



***H. pylori* Treatment Therapeutic Class Review (TCR)**

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FDA-APPROVED COMBINATION PRODUCTS

Drug	Manufacturer	Indication
omeprazole, amoxicillin, clarithromycin (Omeclamox-Pak™) ¹	Cumberland	Components are indicated for the treatment of patients with <i>H. pylori</i> infection and duodenal ulcer disease (active or up to 1-year history) to eradicate <i>H. pylori</i>
lansoprazole, amoxicillin, clarithromycin (Prevpac®) ²	generic, Takeda	Components are indicated for the treatment of patients with <i>H. pylori</i> infection and duodenal ulcer disease to eradicate <i>H. pylori</i> .
bismuth subcitrate potassium, metronidazole, tetracycline (Pylera®) ³	Allergan	Components are indicated in combination with omeprazole for the treatment of patients with <i>H. pylori</i> infection and duodenal ulcer disease to eradicate <i>H. pylori</i> ; omeprazole should be taken with the breakfast dose and dinner dose of Pylera

OVERVIEW

Although the traditional theories regarding the pathogenesis of peptic ulcers focus on acid hypersecretion, this finding is not universal, and it is now known that hypersecretion is not the primary mechanism by which most ulceration occurs.⁴ It appears that certain factors, such as *Helicobacter pylori* (*H. pylori*) and nonsteroidal anti-inflammatory drugs (NSAIDs), disrupt the normal mucosal defense and repair, making the mucosa more susceptible to the attack of acid.

The mechanisms by which *H. pylori* causes mucosal injury are not entirely clear, but several theories have been proposed.^{5,6} Urease produced by the organism catalyzes urea to ammonia. Ammonia, while enabling the organism to survive in the acidic environment of the stomach, may erode the mucous barrier, leading to epithelial damage. Cytotoxins produced by *H. pylori* have also been implicated in host epithelial damage. Mucolytic enzymes (e.g., bacterial protease, lipase) appear to be involved in degradation of the mucous layer, making the epithelium more susceptible to acid damage. Lastly, cytokines produced in response to inflammation may play a role in mucosal damage and subsequent ulcerogenesis.

H. pylori is associated with intestinal-type adenocarcinoma of the gastric body and antrum. Infected persons are 3 to 6 times more likely to develop stomach cancer. Gastric lymphomas and mucosa-associated lymphoma tissue (MALT) lymphomas have also been linked to this infection.⁷ As many as two-thirds of high-grade MALT lymphomas may respond to antibiotic therapy for *H. pylori*.⁸

Eradication of *H. pylori* has been shown to decrease peptic ulcer disease (PUD).⁹ Long-term treatment with H₂ antagonists or PPIs reduces the risk of recurrence proportionally to the amount of acid suppression achieved. One year relapse rate for gastric and duodenal ulcers is more than 60% after cessation of these traditional antiulcer therapies. The rate of ulcer recurrence is considerably lower after *H. pylori* eradication therapy (less than 10%). Recurrent infections are usually due to persistent *H. pylori*, which, if documented, should be treated with a second course of *H. pylori* eradication therapy.

H. pylori eradication consists of multiple drug therapy that combines antibiotics with an acid-suppressive agent (H₂ antagonists or PPI) for 7 to 14 days. Although no regimen offers 100% eradication, it appears that dual drug and short-term therapy result in lower eradication rates,

compared with triple drug regimens lasting 10 to 14 days.^{10,11,12,13,14} Medication compliance, medication-related adverse effects, and antimicrobial resistance may also affect eradication.^{15,16}

