

Disulfiram Shows Promise for Cocaine Addiction

BY CARL SHERMAN
Contributing Writer

NEW YORK — Disulfiram, a drug that has long been used for alcohol dependence, appears promising for the treatment of cocaine addiction, Thomas Kosten, M.D., said at the annual conference of the Association for Research in Nervous and Mental Disease.

A variety of medications, most developed for other indications, may ameliorate

problems associated with cocaine and other stimulants by addressing diverse points of the complex neurobiological processes involved, said Dr. Kosten, professor of psychiatry at Yale University, New Haven.

Increased release of dopamine, particularly in the nucleus accumbens, is the signature of drug reward; addiction, however, induces a hypodopaminergic state by downregulating dopamine receptors. Treatment that addresses this neural substrate should reverse the stim-

ulant-induced dopamine deficiency.

D₂ receptor agonists, such as bromocriptine, have proved ineffective in this regard, but indirect dopamine agonists also seem promising. Most prominent is disulfiram, which inhibits the conversion of dopamine to norepinephrine. The compound has been shown to attenuate the craving induced by administration of cocaine and to reduce withdrawal.

Another mechanism by which disulfiram facilitates reduction in cocaine use appears

to be tied to the acceleration and accentuation of the nervousness and dysphoria that often follow ingestion of the drug, Dr. Kosten said at the meeting, cosponsored by the New York Academy of Medicine.

A metaanalysis of a series of studies involving 337 people given disulfiram or one of several control medications (naltrexone, buprenorphine, or methadone, for example) found that drug-free urines were significantly more frequent in those receiving disulfiram than controls (55% vs. 40%).

Another study suggested a genetic explanation for the superior efficacy of disulfiram in some patients. In half of the sub-

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jects, the drug did not increase nervousness and paranoia after cocaine ingestion, which could be attributed to differences in levels of dopamine hydroxylase (D β H), the target of disulfiram: Low endogenous levels of D β H should

predict the cocaine-induced dysphoria that is linked to treatment response. In fact, disulfiram was associated with significantly more cocaine-free urines than placebo among people with at least one copy of the allele linked to low D β H but not among those who lacked that gene, Dr. Kosten said.

Amantadine, an indirect dopamine agonist that facilitates release of the neurotransmitter, has been shown to be more effective than placebo—but only in people who suffer severe withdrawal symptoms.

The same pattern has been seen with adrenergic antagonists: Propranolol was superior to placebo in reducing cocaine use and increasing treatment retention in patients with high but not low withdrawal severity, he said.

The γ -aminobutyric acid (GABA) system is also dysregulated in cocaine dependence; a two-thirds reduction in GABA tone compromises the inhibitory function of this neurotransmitter system. "Withdrawal from stimulant dependence is anxiogenic, probably due to reduced GABA-ergic tone," Dr. Kosten said.

The GABA agonist baclofen was significantly superior to placebo in achieving abstinence from cocaine, as indicated by cocaine-free urines, and tiagabine has also looked promising in controlled trials. There is less evidence, but other drugs with similar mechanisms (gabapentin, vigabatrin, topiramate) may also be useful.

Modafinil, a glutamate agonist, was shown superior to placebo in reducing cocaine use, possibly through enhancing subject ability to stop unwanted behaviors and to learn relapse-prevention skills, he said.

In a study of 11 patients, TA-CD, a vaccine under development by Xenova Group PLC, to prevent cocaine from crossing the blood-brain barrier, was associated with reduced cocaine use for 1 year, without major adverse effects, he said. ■



Available in 4 mg, 8 mg, and 12 mg tablets and oral solution 4 mg/mL.

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BEFORE PRESCRIBING, PLEASE CONSULT COMPLETE PRESCRIBING INFORMATION OF WHICH THE FOLLOWING IS A BRIEF SUMMARY.

INDICATION

REMINYL[®] (galantamine hydrobromide) is indicated for the treatment of mild to moderate dementia of the Alzheimer's type.

CONTRAINDICATIONS

REMINYL[®] is contraindicated in patients with known hypersensitivity to galantamine hydrobromide or to any excipients used in the formulation.

WARNINGS

Anesthesia: Galantamine is likely to exaggerate the neuromuscular blocking effects of succinylcholine-type and similar neuromuscular blocking agents during anesthesia.

Cardiovascular Conditions: Cholinesterase inhibitors have vagotonic effects on the sinoatrial and atrioventricular nodes, leading to bradycardia and AV block. These actions may be particularly important to patients with supraventricular cardiac conduction disorders or to patients taking other drugs concomitantly that significantly slow heart rate. Bradycardia and all types of heart block have been reported in patients both with and without known underlying cardiac conduction abnormalities. Therefore all patients should be considered at risk for adverse effects on cardiac conduction. In randomized controlled trials, bradycardia was reported more frequently in galantamine-treated patients than in placebo-treated patients. No increased incidence of heart block was observed at the recommended doses. Patients treated with galantamine up to 24 mg/day using the recommended dosing schedule showed a dose-related increase in risk of syncope.

