%), diarrhea (17%), and decreased appetite (16%). Ten patients discontinued treatment due to an adverse event, 3 of whom subsequently re-started CBD.

**Geffrey, A.L., Pollack, S.F., Bruno, P.L., & Thiele, E.A. Drug-drug interaction between clobazam and cannabidiol in children with refractory epilepsy. *Epilepsia* 2015; 56: 1246-1251.**

Study's main purpose was to look for a drug-drug interaction between clobazam (CLB) and CBD (Epidiolex), but the study also included data on any changes in seizure frequency experienced by study participants with refractory epilepsy (ages 4-19). This was an open-label, single design study where participants (n=13) taking CLB took CBD as an adjuvant therapy for an 8-week trial. Note that participants were also taking other anti-epilepsy drugs (AEDs) concurrently with CLB at the time of the study—study investigators note this and mention a larger analysis presumably forthcoming in a future publication. The article includes info on what these other AEDs were; most participants were on 1-2 other AEDs besides CLB. Participants started on 5 mg/kg/day of CBD and increased weekly by 5 mg/kg/day until they reached 25

mg/kg/day (reached 25 mg/kg/day at Week 5). Conclusion: roughly 70% of subjects (9 out of 13) experienced greater than 50% reduction in seizures compared to their baseline levels. Two participants showed an increase in seizure frequency over their baseline levels. Study also concluded that CBD intake was primarily affecting nCLB (norclobazam; an active metabolite of CLB) metabolism – specifically that CBD inhibited nCLB metabolism (investigators found increased concentrations of nCLB in blood levels during CBD trial).

**Mechoulam R, Carini EA. Toward drugs derived from cannabis. *Naturwissenschaften* 1978;65:174179.**

In this double-blind trial nine patients were randomized to either 200 mg CBD daily or placebo for three months, while taking their usual antiepileptic medication. Two of the four patients treated with CBD were completely relieved of their epileptic seizures for the duration of the study and only one of the four had no improvement. None of the five treated with placebo experienced improvement. No toxic effects were observed.

**Porter BE, Jacobson C. Report of a parent survey of cannabidiol-enriched cannabis use in pediatric treatment-resistant epilepsy. *Epilepsy Behav* 2013;29:574-577.**

Stanford University carried out this survey of parents of children (ages 2-16 yrs) with diagnosed, treatment-resistant epilepsy. All of the parents included in the survey had given their children CBD therapy, in extract form, and had recorded the results. They were asked 24 questions about their child's status, including seizure type, frequency, side effects, etc.. Of the 19 parents in the survey, 13 were parents of children with Dravet syndrome. Because there is a drug known to be effective for treatment of Dravet syndrome (stiripentol imported from Europe), an additional survey was performed with parents of children on this treatment to compare reported efficacy. The parents had tried an average of 12 drug therapies

before starting CBD in doses that ranged from 0.5 mg/kg/day to 28.6 mg/kg/day and the duration ranged from 2 weeks to greater than a year. The results were that 16 of 19 parents reported a reduction in seizures, 11 of those stated the reduction was at least 50%, 8 children had greater than 80% reduction. Aside from seizure reduction, many parents also reported their children had improved mood, alertness, and sleep, as well as decreased negative self-stimulation. Some parents had discontinued their child's prior therapy after having such success with CBD (12 of 19). Side effects reported were drowsiness (37%) and fatigue (16%). When compared to the survey on the European drug, stiripentol, 68% of parents reported a decrease in seizure activity, only 4 (of 22) said this reduction was "significant" and the side effects were decreased appetite, weight loss, insomnia, and increased negative self-stimulation.

## Severe and persistent muscle spasms, including those characteristic of multiple sclerosis

Muscle spasm is a consequence of the underlying condition of spasticity seen often in patients with multiple sclerosis, spinal cord injury, amyotrophic lateral sclerosis (ALS), and other neurological diseases. Spasticity is an abnormal increase in muscle tone, resulting in stiffness, muscle spasm, and pain. Most studies of medical cannabis that included evaluation of muscle spasm have been in patients with multiple sclerosis. Two small trials involving spinal cord injury patients are at the end of this section. See the ALS section for additional studies.

## Multiple Sclerosis

Most clinical trials involving multiple sclerosis patients have used cannabis whole plant extractions and a few have used dronabinol, synthetic delta-9-THC. The whole plant extracts in the trials have varied in THC:CBD ratio. The paragraphs below comment briefly on dosages for each of the ratios – 1:1, 2:1, and 3:1. The final paragraph addresses trials that used dronabinol.

Nabiximols (Sativex) is a highly standardized oromucosal spray produced from cloned cannabis chemovars grown in controlled conditions. Each 100 µliter actuation (spray) yields 2.7 mg delta-9-THC and 2.5 mg CBD. An early trial (Wade 2003) demonstrates the need to limit the number of sprays taken within a few hours of each other to avoid undesirable side effects. The typical maximum set in clinical trials is 8 sprays within any 3 hour period (Collin 2010) and 12 (Novotna 2011, Freidel 2015, Leocani 2015) or 24 (Collin 2010) within a 24 hour period. However, when the trials were carried out, patients typically came to an average daily dose of approximately 7 to 15 sprays per day (Wade 2004, Collin 2007, Collin 2010, Novotna 2011, Tomassini 2015, Leocani 2015). Most nabiximols trials in MS patients have lasted 3 months or less, but an extension to the trial reported in Wade 2004 studied participants for variable amounts of time up to more than two years (Wade 2006). Results from this trial suggest patients who continue to derive benefit from nabiximols therapy (i.e. the ones who choose to continue using it) do so at the same or somewhat lower dosing than they were using at six weeks. A safety registry maintained by the manufacturer of Sativex indicates dosing in actual clinical practice is considerably lower than reported in clinical trials, with a reported average dose of 4 sprays per day (Eltayb 2013).