The 2017 American College of Gastroenterology (ACG) guidelines on the treatment of *H. pylori* in North America state all patients with a positive test of active infection with *H. pylori* should be offered treatment (strong recommendations).¹⁷ Clarithromycin triple therapy (clarithromycin, PPI, and amoxicillin or metronidazole) for 14 days is recommended in regions with low *H. pylori* resistance (< 15%) and in patients with no previous history of macrolide exposure (conditional recommendation). Bismuth quadruple therapy (PPI, bismuth, tetracycline, and a nitroimidazole) for 10 to 14 days is a first-line treatment option, and is particularly appropriate in patients with a penicillin allergy or in those with previous macrolide exposure (strong recommendation). Patients in regions with clarithromycin resistance exceeding 15% should be treated with regimens recommended for those with previous macrolide exposure. Therapy with a PPI, clarithromycin, amoxicillin, and a nitroimidazole for 10 to 14 days (strong recommendation) or sequential therapy with a PPI and amoxicillin for 5 to 7 days followed by a PPI, clarithromycin, and a nitroimidazole for an additional 5 to 7 days (conditional recommendation) are also recommended as first-line treatment options. A similar hybrid therapy of a PPI and amoxicillin for 7 days followed by a PPI, amoxicillin, clarithromycin, and a nitroimidazole for an additional 7 days is also a first-line recommendation (conditional recommendation). Finally, use of a fluoroquinolone as a component of the treatment regimen is also recommended as a first-line treatment option using 1 of the following 2 regimens (conditional recommendations): (1) levofloxacin, PPI, and amoxicillin for 10 to 14 days; or (2) PPI and amoxicillin for 5 to 7 days followed by a PPI, fluoroquinolone, and a nitroimidazole for 5 to 7 days. Notably, not all recommended regimens have FDA approval. Previous antibiotic exposure should also be taken into consideration. Testing to confirm eradication should be performed (strong recommendation). The guidelines also detail a variety of salvage therapy options should primary therapy fail, and effort should be made to avoid use of antibiotics previously used by the patient.

The 3 packaged combination products available will be included in this review. PPIs are addressed in a separate review, although dosing for those with approval for *H. pylori* eradication (in combination with other agents) is included within this review.

PHARMACOLOGY^{18,19,20}

PPIs suppress acid and induce rapid ulcer healing. Increased gastric pH accompanying their use can enhance tissue concentration and efficacy of antimicrobials, creating a hostile environment for *H. pylori*.

Bismuth subsalicylate, metronidazole, clarithromycin, and tetracycline individually have demonstrated in vitro activity against most susceptible strains of *H. pylori*. Metronidazole resistance occurs most often in patients previously treated with metronidazole, primarily younger women who are more likely to have had prior exposure to the antibiotic.^{21,22} Studies have reported *H. pylori* resistance rates to metronidazole of 29.1% to 41%.²³ Clarithromycin resistance is not as common (occurrence of 4.1% to 15%) and occurs most often in older, female, and inactive ulcer patients.^{24,25} Primary amoxicillin resistance is very rare (1.4%).²⁶ Successful eradication of *H. pylori* is affected more by the presence of resistance to clarithromycin than to metronidazole.^{27,28,29} It would appear that short regimens that include metronidazole may be subject to a reasonably high failure rate, particularly in young women.

In a study of the effect of differing therapies on the development of resistance, dual therapy with the combination of a PPI and clarithromycin resulted in 88.9% of the patients acquiring clarithromycin resistance. With triple therapy, percentages of patients acquiring clarithromycin-resistant strains after using PPI plus clarithromycin plus amoxicillin or PPI plus clarithromycin plus metronidazole were 38.7% and 90%, respectively ($p < 0.01$).³⁰ These data suggest that regimens containing amoxicillin may prevent the selection of secondary clarithromycin resistance.

PHARMACOKINETICS^{31,32,33}

Pharmacokinetics for Omeclamox-Pak and Prevpac, when all of their components are co-administered, have not been studied. Please consult the individual package inserts for full details.

A comparative pharmacokinetic bioavailability study of Pylera found similar pharmacokinetic parameters for the individual drugs when administered as separate capsule forms or as Pylera. A second pharmacokinetic evaluation showed that food reduces the systemic absorption of all 3 Pylera components: metronidazole by 6%, tetracycline by 34%, and bismuth by 60%. This reduction in absorption is not considered to be clinically significant.

CONTRAINDICATIONS/WARNINGS^{34,35,36}

All products in this category carry a warning and contraindication for any patients with known hypersensitivity to any of the components of the differing formulations. These hypersensitivity reactions may be expressed as anaphylaxis, anaphylactic shock, angioedema, bronchospasm, acute interstitial nephritis, or urticaria.

Omeclamox-Pak is contraindicated when a hypersensitivity to omeprazole, any macrolide antibiotic, any penicillin, or any component of the formulations exists. Additionally, Omeclamox-Pak should not be co-administered with pimozide, ergotamine, or dihydroergotamine.