Gastrointestinal Conditions: Patients should be monitored closely for symptoms of active or occult gastrointestinal bleeding, especially those with an increased risk for developing ulcers, e.g., those with a history of ulcer disease or patients using concurrent nonsteroidal anti-inflammatory drugs (NSAIDs). REMINYL[®] has been shown to produce nausea, vomiting, diarrhea, anorexia, and weight loss. (See **ADVERSE REACTIONS**)

Genitourinary: Cholinomimetics may cause bladder outflow obstruction.

Neurological Conditions: Seizures: Cholinesterase inhibitors are believed to have some potential to cause generalized convulsions. In clinical trials, there was no increase in the incidence of convulsions with REMINYL[®] compared to placebo.

Pulmonary Conditions: Galantamine should be prescribed with care to patients with a history of severe asthma or obstructive pulmonary disease.

PRECAUTIONS

Information for Patients and Caregivers: The recommended administration is twice per day, preferably with morning and evening meal. Dose increases should follow minimum of four weeks at prior dose. Following the recommended dosage and administration can minimize the most frequent adverse events associated with use of the drug. Patients and caregivers should be advised to ensure adequate fluid intake during treatment. If therapy has been interrupted for several days or longer, the patient should be restarted at the lowest dose and the dose escalated to the current dose.

Caregivers should be instructed in the correct procedure for administering REMINYL[®] Oral Solution. In addition, they should be informed of the existence of an Instruction Sheet (included with the product) describing how the solution is to be administered. They should be urged to read this sheet prior to administering REMINYL[®] Oral Solution. Caregivers should direct questions about the administration of the solution to either their physician or pharmacist.

Special Populations

Hepatic Impairment: In patients with moderately impaired hepatic function, dose titration should proceed cautiously (See **CLINICAL PHARMACOLOGY** in full prescribing information and **DOSAGE AND ADMINISTRATION**). The use of REMINYL[®] in patients with severe hepatic impairment is not recommended.

Renal Impairment: In patients with moderately impaired renal function, dose titration should proceed cautiously (See **CLINICAL PHARMACOLOGY** in full prescribing information and **DOSAGE AND ADMINISTRATION**). In patients with severely impaired renal function (CL_{CR} < 9 mL/min) the use of REMINYL[®] is not recommended.

Drug-Drug Interactions

Use with Anticholinergics: Galantamine has the potential to interfere with the activity of anticholinergic medications.

Use with Cholinomimetics and Other Cholinesterase Inhibitors: A synergistic effect is expected when cholinesterase inhibitors are given concurrently with succinylcholine, other cholinesterase inhibitors, similar neuromuscular blocking agents or cholinergic agonists such as bethanechol.

A) Effect of Other Drugs on Galantamine: *In vitro* - CYP3A4 and CYP2D6 were the major enzymes involved in the metabolism of galantamine. CYP3A4 mediated the formation of galantamine-N-oxide, whereas CYP2D6 was involved in the formation of O-desmethyl-galantamine. *In vivo* - Cimetidine increased the bioavailability of galantamine by approximately 16%. Ranitidine had no effect on the PK of galantamine. Ketoconazole increased the AUC of galantamine by 30%. Erythromycin affected the AUC of galantamine minimally (10% increase). Paroxetine increased the oral bioavailability of galantamine by about 40%.

B) Effect of Galantamine on Other Drugs: *In vitro* - Galantamine did not inhibit the metabolic pathways catalyzed by CYP1A2, CYP2A6, CYP3A4, CYP4A, CYP2C, CYP2D6 or CYP2E1. *In vivo* - The protein binding of warfarin was unaffected by galantamine. Galantamine at 24 mg/day had no effect on the steady-state pharmacokinetics of digoxin (0.375 mg daily) when they were coadministered. In this study, however, one healthy subject was hospitalized for 2nd and 3rd degree heart block and bradycardia.

Carcinogenesis, Mutagenesis and Impairment of Fertility: In a 24-month oral carcinogenicity study in rats, a trend for an increase in endometrial adenocarcinomas was observed at 10 mg/kg/day (4 times the Maximum Recommended Human Dose [MRHD]) on a mg/m² basis or 6 times on an exposure [AUC] basis and 30 mg/kg/day (12 times MRHD) on a mg/m² basis or 19 times on an AUC basis. No increase in neoplastic changes was observed in females at 2.5 mg/kg/day (equivalent to the MRHD on a mg/m² basis or 2 times on an AUC basis) or in males up to the highest dose tested of 30 mg/kg/day (12 times the MRHD on a mg/m² and AUC basis). Galantamine was not carcinogenic in a 6-month oral carcinogenicity study in transgenic (P 53-deficient) mice up to 20 mg/kg/day, or in a 24-month oral carcinogenicity study in male and female mice up to 10 mg/kg/day (2 times the MRHD on a mg/m² basis and equivalent on an AUC basis).