Three large trials used a commercially produced and distributed cannabis whole plant extract with 0.8 to 1.8 mg CBD for each 2.5 mg delta-9-THC (Cannador - a TBD:CBD ratio of approximately 2:1) (Cannador). Both the CAMS study (Zajicek 2003)

and the MUSEC study (Zajicek 2012) started patients on 5 mg THC/day in two divided doses, then increased dose to a maximum of 25 mg THC/day in divided doses. Dose escalation was more rapid in the MUSEC trial (dose increased every 3 days vs. weekly), and patients experienced more numerous and more severe side effects than in the CAMS trial. At the end of the MUSEC trial's titration period only 47% of patients were taking 25 mg THC daily. The CAMS trial's maximum was weight dependent with the maximum for the lightest adults 10 mg THC/day; the paper does not describe achieved dosages. Both studies found evidence of effectiveness for patient-reported improvements in muscle spasm and spasticity. The CAMS trial found no treatment effect for clinician-assessed spasticity, but the validity of the tool used for that assessment (Ashworth scale) is now suspect.

One trial used a cannabis extract with a THC:CBD ratio of approximately 3:1 (Vaney 2004). This trial started patients at a dose containing 15 mg THC and increased the dose 5 mg THC/day each day to a maximum of 30 mg THC/day. However, half of the 50 patients could tolerate a dose no larger than the starting dose of 15 mg THC/day and only about a third achieved a dose of 25 mg THC/day or more. During this cross-over study side effects were reported as being only slightly more frequent and more severe during active treatment than during placebo treatment. Results showed no effectiveness for Ashworth scale spasticity score and a trend toward effectiveness for improvement in patient-assessed spasm frequency that became statistically significant when analysis was limited to the 37 patients who took at least 90% of their prescribed doses during the 2-week treatment maintenance phase. The study suggested a correlation between tolerated dose and body weight and increased effectiveness at higher doses.

Finally, two trials used dronabinol, synthetic delta9-THC. In one arm of the CAMS trial (Zajicek 2003) dronabinol was started at 2.5 mg twice daily (5 mg/day) and titrated up at weekly intervals by 5

mg/day to a weight-dependent maximum of 10 mg to 25 mg per day in split doses. Dizziness or lightheadedness, dry mouth, and diarrhea were more common in the dronabinol group than in the placebo group and similar in frequency to the patients taking 2:1 THC:CBD capsules. The large 3-year CUPID trial (Zajicek 2013) used the same starting dose and titration schedule but slightly different weight-based targets of 14 mg to 28 mg daily in split doses. Results showed no effect of dronabinol on disease progression. Adverse events more common in the dronabinol group than in the placebo group were dizziness and lightheadedness (32%) and dissociative thinking or perception disorders (30%).

## Spinal Cord Injury

An early trial involving only one patient gives some information on dosing and effectiveness of delta-9THC (Maurer 1990). The investigators concluded 5 mg oral delta-9-THC and 50 mg oral codeine were equally effective, and more effective than placebo, for pain reduction. Only THC had a significant beneficial effect on spasticity. No altered consciousness occurred with the 5 mg THC.

Three small trials involving spinal cord injury patients were found. One used dronabinol, synthetic delta-9-THC (Hagenbach 2007). The second used nabilone, a synthetic derivative of THC. Since the action of nabilone is different from THC it is not directly relevant to Minnesota's medical cannabis program and is not described here. The third used nabiximols (whole plant cannabis extract with THC:CBD ratio of approximately 1:1) in a group with a variety of neurological conditions including SCI (Wade 2003). Though results for SCI patients were not broken out, the study is included here for completeness.

The dronabinol trial is a small double-blinded, placebo-controlled six week trial preceded by a dose-setting six week study in the same patients, conducted at a Swiss center (Hagenbach 2007). In the dose-setting study 25 adults with spinal cord

injury (11 paraplegic, 14 tetraplegic) had their antispasticity drugs discontinued for three half-lives and were then started on dronabinol with a single 10 mg dose the first day. Titration was individualized without set protocol, with the goal of balancing maximal effectiveness with side effects. Outcomes studied at days 1, 8, and 43 included clinician-assessed Ashworth spasticity score, patient-reported numerical rating scales of spasticity, pain, attention, mood, and side effects, and more. 15 patients completed the six weeks: four dropped out because of increased pain and the other 6 because of anxiety and other side effects. Mean dose achieved was 31 mg/day in divided doses (range: 15 mg to 60 mg). Patients perceived a significant reduction in pain at day 1 compared to baseline. A second dose-setting study using rectally administered dronabinol had to be curtailed at 7 patients because of supply problems, but the daily dose achieved after dosing adjustment for those 7 patients was 43 mg (range 20-60 mg). Methodological issues make interpretation of effectiveness results problematic, but there is suggestion of early effectiveness in reduction of pain and spasticity that diminishes over weeks of treatment.

Wade and colleagues (Wade 2003) carried out a small placebo-controlled crossover trial of nabiximols (Sativex) on patients with neurological disorders and troublesome symptoms (Wade 2003) that indicates the need to set a maximum dose within specified time periods. Twenty-four patients with a variety of neurologic disorders, including 4 with SCI, enrolled and 20 completed the study. Patients first had a two week open-label trial with nabiximols with instructions to increase frequency of sprays, balancing symptom relief with side effects up to a maximum of 8 sprays within 70 minutes. Because of side effects this was changed to four sprays over 2 hours and changed again to two sprays over two hours. After the two week open-label trial the patient entered an eight week double-blind study phase with four two-week stages using nabiximols, or CBD alone or THC alone or placebo. Across all 20 patients, spasticity severity had a statistically significant

reduction on nabiximols, CBD alone, and THC alone, compared with placebo. Spasm frequency saw statistically significant reduction while on nabiximols and THC alone, but not while on CBD alone, compared with placebo. Occurrence of side effects was similar across the four treatment conditions during the placebo-controlled phase and substantially higher during the initial open-label nabiximols treatment phase.