Concomitant administration of Prevpac with any of the following drugs is contraindicated: cisapride, pimozide, ergotamine, or dihydroergotamine. There have been post-marketing reports of cardiac arrhythmias and even fatalities as a result of some of the aforementioned drug interactions. Prevpac is also contraindicated with concurrent use of rilpivirine-containing products which may lead to decreased exposure of rilpivirine.

H. pylori treatments may contain a penicillin-type antibiotic. Serious and occasionally fatal anaphylactic reactions have occurred when patients are hypersensitive to penicillins, including amoxicillin and even some cephalosporins. Although anaphylaxis is more frequent following parenteral therapy, it has occurred in patients on oral penicillin therapy. This type of reaction is more likely to occur in individuals with a history of penicillin hypersensitivity and/or a history of sensitivity to multiple allergens. Serious reactions require immediate emergency treatment with epinephrine, oxygen, intravenous steroids, and airway management, including intubation.

Pylera is contraindicated during pregnancy as the tetracycline component can cause fetal harm. Clarithromycin should not be administered in pregnant women except in clinical circumstances where no alternative treatment option is appropriate. Additionally, *H. pylori* products containing clarithromycin (Omeclamox-Pak, Prevpac) should not be given concomitantly with HMG-CoA reductase inhibitors (statins) which are extensively metabolized by CYP3A4 pathways (e.g., lovastatin or simvastatin), as this may result in an increased risk of myopathy including rhabdomyolysis.

The concurrent use of Pylera in patients receiving methoxyflurane therapy is contraindicated as this may result in fatal renal toxicity due to the tetracycline component. Pylera is also contraindicated in patients receiving disulfiram therapy within 2 weeks of being administered Pylera. Psychotic reactions have been reported in patients due to a disulfiram-like reaction due to the metronidazole component of Pylera. Similarly, alcoholic beverages or other products containing propylene glycol should be avoided while on therapy with a product containing a metronidazole component as well as at least 3 days following therapy completion as a disulfiram-like reaction may occur.

It should also be noted that the Pylera label carries a boxed warning because of the known ability of metronidazole to be carcinogenic in mice and rats. Metronidazole use should be reserved for approved conditions (*H. pylori* being one of them). There is also the added concern of *H. pylori* resistance with metronidazole. It is probably best to reserve combinations containing metronidazole to patients with allergies to clarithromycin or amoxicillin or who have failed therapies with those other antibiotics.

Omeclamox-Pak and Prevpac both carry a warning for the potential development of acute interstitial nephritis (AIN) which has been observed in patients taking proton pump inhibitors (PPIs). AIN may occur at any time during PPI therapy and has been attributed to an idiopathic hypersensitivity reaction. Should AIN develop, the use of PPI therapy should be immediately discontinued. In 2016, both Omeclamox-Pak and Prevpac labeling were required to include warnings for the potential risk of development of cutaneous lupus erythematosus (CLE) and systemic lupus erythematosus (SLE) due to their PPI component. Both new onset and exacerbations of existing autoimmune issues have been reported. The majority of PPI induced lupus cases were CLE, and the most common form was subacute CLE (SCLE). The events occurred from weeks to years following continuous therapy in patients of all age groups. SLE was less common than CLE and, in general, was milder than non-drug induced SLE outbreaks. SLE events due to PPI therapy typically occurred days to years after initiation of therapy and were most frequently seen in all ages; from young adults to the elderly. In all cases where CLE or SLE was noted, therapy should be immediately discontinued, and patients referred to an appropriate specialist. PPIs should be administered no longer than medically indicated to minimize potential lupus events.

Cases of severe hepatotoxicity/acute hepatic failure have been reported with metronidazole-containing products (Pylera) in patients with Cockayne syndrome, including fatal cases with very rapid onset after starting metronidazole. Pylera should only be used after careful benefit-risk assessment, including liver function tests, and if no alternative treatment is available. Liver function test should be repeated during therapy and after end of Pylera treatment.

In adult patients using Prevpac, a symptomatic response to therapy does not eliminate the possibility of gastric malignancy. Additional follow-up and diagnostic testing for patients exhibiting a suboptimal response or an early symptomatic relapse after therapy completion should be strongly considered. For older patients, an endoscopy is also recommended.

