

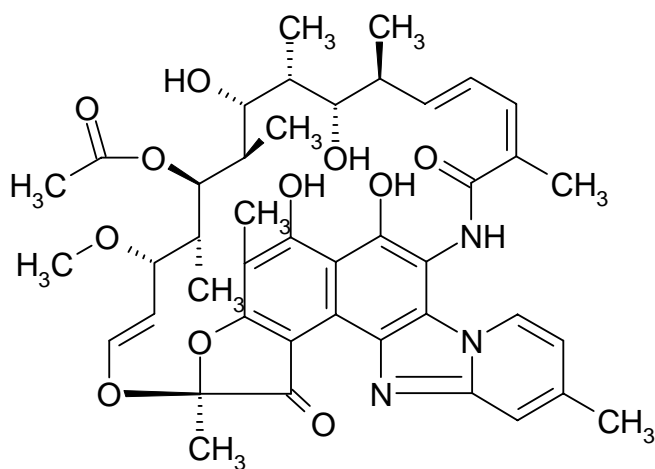
NDA 21-361/S-006

Page 3

XIFAXAN[®] (rifaximin) Tablets
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DESCRIPTION

XIFAXAN[®] Tablets contain rifaximin, a semi-synthetic, nonsystemic antibiotic. The chemical name for rifaximin is (2*S*,16*Z*,18*E*,20*S*,21*S*,22*R*,23*R*,24*R*,25*S*,26*S*,27*S*,28*E*)-5,6,21,23,25-pentahydroxy-27-methoxy-2,4,11,16,20,22,24,26-octamethyl-2,7-(epoxypentadeca-[1,11,13]trienimino)benzofuro[4,5-*e*]pyrido[1,2-*a*]-benzimidazole-1,15(2*H*)-dione,25-acetate. The empirical formula is C₄₃H₅₁N₃O₁₁ and its molecular weight is 785.9. The chemical structure is represented below:



XIFAXAN[®] Tablets for oral administration are film-coated and contain 200 mg of rifaximin. Inactive ingredients are colloidal silicon dioxide, disodium edetate, glycerol palmitostearate, hypromellose, microcrystalline cellulose, propylene glycol, red iron oxide, sodium starch glycolate, talc, and titanium dioxide.

CLINICAL PHARMACOLOGY

Pharmacokinetics

NDA 21-361/S-006

Page 4

Absorption: The mean pharmacokinetic parameters of rifaximin in 14 healthy subjects after a single oral 400-mg dose given as 2 x 200 mg doses under fed and fasting conditions are summarized in Table 1.

Table 1. Effect of Food on the Mean \pm S.D. Pharmacokinetic Parameters Following a Single 400-mg Dose of Rifaximin (N = 14)

Parameter	Fasting	Fed
C _{max} (ng/mL)	3.80 \pm 1.32	9.63 \pm 5.93
T _{max} (h)	1.21 \pm 0.47	1.90 \pm 1.52
Half-Life (h)	5.85 \pm 4.34	5.95 \pm 1.88
AUC (ng·h/mL)	18.35 \pm 9.48	34.70 \pm 9.23
% Excreted in Urine	0.023 \pm 0.009	0.051 \pm 0.017

Rifaximin can be administered with or without food. Systemic absorption of rifaximin was low in both the fasting state and when administered within 30 minutes of a high-fat breakfast.

¹⁴C-Rifaximin was administered as a single dose to 4 healthy male subjects. The mean overall recovery of radioactivity in the urine and feces of 3 subjects during the 168 hours after administration was 96.94 \pm 5.64% of the dose. Radioactivity was excreted almost exclusively in the feces (96.62 \pm 5.67% of the dose), with only a small proportion of the dose (mean 0.32% of the dose) excreted in urine. Analysis of fecal extracts indicated that rifaximin was being excreted as unchanged drug. The amount of radioactivity in urine (<0.4% of the dose) suggests that rifaximin is poorly absorbed from the gastrointestinal tract and is almost exclusively and completely excreted in feces as unchanged drug. Mean rifaximin pharmacokinetic parameters were C_{max} 4.3 \pm 2.8 ng/mL and AUC_t 19.5 \pm 16.5 ng·h/mL with a median T_{max} of 1.25 hours.

