

# Treatment of Tuberculosis Disease

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# Introduction

## Purpose

The overall goals for treatment of tuberculosis (TB) are to cure the patient and to minimize the transmission of *Mycobacterium tuberculosis* to others. Successful treatment of TB has benefits both for the individual patient and the community in which the patient resides.

Use this section to understand and follow national and Nevada guidelines to:

- follow basic treatment principles for TB disease;
- select appropriate treatment regimens, dosages, and duration;
- monitor patients for side effects and adverse reactions;
- assess patients' response to treatment;
- determine completion of therapy;
- determine the need for post-treatment evaluation;
- provide treatment in special situations, such as when a patient has drug-resistant TB or TB and human immunodeficiency virus (HIV) coinfection; and,
- hospitalize and coordinate hospital discharges of patients with infectious TB.

In the 2005, "Controlling Tuberculosis in the United States: Recommendations from the American Thoracic Society, Centers for Disease Control and Prevention, and the Infectious Diseases Society of America," one of the recommended strategies to achieve the goal of reduction of TB morbidity and mortality is the early and accurate detection, diagnosis, and reporting of TB cases, leading to initiation and completion of treatment.<sup>1</sup>

## Policy

Patients with TB disease in Nevada or who move to Nevada with reported TB disease must receive and complete treatment in accordance with the national guidelines set forth in this manual and in accordance with Nevada laws and regulations (see Nevada Laws and Regulations for Tuberculosis Control section of this manual at:

[http://www.health.nv.gov/PDFs/HIV\\_STD\\_TB/Educational/TB\\_Protocol\\_Introduction.pdf](http://www.health.nv.gov/PDFs/HIV_STD_TB/Educational/TB_Protocol_Introduction.pdf)).

## Program Standards

The standard of care for treating TB disease in Nevada is to utilize directly observed therapy (DOT) throughout the prescribed treatment regimen.

## Forms



Required and recommended forms are available on the Nevada State Health Division's Tuberculosis Web page at:

[http://www.health.nv.gov/CD\\_HIV\\_TBManualForms.htm](http://www.health.nv.gov/CD_HIV_TBManualForms.htm)

The Nevada State Health Division's reportable disease form can be found at: <http://www.health.nv.gov/Epidemiology/MorbidityForm-interactive.pdf>

### Tuberculosis reporting requirements:

NAC 441A.350 mandates a health care provider to report certain cases and suspected cases within 24 hours of discovery ([NRS 441A.120](#)). "A health care provider shall notify the health authority within 24 hours of discovery of any case having active tuberculosis or any suspected case considered to have active tuberculosis who fails to submit to medical treatment or who discontinues or fails to complete an effective course of medical treatment."

### Communicable disease reporting requirements:

"It is the duty of; a health care provider, the director or other person in charge of a medical facility, the principal, director or other person in charge of a school, child care facility or correctional facility, the director or other person in charge of a medical laboratory to report a case or suspected case of persons of having a communicable disease to the health authority having jurisdiction for that location."

For complete reporting requirements go to: <http://www.leg.state.nv.us/Nac/NAC-441A.html#NAC441ASec225>



For roles and responsibilities, refer to the chapter on "Roles, Responsibilities, and Contact Information,"

[http://www.health.nv.gov/PDFs/HIV\\_STD\\_TB/Educational/TB\\_Protocol\\_Introduction.pdf](http://www.health.nv.gov/PDFs/HIV_STD_TB/Educational/TB_Protocol_Introduction.pdf)

# Basic Treatment Principles

Follow the basic treatment principles for tuberculosis (TB) disease, as outlined below in Table 1.

Table 1: BASIC TREATMENT PRINCIPLES FOR TUBERCULOSIS DISEASE

Phase	Principles
At Start of Treatment	<b>Patient-centered care and directly observed therapy (DOT).</b> An adherence plan should tailor treatment and supervision to each patient by considering his or her clinical and social circumstances (patient-centered care), as well as emphasizing DOT.
	<b>Cultural competence.</b> It is imperative to become culturally competent and guide other healthcare providers toward culturally competent healthcare. A culturally competent system acknowledges cultural differences regarding healthcare and incorporates them into all levels of the healthcare delivery system, from policy to provider to patient.
	<b>Human immunodeficiency virus (HIV) testing.</b> HIV testing should be offered to all patients with TB disease.
	<b>Medical supervision.</b> Patients with confirmed or suspected tuberculosis (TB) disease must be under the supervision of a medical provider who is licensed in the State of Nevada as a medical physician.
	<b>Prompt start.</b> Start patients with confirmed or suspected TB disease promptly on appropriate treatment. It is not necessary to wait for laboratory confirmation.
Regimen During Treatment	<b>Multiple drugs.</b> Treatment regimens must contain multiple drugs to which the organism is susceptible. The administration of a single drug or the addition of a single drug to a failing regimen can lead to the development of resistance.
	<b>Single doses.</b> TB medications should be administered together as a single dose rather than in divided doses. A single dose leads to higher, and potentially more effective, peak serum concentrations, and facilitates DOT. Although ingesting the medications with food will delay or moderately decrease the absorption of the medications, the effects are of little clinical significance.
	<b>Pyridoxine to prevent neuropathy.</b> Pyridoxine (Vitamin B-6, 25 mg) is recommended for some individuals receiving isoniazid (INH) as part of their treatment regimen to prevent peripheral neuropathy. It should be used in persons at risk for neuropathy (women who are pregnant or breastfeeding or persons with nutritional deficiency, diabetes, HIV infection, renal failure, or alcoholism).
Persistent Positive Cultures	<b>Evaluation when positive cultures persist.</b> Monitor for culture conversion and promptly evaluate patients with persistently positive cultures after 3 months of therapy to identify the cause. Treatment failure is defined as continued or recurrent positive cultures after 4 months of treatment.
At Completion of Treatment	<b>Completion in terms of the number of doses.</b> The criteria for treatment completion are based upon the total number of doses taken and not solely on the duration of therapy.

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# Treatment Regimens and Dosages

Use this information to:

- Identify the appropriate regimen;
- Determine the appropriate dosage for each drug; and
- Determine the duration of treatment.

The information in this topic was provided using guidelines for treating tuberculosis (TB) that have been developed by the American Thoracic Society (ATS), Centers for Disease Control and Prevention (CDC), and Infectious Diseases Society of America (IDSA).



See the “Treatment in Special Situations” topic in this section for information on treatment when there is drug-resistant TB, human immunodeficiency virus (HIV) infection, liver disease, or renal disease; when the patient is taking tumor necrosis factor-alpha (TNF- $\alpha$ ) antagonists; where there is culture-negative TB or extrapulmonary TB; when the patient is pregnant or breastfeeding; or when the patient is considered to be of pediatric age.

As you use this section, remember the abbreviations for first-line drugs, which are listed below.

Table 2: ABBREVIATIONS FOR FIRST-LINE DRUGS

<ul style="list-style-type: none"><li>▪ Ethambutol: EMB</li><li>▪ Isoniazid: INH</li><li>▪ Pyrazinamide: PZA</li></ul>	<ul style="list-style-type: none"><li>▪ Rifabutin: RFB</li><li>▪ Rifampin: RIF</li><li>▪ Rifapentine: RPT</li></ul>
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## Regimens

Identify the appropriate regimen for the patient. There are four basic regimens recommended for treating adults with TB caused by organisms that are known or presumed to be susceptible to isoniazid (INH), rifampin (RIF), pyrazinamide (PZA), and ethambutol (EMB). Children, depending on the circumstances, may not receive EMB in the initial phase of a six-month regimen, but the regimens are otherwise identical.