Prevacid treatment should be temporarily stopped at least 14 days before assessing serum chromogranin A (CgA) levels, which may increase secondary to drug-induced decreases in gastric acidity. The increased CgA level may result in false positive diagnostic results for neuroendocrine tumors. Consider repeated CgA testing if initial levels are high.

Pylera carries 2 warnings regarding the possibility of developing superinfections. If patients have known or previously undiagnosed candidiasis infections, the symptoms may become more prominent as a result of the metronidazole component and require the initiation of antifungal therapy.

Additionally, similar to extended therapy with other antibiotics, prolonged use of tetracycline may result in the overgrowth of nonsusceptible organisms and fungi. Should evidence of a superinfection occur, therapy should be discontinued immediately and appropriate therapy started. Tetracycline may also cause fetal harm when administered to a pregnant women; for this reason and the potential effects of metronidazole on the fetus, Pylera is contraindicated in pregnant women.

Prescribing any antibiotic-containing *H. pylori* treatment in the absence of a proven or strongly suspected bacterial infection, or for a prophylactic indication, is unlikely to provide benefit to the patient and increases the risk of the development of drug-resistant bacteria.

DRUG INTERACTIONS^{37,38,39}

All drug interactions are the same as for the individual agents. Consult prescribing information for full details.

ADVERSE EFFECTS^{40,41,42}

Drug	Abdominal pain	Diarrhea	Headache	Nausea	Melena	Altered taste
omeprazole, amoxicillin, clarithromycin (Omeclamox-Pak)	2 – 5.2	14	7	4	nr	10
lansoprazole, amoxicillin, clarithromycin (Prevpac)	< 3	7	6	< 3	nr	5
bismuth subcitrate potassium, metronidazole, tetracycline (Pylera) + omeprazole	8.8	8.8	8.2	8.2	nr	4.8

Adverse effects are reported as a percentage. Adverse effects data are obtained from prescribing information and should not be considered comparative or all inclusive. nr= not reported.

SPECIAL POPULATIONS^{43,44,45}

Pediatrics

The safety and efficacy of Omeclamox-Pak, Prevpac, and Pylera have not been established in pediatric patients.

Pregnancy

Omeclamox-Pak and Prevpac are both Pregnancy Category C. Previously, Pylera was assigned Pregnancy Category D, but its labeling has been updated to comply with the Pregnancy and Lactation Labeling Rule (PLLR) and now contains descriptive text. Use of Pylera is contraindicated in pregnancy. Use of tetracycline, a component of Pylera, during the second and third trimester pregnancy can cause permanent discoloration of the teeth and may inhibit bone development. Likewise, metronidazole, also a component of Pylera, has been associated with certain congenital anomalies.

Other Considerations

Pylera is contraindicated in patients with severe hepatic and renal insufficiency. Omeclamox-Pak is not recommended in hepatic impairment. With severe hepatic insufficiency, a dose reduction of Prevpac is recommended, and its use is not recommended with a creatinine clearance (CrCl) < 30 mL/min.

Prolonged clarithromycin dosing intervals may be appropriate for Omeclamox-Pak in the presence of severe renal impairment with or without coexisting hepatic impairment. Omeclamox-Pak should be avoided in Asian patients due to differing pharmacokinetics of the omeprazole component unless the benefits outweigh the risks of therapy.

Patients with hepatic impairment metabolize metronidazole more slowly than non-impaired patients and as a result may experience plasma increases of metronidazole. Patients on a regimen with a metronidazole component (Pylera) who have mild to moderate hepatic impairment should be monitored for metronidazole associated adverse events.