Systemic absorption of rifaximin (200 mg three times daily) was also evaluated in 13 subjects with shigellosis on Days 1 and 3 of a three-day course of treatment. Rifaximin concentrations and exposures were low and variable. There was no evidence of accumulation of rifaximin following repeated administration for 3 days (9 doses). Peak plasma rifaximin concentrations after 3 and 9

NDA 21-361/S-006

Page 5

consecutive doses ranged from 0.81 to 3.4 ng/mL on Day 1 and 0.68 to 2.26 ng/mL on Day 3.

Similarly, AUC_{0-last} estimates were 6.95 ± 5.15 ng•h/mL on Day 1 and 7.83 ± 4.94 ng•h/mL on Day

3. Rifaximin is not suitable for treating systemic bacterial infections because less than 0.4% of the drug is absorbed after oral administration (see **WARNINGS**).

Distribution: Animal pharmacokinetic studies have demonstrated that 80% to 90% of orally administered rifaximin is concentrated in the gut with less than 0.2% in the liver and kidney, and less than 0.01% in other tissues. In adults with infectious diarrhea treated with rifaximin 800 mg daily for three days, concentrations of rifaximin in stools averaged ~8000 µg/g the day after treatment ended.

Metabolism: *In vitro* drug interactions studies have shown that rifaximin, at concentrations ranging from 2 to 200 ng/mL, did not inhibit human hepatic cytochrome P450 isoenzymes: 1A2, 2A6, 2B6, 2C9, 2C19, 2D6, 2E1, and 3A4. In an *in vitro* hepatocyte induction model, rifaximin was shown to induce cytochrome P450 3A4 (CYP3A4), an isoenzyme which rifampin is known to induce. Two clinical drug-drug interaction studies using midazolam and an oral contraceptive containing ethinyl estradiol and norgestimate demonstrated that rifaximin did not alter the pharmacokinetics of these drugs (see **Drug-Drug Interactions**).

Excretion: Rifaximin is excreted primarily in the feces. After oral administration of 400 mg ¹⁴C-rifaximin to healthy volunteers, approximately 97% of the dose was recovered in feces, almost entirely as unchanged drug, and 0.32% was recovered in the urine.

Special Populations

Geriatric: The pharmacokinetics of rifaximin in patients ≥ 65 years of age has not been studied.

NDA 21-361/S-006

Page 6

Pediatric: The pharmacokinetics of rifaximin has not been studied in pediatric patients of any age.

Gender: The effect of gender on the pharmacokinetics of rifaximin has not been studied.

Renal Insufficiency: The pharmacokinetics of rifaximin in patients with impaired renal function has not been studied.

Hepatic Insufficiency: Mean peak rifaximin plasma concentrations of 13.5 µg/mL were detected in hepatic encephalopathy patients administered rifaximin 800 mg three times daily for 7 days. Less than 0.1% of the administered dose was recovered after 7 days. Because of the limited systemic absorption of rifaximin, no specific dosing adjustments are recommended for patients with hepatic insufficiency.

Drug-Drug Interactions

In an *in vitro* hepatocyte induction model, rifaximin was shown to induce cytochrome P450 3A4 (CYP3A4), an isoenzyme which rifampin is known to induce. Two clinical drug-drug interaction studies were conducted using midazolam and an oral contraceptive containing ethinyl estradiol and norgestimate to assess the effect of rifaximin on the pharmacokinetics of these drugs.

The midazolam study was an open-label, randomized, crossover, drug-interaction trial designed to assess the effect of rifaximin 200 mg administered orally (PO) every 8 hours (Q8H) for 3 days and every 8 hours for 7 days, on the pharmacokinetics of a single dose of either midazolam 2 mg intravenous (IV) or midazolam 6 mg PO. No significant difference was observed in the metrics of systemic exposure or elimination of IV or PO midazolam or its major metabolite, 1'-hydroxymidazolam, between midazolam alone or together with rifaximin. Therefore, rifaximin was not shown to significantly affect intestinal or hepatic CYP3A4 activity.