The preferred regimen for treating TB disease consists of an initial two-month phase of four drugs: INH, RIF, PZA, and EMB followed by a four-month continuation phase of INH and RIF.<sup>2</sup>

Each regimen has an initial phase of two months, followed by a choice of several options for a continuation phase of either four or seven months. In Table 3: **Drug Regimens for Culture-Positive Pulmonary Tuberculosis Caused by Drug-Susceptible Organisms**, the initial phase is denoted by a number (1, 2, 3, or 4), and the options for the continuation phase are denoted by the respective number and a letter designation (a, b, or c).

Directly observed therapy (DOT) is the preferred management strategy and the standard of care for treating TB disease in Nevada for all regimens and should be used whenever feasible. All patients being given drugs less than seven days per week (five, three, or two days per week) must receive DOT without exception.

The recommended regimens, and the number of doses specified by each regimen, are described on the next page in Table 3.



For consultation regarding the treatment of TB, consult with the medical provider, local health officer, or your regional TB Program. (contact information available at:

[http://www.health.nv.gov/PDFs/HIV\\_STD\\_TB/Educational/TB\\_Protocol\\_Introduction.pdf](http://www.health.nv.gov/PDFs/HIV_STD_TB/Educational/TB_Protocol_Introduction.pdf))

Additional information can be obtained by contacting the Francis J. Curry National TB Center's Warm-line at 415-502-4700.

Table 3: DRUG REGIMENS FOR CULTURE-POSITIVE PULMONARY TUBERCULOSIS CAUSED BY DRUG-SUSCEPTIBLE ORGANISMS<sup>3</sup>

Initial Phase			Continuation Phase			Range of total doses (minimal duration)	Rating* (evidence) <sup>†</sup>	
Regimen	Drugs	Interval and doses <sup>‡</sup> (minimal duration)	Regimen	Drugs	Interval and doses <sup>‡ §</sup> (minimal duration)		HIV–	HIV+
1	INH RIF PZA EMB	Seven days/week for 56 doses (8 wk) or 5 d/wk for 40 doses (8 wk) <sup>¶</sup>	1a	INH RIF	Seven days/week for 126 doses (18 wk) or 5 d/wk for 90 doses (18 wk) <sup>¶</sup>	182–130 (26 wk)	A (I)	A (II)
			1b	INH RIF	Twice weekly for 36 doses (18 wk)	92–76 (26 wk)	A (I)	A (II) <sup>#</sup>
			1c**	INH RPT	Once weekly for 18 doses (18 wk)	74–58 (26 wk)	B (I)	E (I)
2	INH RIF PZA EMB	Seven days/week for 14 doses (2 wk), then twice weekly for 12 doses (6 wk) or 5 d/wk for 10 doses (2 wk), <sup>¶</sup> then twice weekly for 12 doses (6 wk)	2a	INH RIF	Twice weekly for 36 doses (18 wk)	62–58 (26 wk)	A (II)	B (II) <sup>#</sup>
			2b**	INH RPT	Once weekly for 18 doses (18 wk)	44–40 (26 wk)	B (I)	E (I)
3	INH RIF PZA EMB	Three times weekly for 24 doses (8 wk)	3a	INH RIF	Three times weekly for 54 doses (18 wk)	78 (26 wk)	B (I)	B (II)
4	INH RIF EMB	Seven days/week for 56 doses (8 wk) or 5 d/wk for 40 doses (8 wk) <sup>¶</sup>	4a	INH RIF	Seven days/week for 217 doses (31 wk) or 5 d/wk for 155 doses (31 wk) <sup>¶</sup>	273–195 (39 wk)	C (I)	C (II)
			4b	INH RIF	Twice weekly for 62 doses (31 wk)	118–102 (39 wk)	C (I)	C (II)

Definitions of abbreviations: DOT = directly observed therapy; EMB = ethambutol; INH = isoniazid; HIV = human immunodeficiency virus; PZA = pyrazinamide; RIF = rifampin; RPT = rifapentine.

\* Definitions of evidence ratings: A = preferred; B = acceptable alternative; C = offer when A and B cannot be given; D = should generally not be offered; E = should never be given.

† Definition of evidence ratings: I = randomized clinical trial; II = data from clinical trials that were not randomized or were conducted in other populations; III = expert opinion.

‡ When DOT is used, drugs may be given 5 days/week and the necessary number of doses adjusted accordingly. Although there are no studies that compare 5 with 7 daily doses, extensive experience indicates this would be an effective practice.

§ Patients with cavitation on initial chest radiograph and positive cultures at completion of 2 months of therapy should receive a 7-month (31 week; either 217 doses [daily] or 62 doses [twice weekly]) continuation phase.

¶ Five-day-a-week administration is always given by DOT. Rating for 5 day/week regimens is rated AIII.

# Not recommended for HIV-infected patients with CD4+ cell counts <100 cells/microliter.

\*\* Options 1c and 2b should be used only in HIV-negative patients who have negative sputum smears at the time of completion of 2 months of therapy and who do not have cavitation on initial chest radiograph. For patients started on this regimen and found to have a positive culture from the 2-month specimen, treatment should be extended an extra 3 months.

Source: ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):3.



## Dosages



For consultation regarding the treatment of TB, consult with the medical provider, local health officer, or your regional TB Program. (contact information available at: [http://www.health.nv.gov/PDFs/HIV\\_STD\\_TB/Educational/TB\\_Protocol\\_Introduction.pdf](http://www.health.nv.gov/PDFs/HIV_STD_TB/Educational/TB_Protocol_Introduction.pdf))

Additional information can be obtained by contacting the Francis J. Curry National TB Center's Warm-line at 415-502-4700.

Once the appropriate regimen has been identified, refer to the following tables for instructions on dosages for each drug. First-line antituberculosis medications should be administered together; split dosing should be avoided.

The following first-line drugs are available in Nevada for treating TB disease.

- Isoniazid (INH)
- Rifampin (RIF)
- Rifabutin (RFB)
- Rifapentine (RPT)
- Ethambutol (EMB)
- Pyrazinamide (PZA)



For information regarding second-line drugs, consult with the medical provider, local health officer, or your regional TB Program. (contact information available at:

[http://www.health.nv.gov/PDFs/HIV\\_STD\\_TB/Educational/TB\\_Protocol\\_Introduction.pdf](http://www.health.nv.gov/PDFs/HIV_STD_TB/Educational/TB_Protocol_Introduction.pdf))

Additional information can be obtained by contacting the Francis J. Curry National TB Center's Warm-line at 415-502-4700.

Table 4: DOSES\*OF FIRST-LINE ANTITUBERCULOSIS DRUGS FOR ADULTS AND CHILDREN†4

Drug	Preparation	Adults/children	Doses			
			Daily	1x/wk	2x/wk	3x/wk
INH	Tablets (50 mg, 100 mg, 300 mg); elixir (50 mg/5 ml); aqueous solution (100 mg/ml) for intramuscular injection¶	Adults (max.)	5 mg/kg (300 mg)	15 mg/kg (900 mg)	15 mg/kg (900 mg)	15 mg/kg (900 mg)
		Children (max.)	10–15 mg/kg (300 mg)	—	20–30 mg/kg (900 mg)	—
RIF	Capsule (150 mg, 300 mg); powder may be suspended for oral administration; aqueous solution for intravenous injection	Adults† (max.)	10 mg/kg (600 mg)	—	10 mg/kg (600 mg)	10 mg/kg (600 mg)
		Children (max.)	10–20 mg/kg (600 mg)	—	10–20 mg/kg (600 mg)	—
EMB	Tablet (100 mg, 400 mg)	Adults	See Table 6	—	See Table 6	See Table 6
		Children§ (max.)	15–20 mg/kg daily (1.0 g)	—	50 mg/kg (2.5 g)	—
PZA	Tablet (500 mg, scored)	Adults	See Table 5	—	See Table 5	See Table 5
		Children (max.)	15–30 mg/kg (2.0 g)	—	50 mg/kg (2.0 g)	—
RPT	Tablet (150 mg, film coated)	Adults	—	10 mg/kg (continuation phase) (600 mg)	—	—
		Children	This drug is not approved for use in children	This drug is not approved for use in children	This drug is not approved for use in children	This drug is not approved for use in children
RFB	Capsule (150 mg)	Adults‡ (max.)	5 mg/kg (300 mg)	—	5 mg/kg (300 mg)	5 mg/kg (300 mg)
		Children	Appropriate dosing for children is unknown	Appropriate dosing for children is unknown	Appropriate dosing for children is unknown	Appropriate dosing for children is unknown

Definitions of abbreviations: EMB = ethambutol; FDA = Food and Drug Administration; INH = isoniazid; PZA = pyrazinamide; RFB = rifabutin; RIF = rifampin; RPT = rifapentine.