**Collin C, Davies P, Mutiboko IK, et al. Randomized controlled trial of cannabis-based medicine in spasticity caused by multiple sclerosis. *Eur J Neurol* 2007;14:290-6.**

This was a randomized, double-blind, placebo-controlled trial involving patients with multiple sclerosis whose symptoms were not adequately controlled on standard drugs. 189 adult patients from 8 centers in UK and 4 in Romania were randomized in a 2:1 ratio to nabiximols or placebo for a total of 6 weeks. Nabiximols (Sativex) is a highly standardized oromucosal spray developed by GW Pharmaceuticals. It is extracted from whole cloned cannabis chemovars grown under controlled conditions. Each 100 µliter actuation yields 2.7 mg delta-9-THC and 2.5 mg of CBD. Patients were instructed to titrate their daily dose steadily as required over 2 weeks, to a maximum dose of 48 sprays per day (130 mg THC, 120 mg CBD). Total treatment time was six weeks. Primary outcome measure was the change from baseline in the severity of spasticity based on daily diary assessments by the subject on a 0-10 numerical rating scale (NRS). Secondary outcome measures included the Ashworth scale, Motricity Index, mean daily spasm scores (five point spasm frequency score) and the patients' global impression of change in their disease (7 point scale from very much improved to very much worse). Mean and median number of sprays per day were 14.7 (40 mg THC/37 mg CBD) and 13 (35 mg THC/33 mg CBD), respectively. Results showed reduction in spasticity scores for both active treatment and placebo groups, but the larger decrease in the active treatment group was statistically significant. The difference in the

proportion of active treatment patients who achieved  $\geq 30\%$  improvement (40.0%), compared with controls (21.9%), was also statistically significant. There was a trend of greater reduction in spasm frequency in the active treatment group, but the difference lacked statistical significance. Serious adverse effects were equally common in the two groups. Mild and moderate CNS effects (dizziness, impaired balance, disturbance in attention and blurred vision) were more common in the active treatment group, with 32% experiencing dizziness. Eight patients withdrew because of side effects, 6 from the active treatment group and 2 from the placebo group.

**Collin C, Ehler E, Waberzinek G, et al. A doubleblind, randomized, placebo-controlled, parallelgroup study of Sativex, in subjects with symptoms of spasticity due to multiple sclerosis. *Neurol Res* 2010;32:451-459.**

In this multicenter, randomized, double-blinded, parallel group trial 337 MS patients with spasticity not fully relieved with current anti-spasticity medication were randomized to either nabiximols or placebo for 14 weeks. Subjects self-titrated to a maximum dose of 24 sprays daily (with a max of 8 in a 3 hour period). The mean number of daily sprays taken by the active treatment group was 8.5 (range 1-22). Nine active treatment subjects (5%) and 5 on placebo (3%) withdrew because of adverse events. The most commonly reported treatment-related adverse events which showed a higher incidence in the active treatment group compared with placebo were dizziness (32% versus 10%), fatigue (23% versus 16%), somnolence (14% versus 4%), nausea (14% versus 5%), asthenia (13% versus 6%), and vertigo (11% versus 4%). The primary outcome measured was change in 11point patient-reported spasticity scale. The estimated treatment difference in decreased mean spasticity scores, though favoring the active treatment group, did not reach statistical significance. When analysis was limited to the 79% of participants who fully followed the study protocol, the difference was statistically significant. Among the active treatment patients who achieved reduction in

spasticity score of at least 30% at any time, 98, 94, and 73% reported improvements of 10, 20, and 30% respectively within the first 4 weeks.

**Eltayb A, Etges T, Wright S. An observational postapproval registry study of patients prescribed Sativex. Results from clinical practice (abstract no. P1041). *Mult Scler.* 2013;19(suppl 11):480.**

All physicians who prescribe Sativex (nabiximols) in the UK are contacted and asked to participate in a safety registry maintained by the manufacturer, GW Pharmaceuticals. This abstract presents interim results. Physicians representing 687 of 2335 different patients prescribed Sativex (29%) participated. Median dose was 4 sprays per day; dosing considerably lower than used during clinical trials. 26% of patients had stopped taking Sativex. The most common adverse events were: fall (4.9%), depression (3.3%), and dizziness (1.9%).

**Freidel M, Tiel-Wilck K, Schreiber H, Prechtel A, Essner U, Lang M. Drug-resistant MS spasticity treatment with Sativex add-on and driving ability. *Acta Neurologica Scandinavica* 2015; 131: 9-16.**

This prospective, multicenter (Germany) non-interventional, open-label pilot study investigated the effects of Sativex on 1) driving ability, 2) spasticity, and 3) adverse events (AEs). Thirty-three MS participants with treatment-resistant (moderate to severe) spasticity started on Sativex as an add-on therapy. Two dropped out due to mild to moderate AEs, leading to n=31 (33-68 years old) completing this 4-6 week study. Patients started off with a two-week dose titration phase and were allowed to go up to 12 sprays per day. At baseline, the following were administered: 1) driving ability test battery (Schuhfried-Wiener Testsystem) consisting of 5 driving-related measures, and 2) MS spasticity measures (self-rated NRS of spasticity and physician rating of spasticity). While a strict 'fit to drive' criterion is when a participant scores above the 16<sup>th</sup> percentile on all 5 driving measures, they also discussed Germany's more flexible approach to driving fitness that is occasionally applied to drivers.

Specifically, if a participant scores below the 16<sup>th</sup> percentile on a driving measure, they have to perform at 50% or higher to compensate for their low score on the other. At the final visit, the driving test battery and spasticity measures were performed again along with recording for AEs that were experienced by patients from Sativex administration. Conclusions: on average, spasticity had been present for 6.7 years with 39.4% of them concurrently taking other spasticity treatment drugs. The mean dose of Sativex at the end of the study was 5.1 sprays (13.8 mg THC, 12.8 mg CBD). While a proportion of patients were considered unfit to drive at baseline, results showed that the proportion of those unfit to drive did not change at the end of the study. All of the driving ability measures in the test battery did not show a significant change from baseline to final visit except for the stress tolerance determination test (DT). There was increased performance on DT at final visit than at baseline (it measures “attention and individual reaction time in situations requiring continuous, swift and varying responses to rapidly changing visual and acoustic stimuli”; increase on this measure was not explained nor predicted a priori). Overall, the authors interpreted the driving results as indicating that Sativex does not contribute to any significant declines in driving ability. Furthermore, average spasticity NRS self-rating scores showed a significant decrease from baseline to final visit by 2.4 points (6.0 pts at baseline to 3.6 pts at final visit). In addition, there was a reported drop in patients categorized as suffering from ‘severe spasticity’ as reported by the patients’ physicians (7 patients at baseline down to 1 at the final visit). Lastly, 13% of patients (4 out of 31 patients) experienced non-serious AEs (dizziness being the most commonly reported).