RETIRED

DOSAGES^{46,47,48,49}

Drug	Dosage	Additional Medications Required	Duration (days)	Availability
Omeclamox-Pak	omeprazole 20 mg + amoxicillin 1 gm + clarithromycin 500 mg, each given twice a day	omeprazole 20 mg once daily for 18 days if active ulcer is present	10	Individual daily administration pack containing: <ul style="list-style-type: none"> 2 omeprazole 20 mg capsules 4 amoxicillin 500 mg capsules 2 clarithromycin 500 mg tablets
Prevpac	lansoprazole 30 mg + amoxicillin 1 gm + clarithromycin 500 mg, each given twice a day	--	10 or 14	Individual daily administration pack containing: <ul style="list-style-type: none"> 2 lansoprazole 30 mg capsules 4 amoxicillin 500 mg capsules 2 clarithromycin 500 mg tablets
Pylera	Each capsule contains: bismuth subcitrate potassium 140 mg + metronidazole 125 mg + tetracycline HCl 125 mg; 3 capsules given 4 times a day	omeprazole 20 mg twice a day	10	The daily dosing pack (10-day therapy pack) is designed to hold: <ul style="list-style-type: none"> Twelve 3-in-1 capsules of Pylera each containing: 140 mg bismuth subcitrate potassium, 125 mg metronidazole in outer capsule, and 125 mg tetracycline HCl in inner capsule 2 omeprazole 20 mg capsules
esomeprazole (Nexium®)	esomeprazole magnesium 40 mg daily	clarithromycin 500 mg + amoxicillin 1,000 mg, each given twice a day	10	esomeprazole magnesium: 20 mg, 40 mg delayed-release capsules 2.5 mg, 5 mg, 10 mg, 20 mg, 40 mg delayed-release powder for oral suspension esomeprazole strontium: 24.65 mg and 49.3 mg delayed-release capsules of esomeprazole strontium (equivalent to 20 mg and 40 mg of esomeprazole, respectively)

Dosages (continued)

Drug	Dosage	Additional Medications Required	Duration (days)	Availability
lansoprazole (Prevacid®)	lansoprazole 30 mg twice a day	clarithromycin 500 mg + amoxicillin 1,000 mg, each given twice a day	10 to 14	15 mg, 30 mg delayed-release capsules 15 mg, 30 mg delayed-release orally disintegrating tablets
	lansoprazole 30 mg 3 times a day	amoxicillin 1,000 mg 3 times a day	14	
omeprazole (Prilosec®)	omeprazole 20 mg twice a day	clarithromycin 500 mg + amoxicillin 1,000 mg, each given twice a day	10 (14 days recommended by ACG)	10 mg, 20 mg, 40 mg delayed-release capsules 2.5 mg, 10 mg packets for oral suspension Continue with omeprazole 20 mg daily for 14 days in patients with active ulcer
	omeprazole 40 mg daily	clarithromycin 500 mg 3 times a day	14	
rabeprazole (Aciphex®)	rabeprazole 20 mg twice a day	clarithromycin 500 mg + amoxicillin 1,000 mg, each given twice a day	7	20 mg delayed-release tablets

CLINICAL TRIALS

Search Strategy

Articles were identified through searches performed on PubMed and review of information sent by manufacturers. Search strategy included the FDA-approved use of all drugs in this class. Randomized, controlled, comparative trials are considered the most relevant in this category. Studies included for analysis in the review were published in English, performed with human participants, and randomly allocated participants to comparison groups. In addition, studies must contain clearly stated, predetermined outcome measure(s) of known or probable clinical importance, use data analysis techniques consistent with the study question, and include follow-up (endpoint assessment) of at least 80% of participants entering the investigation. Despite some inherent bias found in all studies, including those sponsored and/or funded by pharmaceutical manufacturers, the studies in this therapeutic class review were determined to have results or conclusions that do not suggest systematic error in their experimental study design. While the potential influence of manufacturer sponsorship and/or funding must be considered, the studies in this review have also been evaluated for validity and importance.

Many of the trials with agents in this class were performed over a very short duration of treatment and in an open-label manner; introduction of bias must be considered when evaluating study findings. Likewise, there are limited current studies assessing the efficacy of these agents in the U.S. population.

lansoprazole, amoxicillin, and clarithromycin (Prevpac) for 10 days versus 14 days

A multicenter, randomized, controlled, double-blind U.S. trial with 236 patients evaluated the efficacy of triple therapy (lansoprazole 30 mg, amoxicillin 1,000 mg, and clarithromycin 500 mg) given twice daily for 10 days versus 14 days in the eradication of *H. pylori*.⁵⁰ There was no statistical difference in efficacy between the 10-day group (84% eradication) and the 14-day group (85% eradication). Adverse effects between the groups were similar.

bismuth, metronidazole, tetracycline (Pylera) with omeprazole versus triple therapy

In an open-label, multicenter, parallel group, active-controlled trial, the quadruple therapy of bismuth subcitrate potassium 1,680 mg daily, metronidazole 1,500 mg daily, and tetracycline 1,500 mg daily (Pylera) with omeprazole 20 mg twice daily had similar efficacy as the active control triple therapy of clarithromycin 500 mg daily, amoxicillin 1,000 mg daily, and omeprazole 20 mg twice daily in the treatment of *H. pylori*-positive adults with current duodenal ulcer or a history of duodenal ulcer disease.⁵¹ Eradication rates were 87.7% for quadruple therapy and 83.2% for the active control triple therapy. Gastrointestinal adverse events were similar for both arms.