\* Dose per weight is based on ideal body weight. Children weighing more than 40 kg should be dosed as adults.

† For the purposes of this document, adult dosing begins at the age of 15 years.

¶ INH is used, but not FDA-approved, for intravenous administration. For intravenous use of INH, please consult with the Nevada Department of Health Services, TB Control Section at 602-364-4750.

‡ Dose may need to be adjusted when there is concomitant use of protease inhibitors or nonnucleoside reverse transcriptase inhibitors.

§ The drug can likely be used safely in older children but should be used with caution in children less than 5 years of age, in whom visual acuity cannot be monitored. In younger children, EMB at the dose of 15 mg/kg per day can be used if there is suspected or proven resistance to INH or RIF.

Source: ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):4.

Table 5: SUGGESTED PYRAZINAMIDE DOSES, USING WHOLE TABLETS, FOR ADULTS WEIGHING 40 TO 90 KILOGRAMS (88 – 198 LBS)<sup>5</sup>

Interval	Weight (kg)*		
	40–55 kg or 88-121 lbs	56–75 kg or 123 – 165 lbs	76–90 kg or 167 – 198 lbs
Daily, mg (mg/kg)	1,000 (18.2–25.0)	1,500 (20.0–26.8)	2,000 † (22.2–26.3)
Thrice weekly, mg (mg/kg)	1,500 (27.3–37.5)	2,500 (33.3–44.6)	3,000 † (33.3–39.5)
Twice weekly, mg (mg/kg)	2,000 (36.4–50.0)	3,000 (40.0–53.6)	4,000 † (44.4–52.6)
* Based on estimated lean body weight. † Maximum dose regardless of weight.			

Source: ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):5.

Table 6: SUGGESTED ETHAMBUTOL DOSES, USING WHOLE TABLETS, FOR ADULTS WEIGHING 40 TO 90 KILOGRAMS (88 – 198 LBS)<sup>6</sup>

Interval	Weight (kg)*		
	40–55 kg or 88-121 lbs	56–75 kg or 123 – 165 lbs	76–90 kg or 167 – 198 lbs
Daily, mg (mg/kg)	800 (14.5–20.0)	1,200 (16.0–21.4)	1,600 † (17.8–21.1)
Thrice weekly, mg (mg/kg)	1,200 (21.8–30.0)	2,000 (26.7–35.7)	2,400 † (26.7–31.6)
Twice weekly, mg (mg/kg)	2,000 (36.4–50.0)	2,800 (37.3–50.0)	4,000 † (44.4–52.6)
* Based on estimated lean body weight. † Maximum dose regardless of weight.			

Source: ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):5.

1 kilogram = 2.2 pounds



Conversion formulas are:  
 lbs / 2.2 = kilograms or kg x 2.2 = pounds

A conversion program can be found at: [http://manuelweb.com/kg\\_lbs.htm](http://manuelweb.com/kg_lbs.htm)

## Duration of Treatment

Use the treatment algorithm in Figure 1: **Treatment Algorithm for Tuberculosis** to determine the duration of treatment. The four recommended regimens for treating patients with TB caused by drug-susceptible organisms have a duration of 6 to 9 months. Each regimen has an initial phase of 2 months, followed by a continuation phase of either 4 or 7 months.

Figure 1 gives directions for treating patients with pulmonary and extrapulmonary TB. The standard duration of treatment for pulmonary TB should be 6 months unless **both** cavitation is present **and** the patient is still culture positive after 2 months, in which case 9 months is recommended. Note that there are 3 exceptions to the standard six-month duration of treatment.

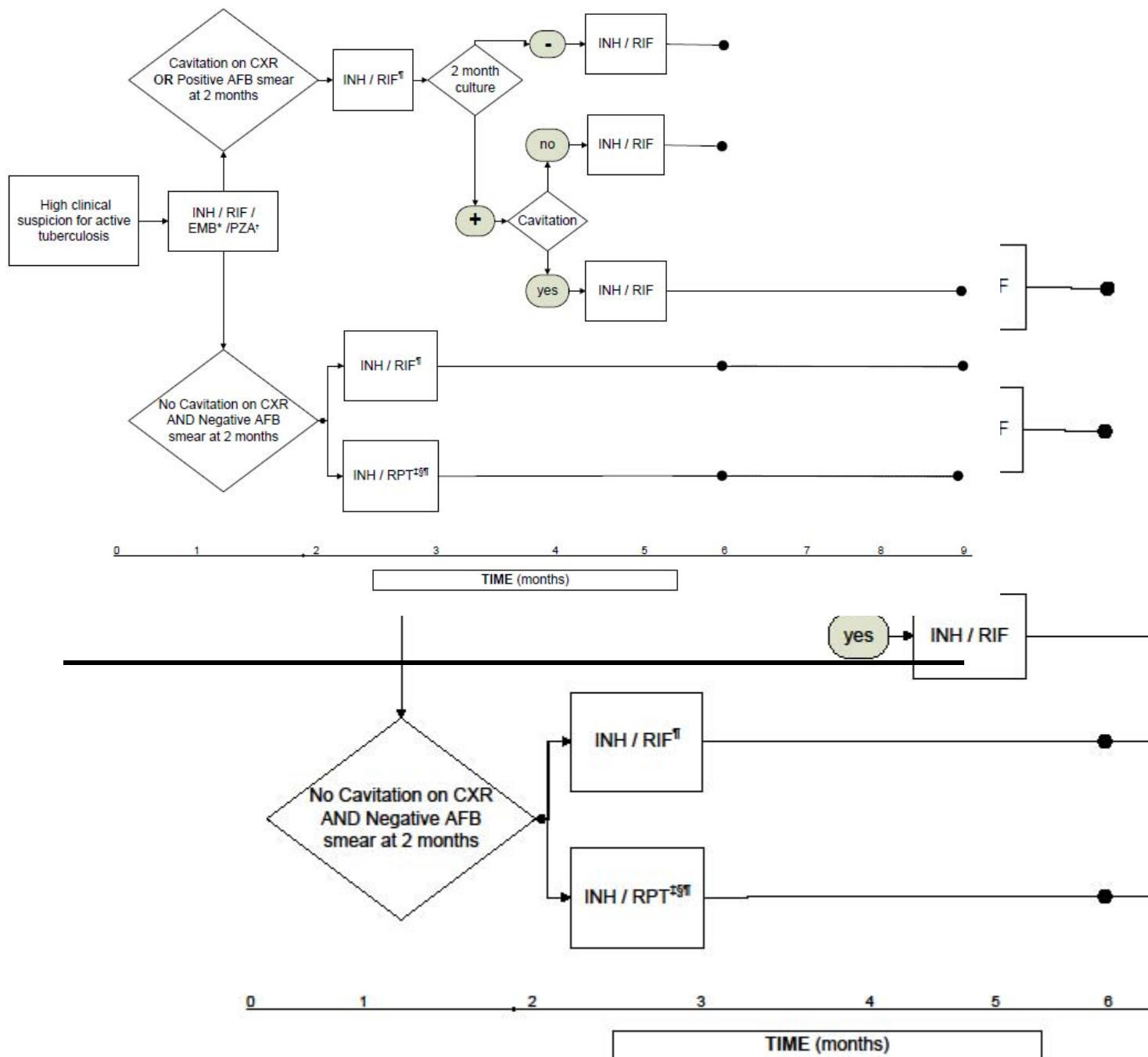
1. For tuberculous meningitis, the optimal length of therapy has not been established, although some experts recommend 9 to 12 months.<sup>7</sup>
2. Treatment for bone or joint TB may need to extend to 9 months.<sup>8</sup>
3. In HIV-negative, culture-negative patients, treatment for 4 months may be adequate if there is clinical or radiographic improvement and no other etiology identified.<sup>9</sup> However, HIV-infected patients with culture-negative pulmonary TB should be treated for a minimum of 6 months.<sup>10</sup>