**Garcia-Merino A. Endocannabinoid system modulator use in everyday clinical practice in the UK and Spain. Expert Rev Neurother 2013;13(3 suppl. 1):9-13.**

This article is a short description and report of interim analysis of the UK and Spanish Sativex registries to monitor safety and effectiveness.

Interim analyses suggest benefits are maintained over long term use and no new safety signals were seen with long term use – beyond what has been seen in published clinical trials.

**Hagenbach U, Lux S, Ghafour N, Berger JM et al. The treatment of spasticity with delta-9tetrahydrocannabinol in persons with spinal cord injury. Spinal Cord 2007;45:551-562.**

A small double-blinded, placebo-controlled six week trial of dronabinol (synthetic delta-9-THC), preceded by a dose-setting six week study in the same patients, conducted at a Swiss center. In the dose-setting study 25 adults with spinal cord injury (11 paraplegic, 14 tetraplegic) had their anti-spasticity drugs discontinued for three half-lives and were then started on dronabinol with a single 10 mg dose the first day. Titration was individualized without set protocol, with the goal of balancing maximal effectiveness with side effects. Outcomes studied at days 1, 8, and 43 included clinician-assessed Ashworth spasticity score, patient-reported numerical rating scales of spasticity, pain, attention, mood, and side effects, and more. 15 patients completed the six weeks: four dropped out because of increased pain and the other 6 because of anxiety and other side effects. Mean dose achieved was 31 mg/day in divided doses (range: 15 mg to 60 mg). Patients perceived a significant reduction in pain at day 1 compared to baseline. A second dose-setting study using rectally administered dronabinol had to be curtailed at 7 patients because of supply problems, but the daily dose achieved after dosing adjustment for those 7 patients was 43 mg (range 20-60 mg). The planned six-week placebo controlled trial was carried out, but because of a large difference in baseline spasticity scores in the active treatment and placebo groups, planned analyses of differences in results between these groups were not conducted. Instead, results for placebo patients from this trial were compared with results for patients from the dose-setting trial. Compared with placebo patients, there were large, statistically significant reductions in clinician assessed spasticity scores in the actively-treated

(dose setting) patients throughout the six week period. Patient assessments of spasticity and pain showed significantly lower pain at day one for the actively treated patients, but the difference narrowed and became non-significant as the study period progressed.

**Koehler J, Feneberg W, Meier M, et al. Clinical experience with THC:CBD oromucosal spray in patients with multiple sclerosis-related spasticity. *Int J Neurosci* 2014;124(9):652-656.**

Retrospective chart review of all multiple sclerosis patients at one German clinic who were started on nabiximols between September, 2011 and January, 2013. Nabiximols is an oromucosal cannabis extract spray developed by GW Pharmaceuticals in Germany. The whole plant extract is highly standardized, produced from cloned cannabis chemovars grown under controlled conditions. Each 100 µliter actuation yields 2.7 mg delta-9THC and 2.5 mg of CBD with these two cannabinoids constituting at least 90% of cannabinoid content. Of the 166 patients studied, 46 discontinued nabiximols therapy: 23 (13.9%) because of adverse effects (dizziness, fatigue, oral discomfort), 14 (8.4%) because of lack of efficacy, and 9 (5.4%) for other reasons. The 120 who continued therapy 95 received nabiximols in addition to other anti-spasticity medications and 25 received it as monotherapy (prior antispasticity medications had not been tolerated or were ineffective and had been discontinued). The 120 patients achieved a 57% mean reduction in spasticity as measured on the 0-10 numerical rating scale. Response to the nabiximols usually occurred within 2 weeks, suggesting that treatment can be discontinued promptly in nonresponders. Mean dosage was 4 sprays per day with a range of 1 to 12 sprays per day, emphasizing the need to individualize therapy.

**Maurer M, Henn V, Dittrich A, and Hoffmann A. Delta-9-tetrahydrocannabinol shows anti-spastic and analgesic effects in a single case double-blind trial. *Eur Arch Psychiatry* 1990;240:1-4.**

Following a dosing study, one patient with spinal cord injury (paraplegia) and leg spasticity and pain despite routine medications, entered a trial to determine effect of delta-9-THC versus codeine versus placebo. At 18 times over 5 months he took by capsule, in randomized order, 5 mg THC (source not specified), 50 mg codeine, or placebo at the evening time when he regularly took codeine. Results showed THC and codeine both had an analgesic effect in comparison with placebo. Only THC showed a significant beneficial effect on spasticity. In the dosage of THC used no altered consciousness occurred.

**Novotna A, Mares J, Ratcliffe S, et al. A randomized double blind placebo-controlled, parallel group, enriched design study of nabiximols (SATIVEX) as add-on therapy in subjects with refractory spasticity caused by multiple sclerosis. *Eur J Neurol* 2011;18:11221131.**