COMPARATIVE EFFICACY (FOR FDA-APPROVED REGIMENS)

Drug	Duration (days)	Eradication Rates (%)
Omeclamox-Pak ⁵²	10	90*
Prevpac ^{53,54,55}	10 or 14	80 – 95.2
Pylera ⁵⁶	10	87.7
esomeprazole (Nexium) ⁵⁷	10	84 – 85
lansoprazole (Prevacid) ^{58,59,60}	10 – 14	80 – 95.2
	14	77
omeprazole (Prilosec) ^{61,62,63,64}	10 (14 days recommended by ACG)	69 – 90
	14	77 – 95
rabeprazole (Aciphex) ⁶⁵	7	77.3 – 84.3

* Patients with an active duodenal ulcer who received the 10-day regimen plus 18 additional days of omeprazole 20 mg therapy daily had an eradication rate of 77% to 78%.⁶⁶

META-ANALYSES

A meta-analysis evaluated randomized clinical trials comparing PPIs to H2 antagonists with the same antibiotics.⁶⁷ Twenty studies fulfilled the inclusion criteria. In the intention-to-treat analysis, the mean eradication rates with PPIs and H2 antagonists plus antibiotics were 74% and 69%, respectively. The analysis concluded that, overall, PPIs were more effective than H2 antagonists when prescribed at usual doses with antibiotics to eradicate *H. pylori* infection.

Triple therapy (PPI, clarithromycin, and amoxicillin or an imidazole) is the first-line treatment for *H. pylori* infection.^{68,69} Quadruple therapy (PPI, tetracycline, metronidazole, and a bismuth salt) is a very effective regimen even in areas of high prevalence of antibiotic resistance.⁷⁰ To compare triple versus quadruple therapy for the first-line treatment of *H. pylori* infection, an extensive literature search identified randomized trials comparing triple versus quadruple therapy. Four studies met the inclusion criteria. Eradication rates with quadruple therapy were slightly higher for both the intention-to-treat (81% versus 78%) and the per protocol analyses (88% versus 85%). The differences were not statistically significant.

SUMMARY

Triple and quadruple drug regimens are more effective at eradicating *H. pylori* than dual drug regimens. The most effective FDA-approved regimens are those that combine a proton pump inhibitor (PPI) with amoxicillin and clarithromycin. This is likely due to the highly effective acid suppression provided by the PPI (in comparison to an histamine H2-receptor antagonist) and the low rate of resistance to the 2 antibiotics (in comparison to metronidazole).

The 2017 American College of Gastroenterology (ACG) guidelines on the treatment of *H. pylori* in North America state all patients with a positive test of active infection with *H. pylori* should be offered treatment (strong recommendations). Triple therapy or quadruple therapy for 10 to 14 days is recommended; however, prior antibiotic, local resistance patterns, and patient factors play a role in treatment choice.

The other triple combination products, Omeclamox-Pak and Prevpac, combine the most effective components of triple therapy including a PPI. Omeclamox-Pak is intended as a 10-day course of therapy while Prevpac is a 14-day regimen. The combination therapy, Pylera along with omeprazole, offers quadruple drug therapy with competitive eradication rates compared to other triple drug regimens. Given the recent warning addition regarding cutaneous lupus erythematosus and systemic lupus erythematosus coupled with overall PPI use advisories, therapy with the triple drug regimens should be closely monitored and kept to the shortest duration required. Pylera may have a place in therapy for those patients who are allergic to amoxicillin or clarithromycin or in whom bacterial resistance is known or suspected. Omeclamox-Pak or Prevpac may be better suited for special populations such as pediatrics, pregnancy, and renal insufficiency. Finally, Prevpac may be suitable for use in patients with hepatic impairment.

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