The most current TB treatment guidelines state that frequent monitoring of a patient's treatment regimen and response to treatment is critical and can be accomplished through use of a drug-o-gram. This electronic resource provides an interface for entering patient's data to create a drug-o-gram specific to your patient. It includes a user's guide with instructions and teachings points. It is available at:

<http://www.umdj.edu/ntbcweb/products/drugogram.htm>

Figure 1. TREATMENT ALGORITHM FOR TUBERCULOSIS<sup>11</sup>



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## Side Effects and Adverse Reactions

The patient should be monitored by a registered nurse and/or clinician or case manager at least monthly for signs and symptoms of adverse reactions until treatment is completed. If a patient is symptomatic, the provider should be consulted and the patient monitored more frequently. Chemistries and complete blood count (CBC), aspartate aminotransferase (AST)/alanine aminotransferase (ALT), or other tests based on specific drugs should be performed at initial diagnosis to establish a baseline and performed periodically based on each individual patients results, medical history, and risk factors. See Table 8: **Monitoring and Interventions for Side Effects and Adverse Reactions** in this section.

As is true with all medications, combination chemotherapy for TB is associated with a predictable incidence of adverse effects, some mild, some serious.<sup>12</sup>

Adverse effects are fairly common and often manageable. Although it is important to be attuned to the potential for adverse effects, it is at least equally important that first-line drugs not be stopped without adequate justification.<sup>13</sup> However, adverse reactions can be severe, and thus, it is important to recognize adverse reactions that indicate when a drug should not be used. Mild adverse effects can generally be managed with symptomatic therapy; whereas with more severe effects, the offending drug or drugs must be discontinued.<sup>14</sup> In addition, proper management of more serious adverse reactions often requires expert consultation.<sup>15</sup> For more information on adverse reactions, see the Official ATS Statement: Hepatotoxicity of Antituberculosis Therapy at: <http://ajrccm.atsjournals.org/cgi/reprint/174/8/935.pdf>

Monitor patients for side effects and adverse reactions following the basic monitoring steps listed below.

### Basic Monitoring Steps

1. All healthcare workers providing treatment for TB disease should be familiar with the American Thoracic Society (ATS)/Centers for Disease Control and Prevention (CDC) guidelines.
  - a. All jurisdictions should follow the national monitoring guidelines identified in the current guidelines for treatment of TB, "Treatment of Tuberculosis" (*MMWR* 2003;52[No. RR-11]) at <http://www.cdc.gov/mmwr/PDF/rr/rr5211.pdf>.
  - b. It is also important to check for guideline updates posted on the CDC's Division of Tuberculosis Elimination home page at <http://www.cdc.gov/tb/> and the list of guidelines by date at [http://www.cdc.gov/tb/pubs/mmwr/Maj\\_guide/List\\_date.htm](http://www.cdc.gov/tb/pubs/mmwr/Maj_guide/List_date.htm).
2. While on treatment, all patients should be evaluated in person, at baseline (before starting treatment) and then at least monthly for side effects and adverse reactions.

3. The common side effects of and adverse reactions to drugs used to treat for TB disease are listed in Table 7: **Reporting Reactions to Antituberculosis Medications**. Educate patients to stop the medicine and promptly report any of the symptoms or signs listed in Table 7 or any unexplained illness to the prescribing clinic immediately.
  - a. If a patient reports a potentially serious adverse reaction, call the patient's provider immediately and alert the local health officer or health authority managing the case.
  - b. If a patient reports a potentially less severe side effect, call the patient's provider immediately, alert the local health authority managing the case and closely monitor the patient.
4. If you suspect that an antituberculosis drug may be causing a particular side effect or adverse reaction:
  - a. Refer to Table 8: **Monitoring and Interventions for Side Effects and Adverse Reactions**.
  - b. Consult with medical provider, local health authority or the NSHD TB program.
5. If you suspect that an antituberculosis drug may be interacting with other medications that the patient is taking, refer to pages 45–47 in the "Treatment of Tuberculosis" (*MMWR* 2003;52[No. RR-11]) at:  
<http://www.cdc.gov/mmwr/PDF/rr/rr5211.pdf>.
6. Document the following patient information:
  - a. Review of symptoms, side effects, and adverse reactions (and any labs that were drawn)
  - b. Education given
  - c. Refill provided
  - d. Description of any problems encountered and action taken for that visit
  - e. Next appointment

## Reporting Reactions

The table below is intended for use by a healthcare worker who performs case management services. The healthcare worker should instruct the patient to report to the provider the side effects and adverse reactions listed in Table 7.

If a patient reports to a healthcare worker a potentially serious adverse reaction, the healthcare worker should call the patient's provider immediately and alert the TB program managing the case.

If a patient reports to a healthcare worker a potentially less severe side effect, the healthcare worker should call the patient's medical provider immediately and monitor the patient.

Table 7: REPORTING REACTIONS TO ANTITUBERCULOSIS MEDICATIONS<sup>16</sup>

Potentially Serious Adverse Reactions*	Less Severe Signs and Symptoms*
<p>Immediately report the following signs and symptoms or other abnormalities or unexpected events to the patient's provider. These signs and symptoms suggest side effects, including hepatotoxicity:</p> <ul style="list-style-type: none"> <li>▪ Jaundice</li> <li>▪ Dark urine</li> <li>▪ Vomiting</li> <li>▪ Abdominal pain</li> <li>▪ Fever</li> <li>▪ Visual changes</li> <li>▪ Marked clinical rash</li> </ul> <p>In consultation with the provider, instruct the patient to stop TB medications until evaluated by the provider.</p>	<p>Report the following signs and symptoms to the patient's provider within 24 hours:</p> <ul style="list-style-type: none"> <li>▪ Anorexia</li> <li>▪ Nausea</li> <li>▪ Malaise</li> <li>▪ Peripheral neuropathy: tingling or burning sensation in hands or feet</li> <li>▪ Rashes</li> </ul> <p>More information is available in the official ATS Statement: Hepatotoxicity of Antituberculosis Therapy at: <a href="http://ajrccm.atsjournals.org/cgi/reprint/174/8/935.pdf">http://ajrccm.atsjournals.org/cgi/reprint/174/8/935.pdf</a></p>
<p>* These lists are not all-inclusive. Second-line drugs are not included. For a complete list, refer to the current guidelines for treatment of TB, "Treatment of Tuberculosis" (<i>MMWR</i> 2003;52[No. RR-11]), at: <a href="http://www.cdc.gov/mmwr/PDF/rr/rr5211.pdf">http://www.cdc.gov/mmwr/PDF/rr/rr5211.pdf</a></p>	

Source: California Department of Health Services (CDHS)/California Tuberculosis Controllers Association (CTCA). TB case management—core components. *CDHS/CTCA Joint Guidelines* [CTCA Web site]. May 11, 1998:9. Available at: <http://www.ctca.org/guidelines/index.html>. Accessed July 11, 2006.