Multi-center, double-blind randomized, placebo-controlled parallel group study in subjects with multiple sclerosis spasticity not fully relieved with current anti-spasticity therapy. Subjects were treated with nabiximols as add-on therapy in a single-blind manner for 4 weeks, after which those achieving an improvement in spasticity of 20% or more as measured by the self-reported 0-10 numerical rating scale progressed to a 12-week randomized phase. Of the 572 subjects enrolled 272 (48%) achieved  $\geq 20\%$  improvement and were randomized for 12 weeks of treatment. Most subjects were taking anti spasticity medications. The purpose of this design was to determine efficacy and safety of nabiximols in a way that more closely reflects likely clinical practice by limiting exposure to those patients who appear to attain benefit during the first few weeks of treatment. Subjects self-titrated during the first ten treatment days according to a pre-defined escalation scheme (not further defined) to their optimum dose, balancing effectiveness and side effects, to a maximum of 12 sprays per 24 hour period. During the first 4-week phase mean number of daily sprays was 6.9. In the 12-week phase mean number of sprays was 8.3 for active



treatment subjects. Mean change in NRS scale for all subjects during the first 4 week phase was decrease of 3.01 units (change from 6.91 to 3.9). Half of those not randomized had an improvement of <5%. Over the course of the 12 week second phase, mean spasticity score improved in the active treatment group by another 0.04 points from a baseline of 3.87. The placebo group worsened (increased) by 0.81 from a baseline of 3.92. The estimated treatment difference between the two groups in mean spasticity NRS was 0.84 points (CI: -1.29 to -0.40; P = 0.0002). A secondary outcome measure during the second phase was spasm frequency, which saw a small decrease in the active treatment group and an increase in the placebo group. The difference between the two groups was reported as being statistically significant. Across both phases, 3 subjects withdrew because of side effects. Two serious treatment-related adverse events occurred and both resolved rapidly after treatment discontinuation. Adverse events that appeared to occur at higher rates in the active treatment group include vertigo, dry mouth, nausea, dizziness, somnolence, and urinary tract infection.

**Serpell MD, Notcutt W, Collin C. Sativex long-term use: an open-label trial in patients with spasticity due to multiple sclerosis. J Neurol 2013;260(1):285-295.**

This study is an extension of the study reported in Collin 2007. Its primary objective was to assess the safety and tolerance of long-term therapy with nabiximols. Its secondary objective was to determine whether there was evidence of tolerance with long-term nabiximols use by assessing ratings of effectiveness over time. The initial trial studied effectiveness of nabiximols in multiple sclerosis patients whose spasticity was not adequately controlled with standard drugs. Nabiximols is an oromucosal cannabis extract spray developed by GW Pharmaceuticals in Germany. The whole plant extract is highly standardized, produced from cloned cannabis chemovars grown under controlled conditions. Each 100 µliter actuation yields 2.7 mg delta-9THC and 2.5 mg of

CBD with these two cannabinoids constituting at least 90% of cannabinoid content. Among the 146 patients who participated in the extension study 68% were taking additional anti-spasticity medications. Patients self-titrated nabiximols dose upward using a pre-defined scheme that limited increases to 50% of the previous day's dose with a maximum of 8 actualizations in any 3 hour period and 48 actualizations during a 24 hour period. The level of spasticity severity was rated each week with a 0-10 numerical rating scale. Within the first 12 months of observation 20 patients (14%) withdrew because of side effects. Another 3 patients, among those followed for more than a year, withdrew because of side effects. Serious adverse events that were considered treatment-related included two cases of 'pneumonia aspiration,' and one case each of 'liver function tests abnormal,' 'convulsions,' 'dizziness,' 'paresthesia,' 'tremor,' 'nausea,' 'delusion perception,' and 'paranoia.' Minor and moderate side effects occurred among nearly all patients with dizziness and fatigue most common. Among 90% of patients some additional improvement in spasticity – beyond that observed in the original 6 week study – for approximately 8 weeks, with maintenance of the improved status for the duration of observation.

**Tomassini V, Onesti E, Tinelli E, Frasca V, Antonilli L, Aragona M, et al. Assessing the Neurophysiological Effects of Cannabinoids on Spasticity in Multiple Sclerosis. Journal of Neuroscience and Rehabilitation 2014;1(2):1-13.**

Authors cited some research evidence suggesting that cannabinoids have actions on the brain that are not specifically tied to actual stimulation of cannabinoid receptors, specifically relating to changes in cortical excitability in motor areas. Therefore, if Sativex leads to decreases in MS-related spasticity, they decided to investigate for an associated change in cortical motor regions via fMRI and TMS. Twenty cannabis-naïve MS participants initially started out in this randomized, double-blind, placebo-controlled crossover study, with eighteen (n=18) eventually completing the

study (10-week study). Baseline measures were: 1) EDSS, 2) Ashworth Scale, and 3) NRS of spasticity. Participants were randomly assigned to either a 3-week Sativex or placebo condition, during which time subjects were instructed to complete a symptom diary along with their daily usage (# of sprays) of treatment. After the 3-week treatment, the following were measured in participants 1) neurophysiological measures (fMRI and TMS), 2) clinical assessments, and 3) THC and CBD plasma measures. fMRI and TMS data were collected during drug steady state concentrations (generally within 3 hours of the last treatment intake). During the fMRI scan, participants engaged in a motor task. TMS was delivered in a region within left M1 (primary motor cortex) to optimally induce first dorsal interosseous muscle contractions. Following all these measures, there was a 2-week washout period after which time participants crossed over into the other condition for a 3-week period (same measures were collected again after this crossover treatment period, and it was followed by another 2-week washout period). Conclusions: the median number of daily sprays were 7.4 with Sativex (20 mg THC, 18.5 CBD) and 16.1 with placebo. Mean plasma concentrations for THC was 1.84 ng/ml and for CBD was 2.13 ng/ml at the end of the Sativex treatment condition (THC/CBD was not detected at the end of placebo treatment). Compared to placebo, Sativex treatment was not any better at improving spasticity symptoms. In addition, there was no difference in cortical motor activation (based on fMRI and TMS results) between Sativex and placebo. And there was no correlation between THC/CBD plasma levels and the neurophysiological measures. They suggest that the failure to find a neurophysiological correlate be indicative of cannabinoids not heavily influencing the motor system. Rather, they suggest that cannabinoids' actions might somehow modulate "the painful components of spasticity". Overall, while study results suggest Sativex's lack of effect on spasticity and modulation of motor regions, limitations in the study itself make their conclusions harder to interpret.

