

Chlorine Dioxide as an Adjunctive Treatment in Three Veterinary Cases: A Case Series

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Abstract

Chlorine dioxide has been investigated as an antimicrobial and oxidative agent with applications in water treatment, food safety, and medical sterilization. Despite limited exploration in veterinary medicine, recent research suggests therapeutic potential for complex infectious and neoplastic conditions.

Three cases are presented: (1) a 17-year-old canine with hepatic failure and suspected hepatocellular carcinoma treated with oral fenbendazole and chlorine dioxide enemas; (2) a 6-year-old feline with refractory upper respiratory infection treated with ivermectin and oral sodium chlorite solution; and (3) a 14-year-old canine with an inflammatory mammary mass treated with intratumoral chlorine

dioxide injections and oral fenbendazole. All cases showed clinical improvement after initiation of the treatment protocols.

These cases suggest that chlorine dioxide may warrant further investigation as an adjunctive treatment in veterinary medicine. The observed outcomes support the hypothesis that chlorine dioxide's antimicrobial properties, anti-inflammatory effects, and wound healing promotion may benefit veterinary patients with limited therapeutic options. Controlled studies are needed to establish safety profiles, optimal dosing protocols, and efficacy in veterinary applications.

Keywords: Chlorine dioxide, fenbendazole, ivermectin, veterinary oncology, alternative veterinary medicine, antimicrobial therapy

Introduction

Chlorine dioxide (ClO₂) is a selective oxidant first synthesized in 1811 that has demonstrated broad-spectrum antimicrobial activity against bacteria, vi-

ruses, fungi, and parasites in vitro. (1) While primarily utilized for water purification and surface disinfection, chlorine dioxide has been explored for potential medical applications due to its unique oxidative properties and antimicrobial efficacy in vitro. (1,2)

The mechanism of action of chlorine dioxide involves selective oxidation of cellular components through one-electron transfer reactions. ClO₂ possesses 19 valence electrons with a single unpaired electron, rendering it a free radical with high reactivity. (3) This molecular structure enables ClO₂ to accept electrons via oxidation-reduction reactions, allowing it to undergo selective oxidation of specific amino acids—particularly cysteine, tryptophan, and tyrosine—in microbial proteins. (1) This oxidative degradation of viral and bacterial proteins disrupts cellular function and replication, potentially offering therapeutic benefits in infectious disease management. (4)

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In veterinary medicine, conventional evidence-based treatments remain the standard of care; however, cases presenting with poor prognosis, multi-drug-resistant infections, or refractory disease may prompt consideration of alternative therapeutic approaches. (5) Chlorine dioxide has been approved by regulatory agencies for diverse applications including water treatment, (6) food safety, (7) and medical equipment sterilization, (8) yet its therapeutic applications in companion animals remain largely unexplored.

Recent investigations in human medicine have documented potential benefits of chlorine dioxide and its related compound chlorite in treating complex wound infections and metabolic disorders *in vivo*. Studies have demonstrated that chlorite-based medications can improve glucose control in diabetic patients, reduce inflammation, enhance wound healing, and provide antimicrobial effects against resistant pathogens. (9,10)

Particularly relevant to wound healing applications, a recent case series documented successful chlorine dioxide treatment of diabetic foot ulcers in three human patients, all with treatment-refractory wounds that had failed multiple conventional therapies. (11) These patients showed complete resolution of their ulcers within 2–4 months using oral and/or topical chlorine dioxide. One 81-year-old patient with over 30 years of type II diabetes not only experienced complete wound healing but also achieved glycemic control without insulin or other pharmaceutical medications following treatment—effects that persisted for three years of follow-up. (11) These cases demonstrated chlorine dioxide's potential to address multiple pathophysiologic factors contributing to chronic wounds, including hyperglycemia, infection, inflammation, and impaired tissue regeneration.

A case report of necrotizing fasciitis in an immunocompromised patient with decompensated cirrhosis, poorly controlled diabetes, and chronic kidney disease showed clinical improvement following treatment with chlorine dioxide when conventional antimicrobial options were limited. (12) The patient, who presented with multidrug-resistant *Escherichia coli* infection and Fournier's gangrene, demonstrated progressive improvement in multiple organ systems, resolution of infection, and wound healing with combined intravenous and topical chlorine dioxide administration.