## Monitoring for Side Effects and Adverse Reactions by Antituberculosis Drug

Refer to Table 8: **Monitoring and Interventions for Side Effects and Adverse Reactions** to

- identify the side effects and adverse reactions associated with particular antituberculosis drugs
- determine how to monitor for side effects and adverse reactions

Drug-induced hepatitis, the most serious common adverse effect, is defined as a serum AST level more than three times the upper limit of normal in the presence of symptoms, or more than five times the upper limit of normal in the absence of symptoms. If hepatitis occurs INH, RIF, and PZA, all potential causes of hepatic injury, should be stopped immediately. Serologic testing for hepatitis viruses A, B, and C (if not done at baseline) should be performed and the patient questioned carefully regarding exposure to other possible hepatotoxins, especially alcohol. Two or more antituberculosis medications without hepatotoxicity, such as EMB, SM, amikacin/kanamycin, capreomycin, or a fluoroquinolone (levofloxacin, moxifloxacin, or gatifloxacin), may be used until the cause of the hepatitis is identified. Once the AST level decreases to less than two times the upper limit of normal and symptoms have significantly improved, the first-line medications should be restarted in sequential fashion. Close monitoring, with repeat measurements of serum AST and bilirubin and symptom review, is essential in managing these patients.

Table 8: MONITORING AND INTERVENTIONS FOR SIDE EFFECTS AND ADVERSE REACTIONS<sup>17,18,19</sup>

Anti-tuberculosis Drug	Side Effects/ Adverse Reactions	Monitoring	Comments
Isoniazid (INH)	<ul style="list-style-type: none"> <li>▪ Rash</li> <li>▪ Hepatic enzyme elevation</li> <li>▪ Hepatitis</li> <li>▪ Peripheral neuropathy</li> <li>▪ Mild central nervous system effects</li> </ul>	<p>Clinical monitoring monthly</p> <p>Liver function tests (aspartate aminotransferase [AST], alanine aminotransferase [ALT], and serum bilirubin) at baseline in selected cases (human immunodeficiency virus [HIV] infection, history of liver disease, alcoholism, and pregnancy)</p> <p>Repeat measurements if</p> <ul style="list-style-type: none"> <li>▪ Baseline results are abnormal</li> <li>▪ Patient is pregnant, in the immediate postpartum period, or at high risk for adverse reactions</li> <li>▪ Patient has symptoms of adverse reactions</li> </ul>	<p>Hepatitis risk increases with age and alcohol consumption.</p> <p>Pyridoxine (vitamin B6, 10–25 mg/d) might prevent peripheral neuropathy and central nervous system effects.</p> <p>Serum concentrations of phenytoin, disulfiram (Antabuse), and carbamazepine may be increased in persons taking INH. Measure serum concentrations of phenytoin and carbamazepine in patients receiving INH (with or without rifampin), and adjust the dose if necessary.</p>

Anti-tuberculosis Drug	Side Effects/ Adverse Reactions	Monitoring	Comments
Rifampin (RIF)	<ul style="list-style-type: none"> <li>▪ Rash</li> <li>▪ Gastrointestinal upset</li> <li>▪ Hepatitis</li> <li>▪ Fever</li> <li>▪ Bleeding problems</li> <li>▪ Thrombocytopenia</li> <li>▪ Renal failure</li> <li>▪ Flu-like symptoms</li> <li>▪ Orange-colored body fluids (secretions, urine, tears)</li> </ul>	<p>Complete blood count, platelets, and liver function tests (aspartate aminotransferase [AST], alanine aminotransferase [ALT], and serum bilirubin) at baseline in selected cases (human immunodeficiency virus [HIV] infection, history of liver disease, alcoholism, and pregnancy)</p> <p>Repeat measurements if</p> <ul style="list-style-type: none"> <li>▪ Baseline results are abnormal</li> <li>▪ Patient has symptoms of adverse reactions</li> </ul>	<p>There are a number of drug interactions with potentially serious consequences. Significant interactions with methadone, birth control hormones, and many other drugs.</p> <p>Contraindicated or should be used with caution when administered with protease inhibitors (PIs) and nonnucleoside reverse transcriptase inhibitors (NNRTIs). Reduces levels of many drugs (e.g., PIs, NNRTIs, methadone, dapsone, ketoconazole, coumadin derivatives, hormonal contraceptive, digitalis, sulfonylureas, diazepam, <math>\beta</math>-blockers, anticonvulsants, and theophylline).</p> <p>Colors body fluids (i.e. urine) orange.</p> <p>May permanently discolor soft contact lenses.</p> <p>For more information, refer to "Section 7: Drug Interactions" on page 45 in "Treatment of Tuberculosis" at <a href="http://www.cdc.gov/mmwr/PDF/rr/rr5211.pdf">http://www.cdc.gov/mmwr/PDF/rr/rr5211.pdf</a>.</p> <p>Because information regarding rifamycin drug interactions is evolving rapidly, consult the CDC's Division of Tuberculosis "News and Updates" Web page at <a href="http://www.cdc.gov/tb/default.htm">http://www.cdc.gov/tb/default.htm</a> to obtain the most up-to-date information.</p>

Anti-tuberculosis Drug	Side Effects/ Adverse Reactions	Monitoring	Comments
Rifabutin (RFB)	<ul style="list-style-type: none"> <li>▪ Rash</li> <li>▪ Hepatitis</li> <li>▪ Fever</li> <li>▪ Thrombocytopenia</li> <li>▪ Orange-colored body fluids (secretions, urine, tears)</li> </ul> <p>With increased levels of RFB:</p> <ul style="list-style-type: none"> <li>▪ Severe arthralgias</li> <li>▪ Uveitis</li> <li>▪ Leukopenia</li> </ul>	<p>Complete blood count, platelets, and liver function tests (aspartate aminotransferase [AST], alanine aminotransferase [ALT], and serum bilirubin) at baseline in selected cases (human immunodeficiency virus [HIV] infection, history of liver disease, alcoholism, and pregnancy).</p> <p>Repeat measurements if</p> <ul style="list-style-type: none"> <li>▪ Baseline results are abnormal</li> <li>▪ Patient has symptoms of adverse reactions</li> </ul> <p>Use adjusted daily dose of RFB and monitor for decreased antiretroviral activity and for RFB toxicity if RFB taken concurrently with protease inhibitors (PIs) or nonnucleoside reverse transcriptase inhibitors (NNRTIs).</p>	<p>Although drug interactions are less problematic with RFB, they still occur and close monitoring is required.</p> <p>Contraindicated for HIV-infected patients taking hard-gel saquinavir or delavirdine; caution is also advised if RFB is administered with soft-gel saquinavir.</p> <p>Similar to rifampin but less potent of an inducer, rifabutin reduces levels of many drugs (e.g., PIs, NNRTIs, methadone, dapsone, ketoconazole, coumadin derivatives, hormonal contraceptive, digitalis, sulfonyleureas, diazepam, <math>\beta</math>-blockers, anticonvulsants, and theophylline).</p> <p>When used with efavirenz, the daily dose of RFB should be increased from 300 mg to 450 mg or 600 mg.</p> <p>May permanently discolor soft contact lenses.</p>

Anti-tuberculosis Drug	Side Effects/ Adverse Reactions	Monitoring	Comments
Rifapentine (RPT)	Similar to those associated with rifampin	Similar to that for rifampin	Drug interactions involving RPT are being investigated and are likely to be similar to those of rifampin. RPT is an inducer of multiple hepatic enzymes and therefore may increase metabolism of coadministered drugs that are metabolized by these enzymes. For more information, refer to "Section 7: Drug Interactions" on page 45 in "Treatment of Tuberculosis" at <a href="http://www.cdc.gov/mmwr/PDF/rr/rr5211.pdf">http://www.cdc.gov/mmwr/PDF/rr/rr5211.pdf</a> .