**Vaney C. Heinzl-Gutenbrunner M, Jobin P, et al. Efficacy, safety and tolerability of an orally administered cannabis extract in the treatment of spasticity in patients with multiple sclerosis: a randomized, double-blind, placebo-controlled, crossover study. *Mult Scler* 2004;10:417-24.**

Randomized, double-blind, placebo-controlled cross-over parallel group study of 50 Swiss multiple sclerosis patients. Patients were randomized to early group or late group active treatment. Active treatment was a cannabis whole plant extract containing 2.5 mg THC and 0.9 mg CBD in a capsule. A five day dose titration phase increased starting dose of six active capsules daily (equivalent to 15 mg THC/day) by two capsules per day with the maximum daily dose of 12 active capsules daily (equivalent to 30 mg THC/day). After 14 days of active treatment patients were switched to placebo capsules without tapering the active dose. Patients received the same number of total capsules each day, but the ratio of active drug capsules to placebo capsules varied. Patients in the early active treatment group stayed on placebo 7 days before initiating active treatment. Outcome measures included daily self-report of spasm frequency and symptoms, clinician-assessed Ashworth Scale of muscle tone, Rivermead Mobility Index, and others. The daily self-report of spasm frequency had the patient record spasm frequency five times per day, asking about the most recent four hours. Response categories were: 0=no spasms, 1= 1 to 3 spasms, 2 =4 to 6 spasms, 3 = >6 spasms. The maximal tolerated dose was 15 mg THC or less for half the patients and there was a weak but significant correlation between mean dose during the 2 week dose maintenance phase and body weight. Results showed no effect on Ashworth Scale measurement and a non-significant trend for spasm frequency. When analysis was limited to the 37 patients who received at least 90% of their prescribed doses ("as treated" set), the observed treatment in spasm frequency was statistically significant. Spasm frequency reduction was greater for early active

treatment group patients who tolerated a significantly higher THC dose (mean 15 mg/day versus 10 mg/day). No serious adverse events were observed, but three patients dropped out of the early treatment group because of side effects. Adverse events were only slightly more common and more severe during active treatment.

**Wade DT, Robson P, House H, et al. A preliminary controlled study to determine whether wholeplant cannabis extracts can improve intractable neurogenic symptoms. Clin Rehabil 2003;17:2129.**

A small placebo-controlled crossover trial of nabiximols (Sativex) on patients with neurological disorders and troublesome symptoms. Twenty four patients with a variety of neurologic disorders enrolled and 20 completed the study (14 with multiple sclerosis, 4 with spinal cord injury, and one each with brachial plexus lesion with neuropathy and an amputated leg with phantom limb pain). The symptoms varied; 16 had muscle spasm as a symptom. Patients first had a two week open-label trial with nabiximols with instructions to increase frequency of sprays, balancing symptom relief with side effects up to a maximum of 8 sprays within 70 minutes. Because of side effects this was changed to four sprays over 2 hours and changed again to two sprays over two hours. After the two week open-label trial the patient entered an eight week double-blind study phase with four two-week stages using nabiximols, or CBD alone or THC alone or placebo. Results were not reported broken out by neurologic condition. Across all 20 patients, spasticity severity had a statistically significant reduction on nabiximols, CBD alone, and THC alone, compared with placebo. Spasm frequency saw statistically significant reduction while on nabiximols and THC alone, but not while on CBD alone, compared with placebo. Occurrence of side effects was similar across the four treatment conditions during the placebo-controlled phase and substantially higher during the initial open-label nabiximols treatment phase.

**Wade T. et al. Do cannabis-based medicinal extracts have general or specific effects on symptoms in multiple sclerosis? A double-blind, randomized placebo-controlled study on 160 patients. Mult Scler 2004; 10:434-441.**

A randomized, double-blind, placebo-controlled, parallel group trial of nabiximols (Sativex) for patients with multiple sclerosis. 160 patients from 3 UK centers were enrolled and indicated whether their primary symptom was spasticity, spasms, bladder problems, tremor, or pain not obviously musculoskeletal. Intensity of each symptom was self-rated on a 100 mm visual analog scale throughout the study. Patients were randomized to nabiximols or placebo for the initial six week double-blind trial and told to titrate slowly during home dosing, aiming for optimal balance between symptom relief and side effects, but not to exceed 120 mg THC (44 sprays) per day or 20 mg THC (7 sprays) within a 3 hour period. Average number of sprays per day in the active treatment group increased steadily over three weeks and then plateaued at 14 to 16 sprays per day (38 to 43 mg/day THC; 35-40 mg/day CBD). Subjects receiving nabiximols showed improvement in subjective (VAS), but not objective (Ashworth scale) measures of spasticity, compared to the placebo group. No significant difference in symptom scores between groups was found for spasms, pain, tremor, bladder control, or a composite symptom score. Side effects that occurred more often in the active treatment group included dizziness, disturbance in attention, fatigue, somnolence, disorientation, vertigo, diarrhea, and mouth ulceration.

**Wade DT, Makela PM, House H, et al. Long-term use of a cannabis-based medicine in the treatment of spasticity and other symptoms in multiple sclerosis. Mult Scler 2006;12(5):639-645.**

Patients who completed the study reported in Wade 2004 and reported receiving benefits from the 10 weeks of active treatment were offered the opportunity to participate in a long-term follow-up study. The purpose of the study was to assess

whether symptom reduction achieved at 10 weeks of treatment was maintained over the long term and to further assess adverse events. 137 choose to participate. The mean duration of study participation in subjects who entered the follow-up study was 434 days (range: 21-814 days). The average number of daily doses taken by the subjects remained constant or was slightly reduced over time. The average number of daily doses of nabiximols was 11 (30 mg THC/28 mg CBD) per day. Results indicated patients with MS who derived symptom relief within 10 weeks of nabiximols treatment generally sustained that symptom relief over an extended period without increase in dose. Side effects were generally minor, but 17 patients withdrew because of side effects.