The safety profile of chlorine dioxide has been extensively characterized. The US Environmental

Protection Agency established a no-observed-adverse-effect level (NOAEL) of 3 mg/kg/day for oral administration, and human studies have found no adverse effects at concentrations of 0.04–0.34 mg/kg/day. (1) Low-dose chlorine dioxide is currently consumed by millions of people daily in municipal drinking water, and chlorite-based medications have received regulatory approval in several countries for various medical indications. (1) Phase I and II clinical trials in patients with amyotrophic lateral sclerosis demonstrated that intravenous sodium chlorite at doses up to 3.2 mg/kg/day was safe and well-tolerated, with no treatment-related serious adverse events. (13,14)

Chlorine dioxide (ClO_2) is a controversial molecule. Preclinical studies have documented antimicrobial and potentially antineoplastic properties at low concentrations, and the theoretical mechanisms are biologically plausible. Yet no adequately powered, controlled clinical trials in humans have been conducted, leaving efficacy unproven. Regulatory agencies, including the FDA, have responded with broad prohibition, describing ClO_2 as "a dangerous bleach" and pursuing criminal enforcement. However, their case rests on adverse events resulting from high-dose misuse, not from therapeutic protocols, and they have made no systematic effort to distinguish between the two. The compound is unpatentable, which ensures that no pharmaceutical company will fund the trials regulators require. Prohibition is justified by the absence of trial data, while prohibition prevents trial data from being generated. This is not straightforward scientific consensus. The fairest summary is that clinical studies have not been performed to support the claim that ClO_2 therapy is a universal cure, as some advocates claim, nor the dangerous fraud regulators describe. It is an insufficiently investigated compound in both human and veterinary medicine whose controversy reveals as much about the structural failures of medical research and drug regulation as it does about the molecule itself.

This case series reports clinical outcomes in three companion animals—two canines and one feline—treated with chlorine dioxide-based protocols as adjunctive therapies for hepatic failure with suspected neoplasia, refractory viral infection, and inflammatory mammary neoplasia, respectively. The purpose is to document observed responses, describe potential mechanisms of action, and stimulate discussion regarding research directions for chlorine dioxide applications in veterinary medicine.

Case Presentations

Case 1: Canine Hepatic Failure with Suspected Hepatocellular Carcinoma

Patient: A 17-year-old spayed female Shih Tzu presented with severe lethargy and anorexia.

Clinical Findings: Initial biochemical analysis revealed marked hepatocellular injury with alanine aminotransferase (ALT) elevation to 7,788 U/L (reference interval: 18–121 U/L)—the highest value observed in the treating clinician's career. Abdominal ultrasonography demonstrated multiple hepatic nodules consistent with suspected hepatocellular carcinoma or metastatic disease. The patient's owner was an elderly client for whom this dog was a beloved companion.

Treatment Protocol: Given the grave prognosis and limited treatment options in a 17-year-old patient, a multimodal treatment approach was implemented with the owner's consent:

- Oral fenbendazole: 222 mg per 10 pounds body weight daily
- Chlorine dioxide solution (CDS) enemas: 1 mL CDS in 30 mL distilled water, administered twice weekly
- Supportive care: intravenous fluid therapy (to maintain hydration and electrolytes) and parenteral antibiotic therapy (to treat a presumptive hepatic infection).

The rationale for fenbendazole treatment was its purported anti-cancer properties. The rationale for chlorine dioxide enemas was based on research suggesting potential hepatic benefits and the compound's established safety profile when used at appropriate concentrations. (1) Chlorine dioxide enemas had been described as potentially beneficial for hepatic functions, and given the patient's poor prognosis, this adjunctive therapy was considered appropriate.

Outcomes: Clinical improvement was noted within days, with restoration of appetite and activity level. Serial biochemical monitoring demonstrated remarkable hepatic enzyme reduction:

Day 7: ALT decreased to 856 U/L (89% reduction from baseline)

Day 14: ALT decreased to 282 U/L

Week 5: ALT normalized to 88 U/L

The patient maintained normal hepatic enzyme values for five months on oral fenbendazole and CDS enemas. The owner reported improved quality of life, with normal appetite, energy, and engagement with family activities. Disease progression eventu-

ally occurred at eight months post-diagnosis, at which time the patient was humanely euthanized. This treatment regimen provided the elderly owner with eight months of quality time with her beloved companion—far exceeding initial prognostic expectations.