NDA 21-361/S-006

Page 7

The oral contraceptive study utilized an open-label, crossover design in 28 healthy female subjects to determine if rifaximin 200 mg PO administered Q8H for 3 days altered the pharmacokinetics of a single dose of an oral contraceptive containing 0.07 mg ethinyl estradiol and 0.50 mg norgestimate. Results showed that the pharmacokinetics of single doses of ethinyl estradiol and norgestimate were not altered by rifaximin.

Microbiology

Rifaximin acts by binding to the beta-subunit of bacterial DNAdependent RNA polymerase resulting in inhibition of bacterial RNA synthesis.

Escherichia coli has been shown to develop resistance to rifaximin *in vitro*. However, the clinical significance of such an effect has not been studied. Rifaximin is a structural analog of rifampin. Organisms with high rifaximin minimum inhibitory concentration (MIC) values also have elevated MIC values against rifampin. Cross-resistance between rifaximin and other classes of antimicrobials has not been studied.

Rifaximin has been shown to be active against the following pathogen in clinical studies of infectious diarrhea as described in the **INDICATIONS AND USAGE** section: *Escherichia coli* (enterotoxigenic and enteroaggregative strains).

Susceptibility Tests

In vitro susceptibility testing was performed according to the National Committee for Clinical Laboratory Standards (NCCLS) agar dilution method M7-A61. However, the correlation between susceptibility testing and clinical outcome has not been determined.

NDA 21-361/S-006
Page 8

INDICATIONS AND USAGE

XIFAXAN[®] Tablets are indicated for the treatment of patients (≥ 12 years of age) with travelers' diarrhea caused by noninvasive strains of *Escherichia coli* (see **WARNINGS, Microbiology**, and **CLINICAL STUDIES**).

XIFAXAN[®] Tablets should not be used in patients with diarrhea complicated by fever or blood in the stool or diarrhea due to pathogens other than *Escherichia coli*.

CONTRAINDICATIONS

XIFAXAN[®] Tablets are contraindicated in patients with a hypersensitivity to rifaximin, any of the rifamycin antimicrobial agents, or any of the components in XIFAXAN[®] Tablets.

WARNINGS

XIFAXAN[®] Tablets were not found to be effective in patients with diarrhea complicated by fever and/or blood in the stool or diarrhea due to pathogens other than *Escherichia coli*.

XIFAXAN[®] Tablets are not effective in cases of travelers' diarrhea due to *Campylobacter jejuni*. The effectiveness of XIFAXAN[®] Tablets in travelers' diarrhea caused by *Shigella* spp. and *Salmonella* spp. has not been proven. XIFAXAN[®] Tablets should not be used in patients where *Campylobacter jejuni*, *Shigella* spp., or *Salmonella* spp. may be suspected as causative pathogens.

XIFAXAN[®] Tablets should be discontinued if diarrhea symptoms get worse or persist more than 24-48 hours and alternative antibiotic therapy should be considered.

NDA 21-361/S-006
Page 9

Pseudomembranous colitis has been reported with nearly all antibacterial agents and may range in severity from mild to life-threatening. Therefore, it is important to consider this diagnosis in patients who present with diarrhea subsequent to the administration of antibacterial agents.

Treatment with antibacterial agents alters the normal flora of the colon and may permit overgrowth of clostridia. Studies indicate that a toxin produced by *Clostridium difficile* is the primary cause of “antibiotic-associated colitis.”

After the diagnosis of pseudomembranous colitis has been established, therapeutic measures should be initiated. Mild cases of pseudomembranous colitis usually respond to drug

discontinuation alone. In moderate to severe cases, consideration should be given to management with fluids and electrolytes, protein supplementation, and treatment with an antibacterial drug clinically effective against *Clostridium difficile*.

PRECAUTIONS

General

The use of antibiotics may promote the overgrowth of nonsusceptible organisms. Should superinfection occur during therapy, appropriate measures should be taken.