Anti-tuberculosis Drug	Side Effects/ Adverse Reactions	Monitoring	Comments
Pyrazinamide (PZA)	<ul style="list-style-type: none"> <li>▪ Gastrointestinal upset</li> <li>▪ Hepatitis</li> <li>▪ Rash</li> <li>▪ Photosensitive dermatitis</li> <li>▪ Hyperuricemia</li> <li>▪ Joint aches</li> <li>▪ Gout (rare)</li> </ul>	<p>Clinical monitoring at weeks 2, 4, and 8</p> <p>If the drug is used in patients with underlying liver disease, laboratory and clinical monitoring should be increased</p> <p>Baseline measurements of uric acid</p> <p>Liver function tests (aspartate aminotransferase [AST], alanine aminotransferase [ALT], and serum bilirubin) at baseline in selected cases (human immunodeficiency virus [HIV] infection, history of liver disease, alcoholism, or pregnancy)</p> <p>Repeat measurements if</p> <ul style="list-style-type: none"> <li>▪ Baseline results are abnormal</li> <li>▪ Patient has symptoms of adverse reactions</li> </ul>	<p>Treat hyperuricemia only if patient has symptoms.</p> <p>Might make glucose control more difficult in persons with diabetes.</p> <p>Serum uric acid measurements are not recommended as routine, but may serve as a surrogate marker for compliance.</p>

Anti-tuberculosis Drug	Side Effects/ Adverse Reactions	Monitoring	Comments
Ethambutol (EMB)	<ul style="list-style-type: none"> <li>Optic neuritis</li> <li>Rash</li> </ul>	<p>Baseline tests of visual acuity (Snellen chart) and color discrimination (Ishihara tests) or other standard tests.</p> <p>At each monthly visit, patients should be questioned regarding possible visual disturbances, including blurred vision or scotomata.</p> <p>Monthly testing of visual acuity and color discrimination is recommended for</p> <ul style="list-style-type: none"> <li>Patients taking doses &gt;15–25 mg/kg</li> <li>Patients receiving EMB for &gt;2 months</li> <li>Patients with renal insufficiency</li> </ul>	<p>Optic neuritis may be unilateral; check each eye separately.</p> <p>Patients should be instructed to contact their physician or public health clinic immediately if they experience a change in vision.</p> <p>EMB should be discontinued immediately and permanently if there are any signs of visual toxicity.</p>
Rifamate® (INH and RIF) Rifater® (INH, RIF, PZA)	See comments under individual drugs above		
<p>Definitions of abbreviations: ALT = alanine aminotransferase; AST = aspartate aminotransferase; EMB = ethambutol; HIV = human immunodeficiency virus; INH = isoniazid; NNRTIs = nonnucleoside reverse transcriptase inhibitors; PZA = pyrazinamide; PIs = protease inhibitors; RFB = rifabutin; RIF = rifampin; RPT = rifapentine.</p>			

Sources: CDC. Targeted tuberculin testing and treatment of latent tuberculosis infection. *MMWR* 2000;49 (No. RR-6):26–29, 38–39; ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):19–25; CDC. Update: Adverse event data and revised American Thoracic Society/CDC recommendations against the use of rifampin and pyrazinamide for treatment of latent tuberculosis infection—United States. *MMWR* 2003;52(No. 31):735–736; CDC. Table 5: first-line anti-TB medications. In: Chapter 7: treatment of TB disease. *Core Curriculum on Tuberculosis (2000)* [Division of Tuberculosis Elimination Web site]. Updated November 2001. November 2001. Available at: <http://www.cdc.gov/tb/pubs/corecurr/index.htm>. Accessed July 3, 2006.

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## Response to Treatment



For consultation regarding a patient's response to treatment, call the patient's provider or health authority managing the case.

Additional information can be obtained by contacting the Francis J. Curry National TB Center's Warm-line at 415-502-4700.

For patients whose sputum cultures are positive before treatment, the best way to measure the effectiveness of therapy is to obtain specimens for culture at least monthly until the cultures convert to negative. Patients with multidrug-resistant tuberculosis (MDR-TB) should have cultures performed monthly for the entire course of treatment.

In some cases, a patient may not be able to produce a sputum specimen after two months of treatment. If the patient has improved clinically and has shown chest radiograph improvement, treatment may be continued as if the patient had a negative sputum specimen at two months.

Radiographic evaluations during treatment are of less importance than sputum evaluation. However, a chest radiograph at completion of treatment provides a baseline for comparison with future films.

Patients whose cultures have not become negative or whose symptoms do not resolve despite three months of therapy should be reevaluated for potential drug-resistant disease, as well as for potential failure to adhere to the regimen. If the patient is receiving self-administered therapy, the remainder of treatment should be directly observed.



If drug susceptibility results show resistance to any of the first-line drugs or if the patient remains symptomatic or smear- or culture-positive after three months, a tuberculosis (TB) medical expert should be consulted. (Francis J. Curry National TB Center's Warm-line at 415-502-4700).

In patients with negative sputum cultures before treatment, the major indicators of response to therapy are the chest radiograph and clinical evaluation. The intervals at which chest radiography should be repeated depend on the clinical circumstances and the differential diagnosis that is being considered, but usually should be no more than every three months. If the radiograph does not improve after the patient has received three months of treatment, the abnormality may be the result of either previous (not current) TB or another process.<sup>20</sup>



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## Completion of Therapy

A full course of therapy (completion of treatment) is determined more accurately if the total number of doses ingested is taken into account, as well as the duration of therapy. If there are no interruptions in drug administration, six months is usually the minimum duration of treatment and accurately indicates the amount of time in which drugs are given. However, in human immunodeficiency virus (HIV)-negative, culture-negative patients, treatment for four months may be adequate if there is clinical or radiographic improvement and no other etiology identified.<sup>21</sup>

In some cases, either because of drug toxicity or nonadherence to the treatment regimen, the specified number of doses cannot be administered within the targeted period. In such cases, the goal is to deliver the specified number of doses within a recommended maximum time. For example, for a six-month daily regimen, the total doses should be administered within nine months of beginning treatment. If treatment is not completed within this period, the patient should be assessed to determine the appropriate action to take, such as continuing treatment for a longer duration or restarting treatment from the beginning.



Treating a patient for a defined duration, without accounting for the number of doses taken, can result in undertreatment.

Interruptions in treatment may have a significant effect on the duration of therapy. Reinstitution of treatment must take into account the extensiveness of the disease (e.g., cavitory versus noncavitory disease on chest radiograph, smears and cultures, immunologic status), the point in time when the interruption occurred, and the duration of the interruption. In general, the earlier in treatment and the longer the duration of the interruption, the more serious the effect and the greater the need to restart therapy from the beginning.<sup>22</sup>



For consultation regarding completion of therapy or considerations for retreatment, contact the local health department, TB Control Program.