Comments: Fenbendazole, a benzimidazole anthelmintic, has demonstrated antineoplastic properties in preclinical models through tubulin inhibition and potential metabolic effects on cancer cells. (15) The contribution of CDS enemas to clinical improvement cannot be determined from this single case; however, chlorine dioxide's oxidative properties and potential effects on cellular metabolism may have complemented fenbendazole's antineoplastic activity. The dramatic 89% reduction in ALT within one week—occurring during the period of both fenbendazole and CDS enema administration—preceded the timeframe typically expected for significant antineoplastic effects. The extended survival time and quality of life warrant further investigation of this combination therapy.

Case 2: Feline Refractory Upper Respiratory Infection

Patient: A 6-year-old spayed female domestic shorthair presented four days post-cystotomy with pyrexia (104.7°F), severe nasal discharge, dysphagia, and anorexia.

Clinical Findings: Polymerase chain reaction testing confirmed feline herpesvirus-1 (FHV-1) and *Mycoplasma* spp. infection. Initial treatment with subcutaneous fluids, enrofloxacin, maropitant, and oral doxycycline provided transient improvement during six-day hospitalization. However, clinical deterioration occurred within 48 hours of discharge, with recurrent pyrexia (103.1°F) and complete anorexia. The patient's condition was concerning, given the refractory nature of the infection despite appropriate conventional antimicrobial therapy.

Treatment Protocol: Following owner consent and discussion of the experimental nature of treatment, alternative therapies were implemented:

- Subcutaneous fluids (250 mL lactated Ringer's solution) with 3 mL CDS added
- Ivermectin: 0.6 mg/kg subcutaneously initially, then 0.2 mL orally for 10 days
- Sodium chlorite solution: 5 drops of 22.4% sodium chlorite in 50 mL water; 10 mL administered orally via syringe five times daily for 10 days

The rationale for this protocol was based on ivermectin's documented antiviral properties and chlorine dioxide's potent antimicrobial activity. When sodium chlorite is exposed to the acidic environment of the feline stomach, it converts to chlorine dioxide, potentially providing antimicrobial effects against both viral and bacterial pathogens. (1)

Outcomes: Rapid clinical improvement occurred within 24 hours of initiating alternative therapy. Pyrexia resolved, appetite returned, and nasal discharge decreased markedly. At five-day follow-up, the owner reported complete clinical recovery with normal appetite, activity, and respiratory function. Treatment was extended for an additional five days prophylactically to ensure complete pathogen clearance. No adverse effects were observed during or after treatment.

Comments: Ivermectin possesses antiviral properties beyond its antiparasitic effects, including demonstrated activity against FHV-1 in vitro. (16) Chlorine dioxide has been shown to rapidly inactivate multiple virus types through oxidation of viral proteins, with activity demonstrated against enveloped viruses, including herpes simplex virus. (17) The rapid clinical response observed in this case suggests potential synergistic antimicrobial activity between ivermectin and chlorine dioxide. The conversion of sodium chlorite to chlorine dioxide in the acidic feline stomach may have provided both systemic and local antimicrobial effects. While the concurrent use of multiple agents prevents definitive attribution of improvement to any single therapy, the treatment failure that occurred with conventional antibiotics and the response to this novel treatment warrant further investigation of this combination.

Case 3: Canine Inflammatory Mammary Mass

Patient: A 14-year-old intact female Golden Retriever presented with a large, painful, inflammatory mammary mass with self-trauma behavior.

Clinical Findings: The mass was approximately 20 cm in diameter and actively inflamed. Initial intervention by a colleague included drainage of 1,600 mL serosanguinous fluid, oral antibiotics, and non-steroidal anti-inflammatory drugs (NSAIDs). The mass required frequent drainage procedures, and surgical excision was deemed inappropriate due to the patient's advanced age, the mass's extensive involvement with surrounding tissues, and the high surgical risk. The long-term prognosis was poor. The owner had financial constraints that precluded

standard oncologic care, including chemotherapy or radiation therapy.