Information for Patients

Patients should be advised that XIFAXAN[®] Tablets may be taken with or without food. Patients should be advised that XIFAXAN[®] Tablets should be discontinued if their diarrhea persists

NDA 21-361/S-006

Page 10

more than 24-48 hours or worsens, or if they have fever and/or blood in the stool that they should seek medical care (see **Patient Information**).

Drug-Drug Interactions

Although *in vitro* studies demonstrated the potential of rifaximin to interact with cytochrome P450 3A4 (CYP3A4), a clinical drug-drug interaction study demonstrated that rifaximin did not significantly affect the pharmacokinetics of midazolam either presystemically or systemically. An additional clinical drug-drug interaction study showed no effect of rifaximin on the presystemic metabolism of an oral contraceptive containing ethinyl estradiol and norgestimate. Therefore, clinical interactions with drugs metabolized by human cytochrome P450 isoenzymes are not expected (see **Pharmacokinetics** and **Drug-Drug Interactions**).

Carcinogenesis, Mutagenesis, Impairment of Fertility

Carcinogenicity studies were not conducted. Rifaximin was not genotoxic in the bacterial reverse mutation assay, chromosomal aberration assay, rat bone marrow micronucleus assay, and the CHO/HGPRT mutation assay. There was no effect on fertility in male or female rats following the administration of rifaximin at doses up to 300 mg/kg (approximately 5 times the clinical dose, adjusted for body surface area).

Pregnancy—Teratogenic Effects (Pregnancy Category C)

Pregnancy

Pregnancy category C: Rifaximin was teratogenic in rats at doses of 150 to 300 mg/kg (approximately 2.5 to 5 times the clinical dose, adjusted for body surface area) and in rabbits at doses of 62.5 to 1000 mg/kg (approximately 2 to 33 times the clinical dose, adjusted for body surface area). These effects include cleft palate, agnatha, jaw shortening, hemorrhage, eye

NDA 21-361/S-006

Page 11

partially open, small eyes, brachygnathia, incomplete ossification, and increased thoracolumbar vertebrae. There are no adequate and well controlled studies in pregnant women. XIFAXAN[®] Tablets should be used during pregnancy only if the potential benefit outweighs the potential risk to the fetus.

Use during lactation

It is not known whether rifaximin is excreted in human milk. Because many drugs are excreted in human milk and because of the potential for adverse reactions in nursing infants from XIFAXAN[®] Tablets, a decision should be made whether to dis-continue nursing or to discontinue the drug, taking into account the importance of the drug to the mother.

Pediatric Use

The safety and effectiveness of XIFAXAN[®] Tablets in pediatric patients less than 12 years of age have not been established.

Geriatric Use

Clinical studies of XIFAXAN[®] Tablets did not include sufficient numbers of subjects aged 65 and over to determine whether they respond differently than younger subjects.

ADVERSE REACTIONS

The safety of XIFAXAN[®] Tablets 200 mg taken three times a day (TID) was evaluated in 320 patients in two placebo-controlled clinical trials with 95% of patients receiving at least three days of treatment with XIFAXAN[®] Tablets. All adverse events for XIFAXAN[®] Tablets 200 mg TID that occurred at a frequency $\geq 2\%$ in the two placebo-controlled trials combined are provided in Table 2. (These include adverse events that may be attributable to the underlying disease.)

NDA 21-361/S-006
Page 12

Table 2. All Adverse Events With an Incidence $\geq 2\%$ Among Patients Receiving XIFAXANTM Tablets, 600 mg/day, in Placebo-Controlled Studies

MedDRA Preferred Term	Number (%) of Patients	
	XIFAXANTM Tablets, 600 mg/day (N = 320)	Placebo N = 228
Flatulence	36 (11.3%)	45 (19.7%)
Headache	31 (9.7%)	21 (9.2%)
Abdominal Pain NOS	23 (7.2%)	23 (10.1%)
Rectal Tenesmus	23 (7.2%)	20 (8.8%)
Defecation Urgency	19 (5.9%)	21 (9.2%)
Nausea	17 (5.3%)	19 (8.3%)
Constipation	12 (3.8%)	8 (3.5%)
Pyrexia	10 (3.1%)	10 (4.4%)
Vomiting NOS	7 (2.2%)	4 (1.8%)

The following adverse events, presented by body system, have also been reported in $<2\%$ of patients taking XIFAXAN[®] Tablets in the two placebo-controlled clinical trials where the 200 mg taken three times a day dose was used. The following includes adverse events regardless of causal relationship to drug exposure.