**Zajicek J, Fox P, Sanders H, et al. Cannabinoids for treatment of spasticity and other symptoms related to multiple sclerosis (CAMS study): multicentre randomized placebo-controlled trial. Lancet 2003;362:1517-26.**

Randomized, placebo-controlled clinical trial involving 630 adult patients with all forms of multiple sclerosis from 33 UK medical centers. Subjects were randomized to cannabis extract (n=211), dronabinol (synthetic delta-9-THC; n=206) or placebo (n=213). The cannabis abstract was Cannador – registered trademark – manufactured to contain 2.5 mg of delta-9-THC and approximately 1.25 mg CBD and less than 5% other cannabinoids in each capsule. The dronabinol capsules contained 2.5 mg delta-9-THC. The trial included a five week titration phase, 8 weeks of maintenance treatment and weaning off treatment over several days. Subjects started with one capsule twice daily and were instructed to increase the dose by one capsule twice daily at weekly intervals. If side effects developed subjects were advised to not increase the dose and if the side effects were considered intolerable the dose was reduced. Target daily dose varied with patient weight: 4 capsules (10 mg THC) for 30-49 kg, 6 capsules (15 mg THC) for 50-69 kg, 8 capsules (20 mg THC) for 70-89 kg, and 10 capsules (25 mg THC)

for >89 kg. Achieved dosages were not described. Primary outcome measure was change in spasticity as measured by the clinician-assessed Ashworth scale. Secondary measures included the Rivermead mobility index (a timed walk) the UK neurological disability score (UKNDS), the Barthel index (an index score related to activities of daily living) and a series of nine category-rating scales – each given at the end of the study to patients with those symptoms at the beginning of the study. The patients were asked to compare their symptoms over the past week with how they were just before the study started. Symptoms surveyed included: irritability, depression, tiredness, muscle stiffness, tremor, pain, sleep, muscle spasm, and amount of energy. Results showed no treatment effect on the primary outcome. Compared to the placebo group, the active treatment groups showed significant improvement in pain, sleep quality, spasm, and spasticity, though no effect was noted with respect to irritability, depression, tiredness, tremor, or energy. Improvement in these categories was similar among patients taking cannabis extract and those taking dronabinol, with approximately half reporting improvement in each of these categories. Numbers of serious adverse events were similar across the three treatment groups, with slightly more events in the placebo group. Dizziness or lightheadedness, dry mouth and diarrhea were more common among both active treatment groups. Constipation was more common in the cannabis extract group.

**Zajicek JP, Sander HP, Wright P, et al. Cannabinoids in multiple sclerosis (CAMS) study: safety and efficacy data for 12 months follow up. J Neurol Neurosurg Psychiatry 2005;76:1664-1669.**

At the end of the 13 week CAMS study, subjects were given the option of continuing treatment, at their previously determined dose, for a total of 52 weeks. Participation was as follows: cannabis extract group – 138, dronabinol – 125, placebo – 120. Results showed a small treatment effect on the change in Ashworth score (spasticity). Responses to category response scales, comparing symptoms at 52 weeks to those symptoms before

treatment began showed significant improvement in active treatment groups, compared to placebo, in pain, shaking, spasms, spasticity, sleep, energy, and tiredness, but not in depression or irritability. All hospital admissions were classified as serious adverse events and similar numbers occurred across the three treatment groups.

**Zajicek JP, Hobart JC, Slade A, Barnes D, Pattison PG, on behalf of the MUSEC Research Group. Multiple Sclerosis and Extract of Cannabis: results of the MUSEC trial. J Neurol Neurogurg Psychiatry 2012;83:1125-1132.**

Double-blind placebo controlled study of 279 patients age 18-64 with MS by McDonald criteria, stable disease for the last 6 months and troublesome and ongoing muscle stiffness for at least 3 months before enrollment (as shown by a current disability score of at least 4 on an 11 point category rating scale (CRS) at 22 UK centers). Treatment = 144, placebo = 135. Physiotherapy regimens or medications likely to affect spasticity were adjusted where necessary and then not altered in the 30 days before study start. Patients with active sources of infection or taking immunomodulatory drugs that might affect spasticity (e.g. Beta-interferon, but not azathioprine) were excluded. Active treatment was an extract of *Cannabis sativa L* (extraction ethanol 96%) in soft gelatin capsules, standardized on cannabidiol (range 0.8-1.8 mg) and containing 2.5 mg delta-9 THC as the main cannabinoid (CANNADOR). The study consisted of a screening period of 1-2 weeks, 2 week dose titration phase and a 10 week maintenance phase. Total treatment duration was 12 weeks. Participants were assessed at 2,4,8, and 12 weeks after start of treatment. Starting dose was 2.5 mg THC (one capsule) twice daily. Subsequent doses were individually titrated upwards by 5 mg THC/day every 3 days for up to 12 days to optimize the balance between therapeutic effect and side effects, and to achieve a maximum daily dose. Maximum total allowable daily dose was 25 mg THC. In the event of intolerable side effects, the daily dose was reduced by one capsule until the

side effect(s) resolved. After resolution, one rechallenge with a further dose escalation was required. If the side effect(s) returned, the dose was reduced again, with no further re-challenge allowed. The primary outcome measure was an 11 point CRS to evaluate perceived change in muscle stiffness after 12 weeks of treatment compared with the premedication phase. At the final visit, participants answered the following question on a symptom questionnaire: "Compared with before the study started, my muscle stiffness over the last week has been ..." providing a rating on an 11 point numerical CRS where 0=very much better, 5= no difference and 10=very much worse. Categories 0-3 of the rating scale were classified as 'relief of muscle stiffness' – that is, as a clinically relevant response. Secondary measures included relief from body pain, muscle spasms and sleep disturbance using 11 point scales. Also, the validated disease specific multi-item rating scales measuring aspects of spasticity in MS (MS Spasticity Scale (MSSS-88), and other scales including Expanded Disability Status Scale (EDSS). Main result: proportion with self-reported relief from stiffness was higher by a statistically significant amount compared to the placebo group (29.4% vs. 15.7%). 30.8% of active group experienced relief from muscle spasm vs. 13.4% in placebo group ( $p<0.0025$ ). At the end of the titration period approximately 87% of participants in the placebo group were taking the maximum daily 'dose' of 25.0 mg. In contrast, only 47% of participants in the CE group had titrated up to a maximum daily dose of 25.0 mg. Of the CE patients who did not achieve the maximum daily dose, most were taking daily doses of 10.0 to 15.0 mg. Sixteen participants in the active treatment group discontinued study medication during titration, compared with four in the placebo group. At the end of the study, only 24.5% of the active treatment group was taking the 25.0 mg dose. By the end of the study, 84% of all patients experienced at least one treatment emergent adverse events: 98% in active treatment group and 74.6% in the placebo group. 23.8% in the active treatment group and 14.9% in placebo group