Treatment Protocol: Following owner consent and discussion of experimental approach:

- Intratumoral chlorine dioxide injections: Initial concentration of 50% CDS (3,000 ppm) / 50% saline, approximately 20 mL per treatment session, administered every two weeks for 8 months with no sedation required
- Concentration increased to 70% CDS / 30% saline at six weeks based on excellent tolerance
- CAS medicinal mushroom supplement (*Coriolus versicolor*) for potential immunomodulation
- Oral fenbendazole: 4 grams three times weekly. This treatment was delayed until three months after the injections of chlorine dioxide began due to the owners financial constraints. Fenbendazole was continued for 5 months.

In summary, the total duration of treatment was 8 months (3 months of intratumoral chlorine dioxide injections alone, 5 months of chlorine dioxide injections and oral fenbendazole).

The rationale for fenbendazole was its purported anti-cancer properties. The rationale for intratumoral chlorine dioxide was based on its oxidative properties and potential direct cytotoxic effects on abnormal cells. This canine tolerated the injections remarkably well, lying calmly on her side during procedures with no signs of discomfort, eliminating the need for sedation.

Outcomes: Progressive clinical improvement was observed throughout treatment:

- Decreased fluid accumulation with each drainage procedure, eventually eliminating the need for drainage
- Resolution of inflammation and cessation of self-trauma behavior
- Significant mass reduction from approximately 20 cm diameter to 5 cm diameter over six months. The initial reduction in the size of the mass during the first month of treatment was most likely due to a decrease in fluid retention. Treatment with fenbendazole had not been initiated at this point in time.
- Improved quality of life maintained for nine months
- Mass became progressively more detached from the body wall with each treatment session

The patient was ultimately euthanized due to severe osteoarthritis limiting mobility, not due to mam-

mary disease progression. The owner expressed profound gratitude for the additional quality time with Maya, which exceeded initial expectations given the poor prognosis.

Comments: Intratumoral injection of oxidative agents represents an emerging strategy in oncology, with several mechanisms potentially contributing to tumor reduction (18). The observed tumor reduction in this case may reflect: (1) direct cytotoxic effects of chlorine dioxide oxidation on neoplastic cells, (2) disruption of tumor vasculature leading to ischemia (believed to be related to treatment with fenbendazole, based on the author's personal clinical experience with the surgical resection of tumors in other animals that had undergone treatment with fenbendazole), (3) immunomodulation from medicinal mushroom supplementation, and (4) antineoplastic effects of fenbendazole. While the concurrent use of multiple agents prevents definitive attribution of benefit to chlorine dioxide alone, the excellent local tolerance, lack of systemic adverse effects, and substantial tumor reduction support further investigation of intratumoral chlorine dioxide therapy. The progression from requiring frequent drainage to complete cessation of fluid accumulation suggests significant alteration of tumor biology beyond simple cytoreduction.

Discussion

Chlorine dioxide (ClO_2) remains a controversial therapeutic in humans despite preclinical studies documenting antimicrobial and potentially anti-cancer properties at low concentrations, and scientifically plausible mechanisms of action. A patent was granted to Howard Alliger in 2018 for the use of intratumoral injections of chlorine dioxide to treat tumors. (19) However, to our knowledge, no preclinical or clinical controlled trials have been conducted. Thus, this treatment's efficacy and therapeutic safety remain unestablished. The response of regulatory agencies has included prohibition, labeling ClO_2 "a dangerous bleach," and pursuing criminal charges against individuals who promote its use. Yet, this stance is based primarily on reports of adverse events that are associated with high-dose misuse rather than properly formulated low-dose therapeutic protocols. No systematic effort has been attempted to distinguish between the effects of higher doses versus lower doses. This is akin to labeling chemotherapeutic agents "poisons," and attempting to suppress their use because at high doses they cause severe, even potentially fatal, adverse effects. Exacerbating this impasse is the compound's un-

patentable status, which eliminates the financial incentive for pharmaceutical sponsorship of the clinical trials that are required by regulators. This prohibition, which is justified by the absence of trial data, simultaneously prevents that data from being generated. The current state of the literature therefore supports neither the claims of universal therapeutic benefits advanced by some advocates nor the characterization of ClO_2 as an inherently dangerous fraud. Rather, it reflects the status of an insufficiently investigated therapy in both human and veterinary medicine — one whose controversy illuminates structural failures in medical research and drug regulation as much as it does any intrinsic property of the molecule itself. Rigorous, prospective clinical investigation remains both warranted and absent.