Blood and Lymphatic System Disorders: lymphocytosis, monocytosis, neutropenia

Ear and Labyrinth Disorders: ear pain, motion sickness, tinnitus

Gastrointestinal Disorders: abdominal distension, diarrhea NOS, dry throat, fecal abnormality NOS, gingival disorder NOS, inguinal hernia NOS, dry lips, stomach discomfort

General Disorders and Administration Site Conditions: chest pain, fatigue, malaise, pain NOS, weakness

Infections and Infestations: dysentery NOS, respiratory tract infection NOS, upper respiratory tract infection NOS

Injury and Poisoning: sunburn

Investigations: aspartate aminotransferase increased, blood in stool, blood in urine, weight decreased

Metabolic and Nutritional Disorders: anorexia, dehydration

NDA 21-361/S-006

Page 13

Musculoskeletal, Connective Tissue, and Bone Disorders: arthralgia, muscle spasms, myalgia, neck pain

Nervous System Disorders: abnormal dreams, dizziness, migraine NOS, syncope, loss of taste

Psychiatric Disorders: insomnia

Renal and Urinary Disorders: choluria, dysuria, hematuria, polyuria, proteinuria, urinary frequency

Respiratory, Thoracic, and Mediastinal Disorders: dyspnea NOS, nasal passage irritation, nasopharyngitis, pharyngitis, pharyngolaryngeal pain, rhinitis NOS, rhinorrhea

Skin and Subcutaneous Tissue Disorders: clamminess, rash NOS, sweating increased

Vascular Disorders: hot flashes NOS

Postmarketing Experience

The following events: hypersensitivity reactions, including exfoliative dermatitis, rash, angioneurotic edema (swelling of face and tongue and difficulty swallowing), urticaria, flushing, and pruritus; have been identified during post-approval use of XIFAXAN[®] Tablets. These events occurred as early as within 15 minutes of drug administration.

DRUG ABUSE AND DEPENDENCY

Abuse

None reported.

Dependency

None reported.

OVERDOSAGE

NDA 21-361/S-006

Page 14

No specific information is available on the treatment of overdose with XIFAXAN[®] Tablets. In clinical studies at doses higher than the recommended dose (> 600 mg/day), adverse events were similar to the recommended dose (200 mg taken three times a day) and to placebo. In the case of overdose, discontinue XIFAXAN[®] Tablets, treat symptomatically, and institute supportive measures as required.

DOSAGE AND ADMINISTRATION

XIFAXAN[®] Tablets can be administered orally with or without food. For travelers' diarrhea, the recommended dose is one 200 mg tablet taken three times a day for 3 days.

HOW SUPPLIED

XIFAXAN[®] Tablets are available as circular, pink-colored, biconvex tablets containing 200 mg rifaximin, debossed with "Sx" on one side.

NDC 65649-301-03 Bottles of 30 tablets

NDC 65649-301-41 Bottles of 100 tablets

NDC 65649-301-05 Carton of 100 Tablets, Unit Dose

Store XIFAXAN[®] Tablets at 20–25°C (68–77°F); excursions permitted to 15–30°C (59–86°F). See USP Controlled Room Temperature.

CLINICAL STUDIES

NDA 21-361/S-006

Page 15

The efficacy of rifaximin (200 mg orally taken three times a day for 3 days) was evaluated in two-

randomized, multi-center, double-blind, placebo controlled studies in adult subjects with

travelers' diarrhea. One study was conducted at clinical sites in Mexico, Guatemala, and Kenya (Study

1). The other study was conducted in Mexico, Guatemala, Peru, and India (Study 2).