were withdrawn from the study or discontinued study medication due to AEs. In the active treatment group adverse events were highest during titration and decreased continuously over the course of the study. Adverse events that occurred at clearly higher rates in the active treatment group than in the placebo group were dizziness, disturbance in attention, balance disorder, somnolence, dry mouth, nausea, diarrhea, fatigue, asthenia, feeling abnormal, urinary tract infection, disorientation, confusional state, and fall. The relatively rapid titration was done for technical study reasons – in clinical practice it is not likely to be done so rapidly. Results in this study confirm results in the CAMS study, which was larger, and are similar to two other studies that showed significant reduction in spasticity using an 11 point rating scale (Novotna 2011; Colin 2007).

**Zajicek J, Ball S, Wright D, Vickery J, et al. Effect of dronabinol on progression in progressive multiple sclerosis (CUPID): a randomized, placebocontrolled trial. Lancet Neurol 2013;12(9):857865.**

Multi-center (UK), randomized, double-blind, placebo-controlled three year study of the effect of dronabinol (synthetic delta-9-THC) on MS disease progression. 493 subjects age 18-65 with primary or secondary progressive multiple sclerosis. Dronabinol was initiated at a starting dose of one capsule (3.5 mg THC) twice daily. Participants were instructed to increase their twice-daily dose by one capsule twice daily (i.e. first increase = 7.0 mg twice daily) at weekly intervals. If adverse effects appeared, participants were advised to not increase the dose; if unwanted side-effects were intolerable, dose was reduced. Maximum daily dose varied by weight: < 60 kg = 14 mg/day, 60-80 kg = 21 mg/day, >90 kg = 28 mg/day. Primary outcomes were time to disease progression as measured by the expanded disability status scale (EDSS) and change from baseline to end of study in the physical impact subscale of the patient-reported 29-item MS impact scale (MSIS). Secondary measures outcomes included adverse

events, MS functional composite (MSFC) Z score change from baseline to final visit, MS walking scale (MSWS-12) and Rivermead Motility Index. Subjects were reviewed after 2 weeks and 4 weeks from when they began taking the study drug for adverse event screening and drug monitoring and dose adjustment. Assessment visits were held at 3 months, 6 months, and then every 6 months to 36 months. Results showed no overall treatment effect on clinical disease course. And results showed little evidence of an effect of treatment on MSFC, MSWS-12 or RMI. Serious adverse events (life threatening event, hospitalization, death) were common, with no significant difference between treatment (35%) and placebo (28%) groups. Moderate adverse effects were common in both groups. Those that occurred in the treatment group at a significantly higher frequency than in the control group were dizziness and lightheadedness (32%) and dissociative and thinking or perception disorders (30%).

## Crohn's Disease

One small clinical trial using smoked cannabis has been published, showing symptom reduction during the time of cannabis use. No clinical trials or prospective clinical studies of cannabis extract products or synthetic cannabinoids have been published. Two trials in progress or recently completed (and not yet published) have emphasized CBD, but with somewhat different approaches. The trial now recruiting patients (clinicaltrials.gov NCT01826188) is using capsules with 5 mg THC and 50 mg CBD in olive oil, twice daily. The study that is completed but has not yet been published (clinicaltrials.gov NCT01037322) used 5 mg CBD in olive oil drops, sub-lingual, twice per day.

**“Use of Cannabidiol for the Treatment of Inflammatory Bowel Disease” Study Chair: Fred Konikoff; Responsible party: Timna Naftali. Both from Meir Hospital, Israel. (clinicaltrials.gov NCT01037322)**

This small double-blind, placebo-controlled trial was completed in September, 2012, but it has not yet been published. It anticipated recruiting 20 patients 20 years and older with a Crohn's Disease Activity Index (CDAI) of 200 or greater or Mayo Score > 3 in ulcerative colitis. Prior use of marijuana was not an exclusion criterion. The methodology calls for patients to be randomized to CBD (5 mg CBD in olive oil drops, sub-lingual, twice per day,) or to placebo drops, for eight weeks of treatment. Primary outcome: reduction of 70 points on CDAI. Secondary outcomes: change in quality of life score, adverse events.

specifically targeted patients with short life expectancy, cutting across medical conditions.

**“Combined THC and CBD Drops for Treatment of Crohn’s Disease” Principal Investigator: Timna Naftali, Meir Medical Center, Israel. (clinicaltrials.gov NCT01826188)**

This double-blind, placebo controlled trial is now in recruitment, with an estimated completion date of March, 2015. It anticipates enrolling 50 patients age 20 years or older with Crohn's Disease Activity Index (CDAI) of 200 or more. Prior use of marijuana is not an exclusion criterion. Patients will be randomized to THC plus CBD (5 mg THC and 50 mg CBD in olive oil, twice daily) or placebo for eight weeks of treatment. Primary outcome: reduction of CDAI of at least 100 points. Secondary outcomes: remission of disease, as defined by CDAI <150, improvement of at least 1 point in endoscopic activity index, improvement of CRP and calprotectin levels, improvement of blood cytokine levels (IL-10, TNF, IL-23), improvement of at least 30 points in SF-36 quality of life survey, monitor safety and side effects.

## Terminal illness

with a probable life expectancy of under one year, if the illness or its treatment produces one or more of the following: severe or chronic pain; nausea or severe vomiting; or cachexia or severe wasting

Relevant studies can be found in other sections of this report, particularly the cancer sections. No published medical cannabis trials were found that