This case series presents three companion animals with serious medical conditions—hepatic failure with suspected neoplasia, refractory viral infection, and inflammatory mammary neoplasia—that demonstrated clinical improvement following treatment protocols incorporating chlorine dioxide. These cases may justify formal prospective investigation, but do not establish efficacy, safety, or reproducible therapeutic utility.

Mechanisms of Action

Chlorine dioxide's antimicrobial and therapeutic properties stem from its unique chemical structure and oxidative capacity. As established by Liester, (1) ClO_2 functions as a potent oxidizing agent through several key mechanisms:

Antimicrobial Effects: Chlorine dioxide exerts antimicrobial activity through selective oxidation of cellular components. (1) After contact with microorganisms, ClO_2 rapidly oxidizes specific amino acids—primarily cysteine, tryptophan, and tyrosine—in microbial proteins. (20) This redox reaction degrades essential proteins, rendering pathogens unable to replicate or infect host cells. (21–23) This oxidative mechanism differs fundamentally from conventional antibiotics, potentially explaining activity against multidrug-resistant organisms and lack of typical resistance development. (1)

ClO_2 has demonstrated virucidal activity against diverse viral pathogens including Poliovirus, Adenovirus, Herpes simplex virus-1, Influenza virus, and coronaviruses. (17,24,25) The rapid virucidal action—often occurring within minutes—distinguishes ClO_2 from many conventional antiviral agents. (1)

Anti-inflammatory Properties: Recent research has characterized chlorine dioxide's immunomodulatory effects. Chlorite (the reduced form of ClO_2) has been shown to inhibit polymorphonuclear cell migration, enhance macrophage phagocytic activity, down-regulate pro-inflammatory gene expression in monocytes, stimulate production of taurine chloramine (an endogenous anti-inflammatory mediator), and promote conversion of pro-inflammatory M1 macrophages to anti-inflammatory M2 phenotype. These anti-inflammatory mechanisms may contribute to improved clinical outcomes beyond direct antimicrobial effects. (9)

Wound Healing Enhancement: Chlorine dioxide and chlorite have demonstrated multiple effects promoting tissue repair including enhanced granulation tissue formation, improved angiogenesis and tissue oxygenation, modulation of oxidative stress through effects on reactive oxygen species, stimulation of collagen deposition, and increased activity of antioxidant enzymes (superoxide dismutase, glutathione peroxidase). A study in diabetic rats demonstrated that topical chlorine dioxide gel significantly accelerated wound healing compared to controls, with histological evidence of increased collagen content, enhanced capillary proliferation, and reduced inflammatory cell infiltration. (26,27)

Effects on Glucose Metabolism: Emerging evidence suggests chlorite may influence glucose homeostasis. Studies in diabetic patients with foot ulcers found significant reductions in hemoglobin A1c levels following chlorite treatment, suggesting systemic metabolic effects beyond local wound healing. (10,11) One particularly striking case involved an 81-year-old patient with over 30 years of poorly controlled type II diabetes who, following treatment with oral chlorine dioxide (20 mL at 60 ppm daily) for diabetic foot ulcers, achieved complete wound healing and normalization of blood glucose levels without requiring insulin or other diabetes medications—effects that persisted for three years of follow-up. (11)

Safety Considerations

The safety profile of chlorine dioxide has been extensively characterized in both animal and human studies, as comprehensively reviewed by Liester (1) and Calliperis et al. (11) Key safety findings include:

Established Safety Thresholds: The US Environmental Protection Agency determined a NOAEL of

3 mg/kg/day for oral chlorine dioxide. The Agency for Toxic Substances and Disease Registry established a NOAEL of 2.9 mg/kg/day. Human studies found no adverse effects at doses of 0.04–0.34 mg/kg/day. (28) Millions of people consume low-dose chlorine dioxide daily in municipal drinking water without adverse effects.