Stool specimens were collected before treatment and 1 to 3 days following the end of treatment to

identify enteric pathogens. The predominant pathogen in both studies was *Escherichia coli*.

The clinical efficacy of rifaximin was assessed by the time to return to normal, formed stools and

resolution of symptoms. The primary efficacy endpoint was time to last unformed stool

(TLUS) which is defined as the time to the last unformed stool passed, after which clinical cure was

declared. Table 3 displays the median TLUS and the number of patients who achieved

clinical cure for the intent to treat population (ITT) of Study 1. The duration of diarrhea was

significantly shorter in patients treated with rifaximin than in the placebo group. More rifaximin-

treated patients were classified as clinical cures than were those in the placebo group.

Table 3 - Clinical Response in Study 1 (ITT population)

	Rifaximin (n=125)	Placebo (n=129)	Estimate (97.5% CI)	P-Value
Median TLUS (hours)	32.5	58.6	1.78 ^a (1.26, 2.50)	0.0002
<u>Clinical cure</u> , n (%)	99 (79.2)	78 (60.5)	18.7 ^b (5.3, 32.1)	0.001

^a Hazard Ratio

^b Difference in rates

Microbiological eradication (defined as the absence of a baseline pathogen in culture of stool after 72

hours of therapy) rates for Study 1 are presented in Table 4 for patients with any

pathogen at baseline and for the subset of patients with *Escherichia coli* at baseline. *Escherichia coli*

was the only pathogen with sufficient numbers to allow comparisons between treatment groups.

NDA 21-361/S-006

Page 16

Even though rifaximin had microbiologic activity similar to placebo, it demonstrated a clinically significant reduction in duration of diarrhea and a higher clinical cure rate than placebo. Therefore, patients should be managed based on clinical response to therapy rather than microbiologic response.

Table 4 - Microbiologic Eradication Rates in Study 1
Subjects with a Baseline Pathogen

	Rifaximin	Placebo
Overall	48/70 (68.6)	41/61 (67.2)
<i>E. coli</i>	38/53 (71.7)	40/54 (74.1)

Study 2 provided additional information to support the results presented for Study 1. This study also provided evidence that rifaximin-treated subjects with fever and/or blood in the stool at baseline had prolonged TLUS. These subjects had lower clinical cure rates than those without fever or blood in the stool at baseline. Many of the patients with fever and/or blood in the stool (dysentery-like diarrheal syndromes) had invasive pathogens, primarily *Campylobacter jejuni*, isolated in the baseline stool.

Also in this study, the majority of the rifaximin-treated subjects who had *Campylobacter jejuni* isolated as a sole pathogen at baseline failed treatment and the resulting clinical cure rate for these patients was 23.5% (4/17). In addition to not being different from placebo, the microbiologic eradication rates for subjects with *Campylobacter jejuni* isolated at baseline were much lower than the eradication rates seen for *Escherichia coli*.

In an unrelated Phase 1, open-label, pharmacokinetic study of oral XIFAXAN[®] Tablets 200 mg taken every 8 hours for 3 days, 15 adult subjects were challenged with *Shigella flexneri* 2a, of whom 13 developed diarrhea or dysentery and were treated with rifaximin. Although this open-label challenge trial was not adequate to assess the effectiveness of rifaximin in the treatment of shigellosis, the following observations were noted.

NDA 21-361/S-006
Page 17

Eight subjects received rescue treatment with ciprofloxacin either because of lack of response to rifaximin treatment within 24 hours (2), or because they developed severe dysentery (5), or because of recurrence of *Shigella flexneri* in the stool (1). Five of the 13 subjects received ciprofloxacin although they did not have evidence of severe disease or relapse.

REFERENCES

1. Methods for dilution antimicrobial susceptibility tests for bacteria that grow aerobically. National Committee for Clinical Laboratory Standards, Sixth Edition, Wayne PA.
Approved Standard NCCLS Document M7-A6 January 2003; 23 (2).

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Part #
Revision Date

NDA 21-361/S-006
Page 18

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