See Roles & Responsibilities & Contact information at:

[http://www.health.nv.gov/PDFs/HIV\\_STD\\_TB/Educational/TB\\_Protocol\\_Introduction.pdf](http://www.health.nv.gov/PDFs/HIV_STD_TB/Educational/TB_Protocol_Introduction.pdf)

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## Post-Treatment Evaluation

Routine follow-up after completion of therapy is not necessary for patients with a satisfactory and prompt bacteriologic response to a six- or nine-month regimen that included both isoniazid and rifampin.

The table below describes the clinician's responsibilities at completion of therapy for cases in which the organisms are drug-susceptible and drug-resistant.

Table 9: CLINICIAN'S RESPONSIBILITIES AT COMPLETION OF THERAPY

Drug Susceptibility	Clinician's Actions
Drug-susceptible organisms	Instruct the patient to promptly report the development of any symptoms, particularly prolonged cough, fever, or weight loss.
Organisms resistant to isoniazid, rifampin, or both	Individualize follow-up evaluation. <sup>23</sup>



For consultation regarding post-treatment evaluation, contact the local health department, TB Control Program.

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# Treatment in Special Situations

Treatment of tuberculosis (TB) in the following situations requires a high level of expertise or close consultation with an expert to provide appropriate management:

- Drug-resistant TB
- Human immunodeficiency virus (HIV) infection
- Liver disease
- Renal insufficiency and end-stage renal disease (ESRD)
- TB associated with tumor necrosis factor-alpha (TNF- $\alpha$ ) antagonists
- Culture-negative pulmonary TB
- Extrapulmonary TB
- Pregnancy and breastfeeding
- TB in children



For consultation regarding treatment in the following situations, contact the medical provider, local health officer, or your regional TB Program. (contact information available at:

[http://www.health.nv.gov/PDFs/HIV\\_STD\\_TB/Educational/TB\\_Protocol\\_Introduction.pdf](http://www.health.nv.gov/PDFs/HIV_STD_TB/Educational/TB_Protocol_Introduction.pdf))

Additional information can be obtained by contacting the Francis J. Curry National TB Center's Warm-line at 415-502-4700.

## Drug-Resistant Tuberculosis



Treatment of TB caused by drug-resistant organisms should be provided by, or in close consultation with, an expert in the management of these difficult situations. Second-line regimens often represent the patient's last hope for being cured, and inappropriate management can have life-threatening consequences.<sup>24</sup>

Drug resistance is proven only by drug-susceptibility testing performed in a competent laboratory. The Nevada State Public Health Laboratory is the only laboratory currently performing this test in Nevada. A patient with a strain of *Mycobacterium tuberculosis* resistant to both isoniazid (INH) and rifampin (RIF) has multidrug-resistant TB (MDR-TB). Refer MDR-TB patients immediately to a specialist or seek consultation with a specialized treatment center.<sup>25</sup>

Acquired drug resistance usually develops when an inadequate drug regimen is prescribed (e.g., inappropriate drugs or insufficient dosage) or when there is a combined failure of both the patient and the provider to ensure that an adequate regimen is taken. A patient with acquired drug resistance may transmit his or her strain to others, who may then develop primary drug-resistant TB.<sup>26</sup>



## Resources

- ATS, CDC, IDSA. “Treatment of Tuberculosis” (*MMWR* 2003;52[No. RR-11]:11-12, 68–70). Available at: <http://www.cdc.gov/mmwr/PDF/rr/rr5211.pdf>
- CDC. “Multidrug-Resistant” Drug-Resistant Tuberculosis (MDR TB)” (*TB Elimination Fact Sheet*), and “Extensively Drug-Resistant Tuberculosis (XDR TB)” (*TB Elimination Fact Sheet*); Available at: <http://www.cdc.gov/tb/publications/factsheets/drtb/mdrtb.htm>

## Human Immunodeficiency Virus Infection

Management of HIV-related TB is complex and requires expertise in the management of both HIV disease and TB. Because HIV-infected patients often take numerous medications, some of which interact with antituberculosis medications, clinicians are strongly encouraged to consult with experts who treat HIV-related TB.

It is especially important to use directly observed therapy (DOT) and other adherence-promoting strategies with patients with HIV-related TB.



The following are contraindicated in HIV-infected patients:

- Isoniazid-rifapentine (INH-RPT) once weekly
- Twice-weekly rifampin (RIF)- or rifabutin (RFB)-based regimens in patients with CD4+ cell counts of less than 100 per microliter<sup>27</sup>



Patients with HIV-related TB may experience a temporary exacerbation of symptoms, signs, or radiographic manifestations (paradoxical reactions) of TB while receiving antituberculosis treatment.<sup>28</sup>



## Resources

- ATS, CDC. “Notice to Readers: Updated Guidelines for the Use of Rifamycins for the Treatment of Tuberculosis among HIV-infected Patients Taking Protease Inhibitors or Nonnucleoside Reverse Transcriptase Inhibitors” (*MMWR* 2000 / 49(09);185-9). Available at: <http://www.cdc.gov/mmwr/preview/mmwrhtml/mm4909a4.htm>
- CDC. “Treatment of Drug-Susceptible TB in HIV-Infected Persons” (*TB Elimination Fact Sheet*; April 2010). Available at: <http://www.cdc.gov/tb/publications/factsheets/treatment/treatmentHIVpositive.htm>
- CDC. “Treating Opportunistic Infections Among HIV-exposed and Infected Children” (*MMWR* 2004;53[No. RR-14]). Available at: <http://www.cdc.gov/mmwr/PDF/rr/rr5314.pdf>
- CDC. *Self-Study Modules on Tuberculosis* (Division of Tuberculosis Elimination Web site; 2008). Available at: <http://www.cdc.gov/tb/education/ssmodules/default.htm>
- ATS, CDC, IDSA. “Treatment of Tuberculosis” (*MMWR* 2003;52[No. RR-11];11-12, 68–70). Available at: <http://www.cdc.gov/mmwr/PDF/rr/rr5211.pdf>

## Alcoholism

### Alcohol-Related Treatment Complications

Risk of drug-induced liver injury and non-adherence complicate health interventions for patients who are diagnosed with TB disease or latent tuberculosis infection (LTBI) and who also are known or suspected to have an alcohol use disorder, who drink heavily, or who regularly consume alcohol.

In several important ways related to tuberculosis and its treatment, alcohol consumption increases health risks and can complicate the treatment of patients.

- **Immunosuppression:** Persons who use alcohol may be at increased risk for acquiring or developing TB, but given the many other potential risk factors that commonly occur among such persons, alcohol use has been difficult to identify as a separate risk factor for TB.<sup>29</sup> However, studies have shown that “alcohol consumption is a major risk factor for infection with opportunistic bacterial, viral, fungal, and parasitic pathogens.”<sup>30</sup>
- **Liver injury and death:** Drug-induced liver injury “may occur with all currently recommended regimens for the treatment of LTBI”.<sup>31</sup> In the treatment of TB disease, “the crucial efficacy of isoniazid, and particularly (INH), rifampin, warrants their use

and retention, (RIF), and pyrazinamide (PZA), they should be used if at all possible, even in the face of preexisting liver disease.”<sup>32</sup> However, it is not fully understood yet how antituberculosis medications cause drug-induced liver injury.<sup>33</sup> For persons taking isoniazid, an association of hepatitis was found with alcohol consumption, with rates being fourfold higher among persons consuming alcohol daily than among those who did not drink alcohol.<sup>34</sup> When a patient has hepatic disease, the risk of drug accumulation and drug-induced hepatitis is increased. However, with more frequent laboratory and clinical monitoring, isoniazid may be used in patients with stable hepatic disease. Transient asymptomatic hyperbilirubinemia may occur in patients taking rifampin or rifapentine, and more severe clinical hepatitis may also occur. Hepatitis is more common when rifampin is given with isoniazid than when rifampin is given alone or with drugs other than isoniazid.<sup>35,36</sup> Pyrazinamide has slightly lower rates of hepatotoxicity than isoniazid or rifampin, but pyrazinamide can cause liver injury that may be severe and prolonged.<sup>37</sup> To prevent and manage drug-induced liver injury, the American Thoracic Society recommends the following systematic steps: consideration of benefits and risks in selecting patients and regimens, careful and thorough staff and patient education, ready access to care, good communication between providers, and clinical and biochemical monitoring.<sup>38</sup> The most serious common adverse reaction, is defined as a serum aspartate aminotransferase (AST) level more than three times the upper limit of normal in the presence of symptoms or five times the upper limit of normal in the absence of symptoms.