Galantamine produced no evidence of genotoxic potential when evaluated in the *in vitro* Ames S. typhimurium or E. coli reverse mutation assay, *in vitro* mouse lymphoma assay, *in vivo* micronucleus test in mice, or *in vitro* chromosome aberration assay in Chinese hamster ovary cells.

No impairment of fertility was seen in rats given up to 16 mg/kg/day (7 times the MRHD on a mg/m² basis).

Pregnancy Category B: In a study in which rats were dosed from day 14 (females) or day 60 (males) prior to mating through the period of organogenesis, a slightly increased incidence of skeletal variations was observed at doses of 8 mg/kg/day (3 times the Maximum Recommended Human Dose [MRHD]) on a mg/m² basis and 16 mg/kg/day. In a study in which pregnant rats were dosed from the beginning of organogenesis through day 21 post-partum, pup weights were decreased at 8 and 16 mg/kg/day, but no adverse effects on other postnatal developmental parameters were seen. The doses causing the above effects in rats produced slight maternal toxicity. No major malformations were caused in rats given up to 16 mg/kg/day. No drug related teratogenic effects were observed in rabbits given up to 40 mg/kg/day (32 times the MRHD on a mg/m² basis) during the period of organogenesis. There are no adequate and well-controlled studies of REMINYL[®] (galantamine hydrobromide) in pregnant women. REMINYL[®] should be used during pregnancy only if the potential benefit justifies the potential risk to the fetus.

PRECAUTIONS (continued)

Nursing Mothers: It is not known whether galantamine is excreted in human breast milk. REMINYL[®] has no indication for use in nursing mothers.

Pediatric Use: There are no adequate and well-controlled trials documenting the safety and efficacy of galantamine in any illness occurring in children. Therefore, use of REMINYL[®] in children is not recommended.

ADVERSE REACTIONS

Adverse Events Leading to Discontinuation: In two large scale, placebo-controlled trials of 6 months duration, in which patients were titrated weekly from 8 to 16 to 24, and to 32 mg/day, the risk of discontinuation because of an adverse event in the galantamine group exceeded that in the placebo group by about threefold. In contrast, in a 5-month trial with escalation of the dose by 8 mg/day every 4 weeks, the overall risk of discontinuation because of an adverse event was 7%, 7%, and 10% for the placebo, galantamine 16 mg/day, and galantamine 24 mg/day groups, respectively, with gastrointestinal adverse effects (nausea, vomiting and anorexia) the principle reason for discontinuing galantamine.

Adverse Events Reported in Controlled Trials: The majority of reported adverse events occurred during the dose-escalation period of the controlled trials. In those patients who experience the most frequent adverse event, nausea, the median duration of the nausea was 5 to 7 days.

Administration of REMINYL[®] with food, the use of anti-emetic medication, and ensuring adequate fluid intake may reduce the impact of these events.

The most frequent adverse events, those occurring at a frequency of at least 5% and at least twice the rate on placebo with the recommended maintenance dose of either 16 or 24 mg/day of REMINYL[®] under conditions of every 4 week dose-escalation, were primarily gastrointestinal and tended to be less frequent with the 16 mg/day recommended initial maintenance dose. They included nausea (5%, 13% and 17%), vomiting (1%, 6% and 10%), diarrhea (6%, 12% and 6%), anorexia (3%, 7% and 9%) and weight decrease (1%, 5% and 5%) for placebo, 16-mg/day and 24-mg/day treatment groups respectively.

The most common adverse events (adverse events occurring with an incidence of 2% with REMINYL[®] treatment and in which the incidence was greater than with placebo treatment) for patients in controlled trials who were treated with 16 or 24 mg/day of REMINYL[®] were: fatigue 5%, syncope 2%, dizziness 9%, headache 8%, tremor 3%, nausea 24%, vomiting 13%, diarrhea 9%, abdominal pain 5%, dyspepsia 5%, bradycardia 2%, weight decrease 7%, anorexia 9%, depression 7%, insomnia 5%, somnolence 4%, anemia 3%, rhinitis 4%, urinary tract infection 8% and hematuria 3%.

Adverse events occurring with an incidence of at least 2% in placebo-treated patients that was either equal to or greater than with REMINYL[®] treatment were constipation, agitation, confusion, anxiety, hallucination, injury, back pain, peripheral edema, asthenia, chest pain, urinary incontinence, upper respiratory tract infection, bronchitis, coughing, hypertension, fall, and purpura.