Clinical Trial Safety Data: Phase I and II clinical trials in humans have demonstrated excellent safety profiles. Single ascending doses up to 3.2 mg/kg intravenous sodium chlorite were safe and well-tolerated with no treatment-related serious adverse events. (13) Daily intravenous administration of 2 mg/kg sodium chlorite for 6 months showed no significant adverse effects in ALS patients. (14) The lowest observed adverse effects level (LOAEL) was 5.7 mg/kg/day, equivalent to 400 mg/day for an average 70 kg adult. (11)

Dose-Dependent Safety: As emphasized by Liester (1) and Calliperis et al., (11) the critical determinant of chlorine dioxide safety is dosage. Low doses are well-tolerated, while high doses can cause adverse hematologic and renal effects. This principle—articulated by Paracelsus over 500 years ago as "the dose makes the poison"—applies equally to chlorine dioxide as to conventional medications. The cases presented here utilized conservative dosing approaches well below established safety thresholds.

Topical Safety: Topical chlorine dioxide has demonstrated excellent safety in both animal and human studies. A study using equine fibroblasts found chlorine dioxide less toxic than chlorhexidine, a commonly used antiseptic. (29) A human clinical trial using chlorine dioxide as a wound irrigant at 50 ppm found the treatment safe without adverse events. (30) The diabetic foot ulcer case series reported no adverse effects with topical chlorine dioxide gel application or with oral administration at concentrations of 30–60 ppm. (11)

Observed Safety in Cases: In the three veterinary cases presented, no adverse effects were attributed to chlorine dioxide administration at the doses employed. Case 1 (CDS enemas) showed no gastrointestinal adverse effects over five months of twice-weekly administration. Case 2 (oral sodium chlorite) demonstrated no adverse effects during or after the 10-day treatment course. Case 3 (intratumoral injections) showed remarkable local tolerance with no sedation required and no injection site complications over six months of treatment.

Limitations

Each case involved multimodal treatment protocols, creating significant challenges in attributing clinical improvement to specific interventions. Case 1 utilized concurrent fenbendazole and supportive care; Case 2 combined ivermectin with chlorine dioxide; and Case 3 incorporated medicinal mushrooms and fenbendazole alongside intratumoral chlorine dioxide. This case series has inherent limitations characteristic of uncontrolled observations including small sample size (n=3), lack of control groups preventing causal inference, absence of histopathologic confirmation in Cases 1 and 3, subjective outcome measures, inability to control for natural disease variation, potential publication bias, and variable chlorine dioxide concentrations and routes of administration across cases.

These cases should be interpreted as hypothesis-generating observations rather than evidence of efficacy. Controlled studies are needed to establish safety profiles, optimal dosing protocols, and efficacy in veterinary applications.

Conclusion

This case series describes three veterinary patients who improved clinically while receiving chlorine dioxide-containing adjunctive protocols. However, due to major methodological limitations—including concurrent therapies, lack of controls, and incomplete diagnostic confirmation—no conclusions can be drawn regarding efficacy or safety. The observations are hypothesis-generating only and may inform future controlled research.

The favorable outcomes in these three veterinary cases, combined with emerging human medical data and comprehensive safety information, justify continued investigation of chlorine dioxide's potential role in veterinary therapeutics. As the veterinary profession faces growing challenges with antimi-

crobial resistance, limited treatment options for certain viral diseases, and the need for safe wound healing adjuncts, chlorine dioxide merits serious scientific consideration.

These cases demonstrate that when applied thoughtfully in carefully selected patients with appropriate owner consent and clinical monitoring, chlorine dioxide-based protocols may offer therapeutic benefits worthy of rigorous investigation. The next phase must transition from anecdotal case reports to properly controlled research that can definitively establish—or refute—chlorine dioxide's role in evidence-based veterinary medicine.

Ethical Considerations

This was a retrospective collection of cases. All treatments were administered with informed owner consent after thorough discussion of the experimental nature of chlorine dioxide therapy, available evidence from other species, potential risks and benefits, and alternative treatment options. Given the poor prognoses and limited conventional therapeutic options in these cases, the decision to utilize investigational treatments was made collaboratively with owners following transparent communication. This approach aligns with veterinary ethical principles of informed consent and client autonomy. Formal ethics committee approval was not required for these clinical cases as they involved treatment decisions made in the course of veterinary practice with full client consent.

Conflicts of Interest

The authors declare no conflicts of interest related to this work. No financial support was received for the preparation of this manuscript, and the authors have no financial relationships with any organizations that might have an interest in the submitted work.

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