There were no important differences in adverse event rates related to dose or sex. There were too few non-Caucasian patients to assess the effects of race on adverse event rates.

No clinically relevant abnormalities in laboratory values were observed.

Other Adverse Events Observed During Clinical Trials: The incidence of all adverse events occurring in approximately 0.1% of the patients during clinical trials, except for those adverse events already listed elsewhere in labeling, are defined as: frequent adverse events - those occurring in at least 1/100 patients; infrequent adverse events - those occurring in 1/100 to 1/1000 patients; and rare adverse events - those occurring in fewer than 1/1000 patients. **Body As a Whole - General Disorders:** Frequent: chest pain; **Cardiovascular System Disorders:** Infrequent: postural hypotension, hypotension, dependent edema, cardiac failure; **Central & Peripheral Nervous System Disorders:** Infrequent: vertigo, hypertonia, convulsions, involuntary muscle contractions, paresthesia, ataxia, hypokinesia, hyperkinesia, apraxia, aphasia; **Gastrointestinal System Disorders:** Frequent: flatulence; Infrequent: gastritis, melena, dysphagia, rectal hemorrhage, dry mouth, saliva increased, diverticulitis, gastroenteritis, hiccup; rare: esophageal perforation; **Heart Rate & Rhythm Disorders:** Infrequent: AV block, palpitation, atrial fibrillation, QT prolonged, bundle branch block, supraventricular tachycardia, T wave inversion, ventricular tachycardia; **Metabolic & Nutritional Disorders:** Infrequent: hyperglycemia, alkaline phosphatase increased; **Platelet, Bleeding & Clotting Disorders:** Infrequent: purpura, epistaxis, thrombocytopenia; **Psychiatric Disorders:** Infrequent: apathy, paroniria, paranoid reaction, libido increased, delirium; **Urinary System Disorders:** Frequent: incontinence; Infrequent: hematuria, micturition frequency, cystitis, urinary retention, nocturia, renal calculi.

Post-Marketing Experience:

Other adverse events from post-approval controlled and uncontrolled clinical trials and post-marketing experience observed in patients treated with REMINYL[®] include:

Body as a Whole - General Disorders: dehydration (including rare, severe cases leading to renal insufficiency and renal failure)

Central & Peripheral Nervous System Disorders: aggression

Gastrointestinal System Disorders: upper and lower GI bleeding

Metabolic & Nutritional Disorders: hypokalemia

These adverse events may or may not be causally related to the drug.

OVERDOSAGE

Because strategies for the management of overdose are continually evolving, it is advisable to contact a poison control center to determine the latest recommendations for the management of an overdose of any drug. As in any case of overdose, general supportive measures should be utilized. Signs and symptoms of significant overdosing of galantamine are predicted to be similar to those of overdosing of other cholinomimetics.

In a postmarketing report, one patient who had been taking 4 mg of galantamine daily for a week inadvertently ingested eight 4 mg tablets (32 mg total) on a single day. Subsequently, she developed bradycardia, QT prolongation, ventricular tachycardia and torsades de pointes accompanied by a brief loss of consciousness for which she required hospital treatment.

DOSAGE AND ADMINISTRATION

The dosage of REMINYL[®] shown to be effective in controlled clinical trials is 16-32 mg/day given as twice daily dosing. As the dose of 32 mg/day is less well tolerated than lower doses and does not provide increased effectiveness, the recommended dose range is 16-24 mg/day given in a BID regimen. The dose of 24 mg/day did not provide a statistically significant greater clinical benefit than 16 mg/day. It is possible, however, that a daily dose of 24 mg of REMINYL[®] might provide additional benefit for some patients. The recommended starting dose of REMINYL[®] is 4 mg twice a day (8 mg/day). The dose should be increased to the initial maintenance dose of 8 mg twice a day (16 mg/day) after a minimum of 4 weeks. A further increase to 12 mg twice a day (24 mg/day) should be attempted after a minimum of 4 weeks at 8 mg twice a day (16 mg/day). Dose increases should be based upon assessment of clinical benefit and tolerability of the previous dose. REMINYL[®] should be administered twice a day, preferably with morning and evening meals. Patients and caregivers should be advised to ensure adequate fluid intake during treatment. If therapy has been interrupted for several days or longer, the patient should be restarted at the lowest dose and the dose escalated to the current dose.

Doses in Special Populations: Galantamine plasma concentrations may be increased in patients with moderate to severe hepatic impairment. In patients with moderately impaired hepatic function (Child-Pugh score of 7-9), the dose should generally not exceed 16 mg/day. The use of REMINYL[®] in patients with severe hepatic impairment (Child-Pugh score of 10-15) is not recommended. For patients with moderate renal impairment the dose should generally not exceed 16 mg/day. In patients with severe renal impairment (creatinine clearance < 9 mL/min), the use of REMINYL[®] is not recommended.

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