- Nonadherence to treatment:** Patients who do not complete LTBI treatment risk progression to TB disease, and those who do not complete treatment for TB disease risk relapse, development of drug-resistant TB, serious illness, and possible death. Barriers to adherence may be patient related, such as conflicting health beliefs, alcohol or drug dependence, or mental illness, or they may be system related, such as lack of transportation, inconvenient clinic hours, and lack of interpreters.<sup>39</sup> It is more difficult for patients who have an alcohol use disorder to adhere to therapy. In a prospective study of 224 patients, “noncompliance was significantly associated with homelessness and alcoholism.”<sup>40</sup> In a study of 237 patients in the Russian Federation undergoing Directly Observed Therapy Shortcourse (DOTS) treatment for TB disease, “substance abuse was identified as the only factor that was strongly associated with non-adherence...These results suggest that DOTS programmes [sic] might be more likely to achieve TB control targets if they include interventions aimed at improving adherence by diagnosing and treating substance abuse concurrently with standard TB therapy.”<sup>41</sup> DOTS programs that have explicitly offered substance abuse treatment have reported better outcomes than those that have not.<sup>42</sup> In South Carolina, joint treatment programs to treat patients with TB who have alcohol and substance abuse problems were used in conjunction with incentives, enablers, and a process of increasing restrictions (health department warnings, then court-ordered directly observed therapy, then involuntary confinement) as needed to address noncompliance. This combination of strategies was associated with an increase in overall completion of antituberculosis therapy and a decrease in new cases between 1986-1991.<sup>43</sup>

## Safe Treatment Guidelines

In 2006, the American Thoracic Society (ATS) issued “An Official ATS Statement: Hepatotoxicity of Antituberculosis Therapy.” on pages 943-947 guidance in the following areas for the safe treatment of LTBI and TB Disease can be referenced:

- **Program Infrastructure** Adopt these standardized approaches to develop safe treatment of LTBI and TB disease.
- **Provider Education and Resources** Develop these written resources, educational programs, and referral mechanisms to assure that healthcare providers have the skills, knowledge, and resources to safely diagnose and treat patients with TB disease and LTBI.
- **Pretreatment Clinical Evaluation** Refer here for a list of what to include in the pretreatment clinical evaluation and the initial physical examination and when to screen for viral hepatitis.
- **Patient Education** Follow these suggestions to improve patients’ awareness of and communication about their symptoms of liver disorders. Communicate with patients in their preferred language<sup>44</sup> and carefully confirm that they understand the educational points being made.
- **Medication Administration and Pharmacy** Use these tips to distribute antituberculosis medications in ways that encourage and reinforce prompt reporting by patients of adverse effects.
- **Treatment of LTBI and Treatment of TB Disease** Use these recommendations to guide treatment decisions and monitoring activities. Numbered lists of recommendations provide detailed information. Three flowcharts show key data and decisions in the following areas: LTBI pretreatment clinical evaluation and counseling, monitoring for hepatotoxicity during LTBI treatment, and monitoring for hepatotoxicity during treatment of TB disease.<sup>45</sup>

Consult these recommendations at:

<http://www.thoracic.org/statements/resources/mtpi/hepatotoxicity-of-antituberculosis-therapy.pdf>

## Liver Disease

Management of TB in patients with unstable or advanced liver disease is difficult. The likelihood of drug-induced hepatitis may be greater in these patients. The implications of drug-induced hepatitis for patients with marginal hepatic reserve are potentially serious, even life-threatening. Also, fluctuations in the biochemical indicators of liver function (with/without symptoms) related to the preexisting liver disease confound monitoring for drug-induced hepatitis.<sup>46</sup>



For all patients with preexisting liver disease, frequent clinical and laboratory monitoring should be performed to detect drug-induced hepatic injury.<sup>47</sup>



## Resources

- ATS, CDC, IDSA. “Treatment of Tuberculosis” (*MMWR* 2003;52[No. RR-11]:11, 65). Available at: <http://www.cdc.gov/mmwr/PDF/rr/rr5211.pdf>
- Francis J. Curry National Tuberculosis Center and California Department of Public Health “Drug-Resistant Tuberculosis: A Survival Guide for Clinicians, 2<sup>nd</sup> edition” (chapter 5) Available at: <http://www.nationaltbcenter.edu/drtb>

## Renal Insufficiency and End-Stage Renal Disease

Renal insufficiency complicates the management of TB because some antituberculosis medications are cleared by the kidneys. Management may be further complicated by the removal of some antituberculosis agents via hemodialysis. To facilitate DOT (three times per week) and avoid premature removal of the drugs, administer all antituberculosis drugs immediately after hemodialysis.<sup>48</sup> Alterations in antituberculosis medication dosing regimens are common in patients with renal insufficiency and end-stage renal disease (ESRD) who are receiving hemodialysis.

### Creatinine Clearance

Dosing recommendations are based on patients’ creatinine clearance.

Administration of drugs that are cleared by the kidneys is managed in the same manner, with an increase in dosing interval for patients having a creatinine clearance of less than 30 ml/minute or for patients receiving hemodialysis.

In patients having a reduced creatinine clearance (but not less than 30 ml/minute), standard doses should be used, but measurement of serum concentrations should be considered to avoid toxicity.<sup>49</sup>

### Dosing Recommendations

For patients having a creatinine clearance of less than 30 ml/minute or for patients receiving hemodialysis, the following adjustments to conventional dosing are recommended.



Table 10: DOSING RECOMMENDATIONS FOR ADULT PATIENTS WITH REDUCED RENAL FUNCTION AND FOR ADULT PATIENTS RECEIVING HEMODIALYSIS<sup>50</sup>

Drug	Change in Frequency?	Recommended dose and frequency for patients with creatinine clearance <30 ml/min for patients receiving hemodialysis
Isoniazid	No Change	300 mg once daily, or 900 mg three times per week
Rifampin	No Change	600 mg once daily, or 600 mg three times per week
Pyrazinamide	Yes	25-35 mg/kg per dose three times per week (not daily)
Ethambutol	Yes	15-25 mg/kg per dose three times per week (not daily)
Levofloxacin	Yes	750-1,000 mg per dose three times per week (not daily)
Moxifloxacin	No Change	400 mg/dose daily <sup>†</sup>
Cycloserine	Yes	250 mg once daily, or 500 mg/dose three times per week*
Ethionamide	No Change	250-500 mg/dose daily
p-Aminosalicylic acid (PAS)	No Change	4 g/dose, twice daily
Streptomycin	Yes	12-15 mg/kg per dose two or three times per week (not daily)
Capreomycin	Yes	12-15 mg/kg per dose two or three times per week (not daily)
Kanamycin	Yes	12-15 mg/kg per dose two or three times per week (not daily)
Amikacin	Yes	12-15 mg/kg per dose two or three times per week (not daily)
<p>Standard doses are given unless there is intolerance. The medications should be given after hemodialysis on the day of hemodialysis. Monitoring of serum drug concentrations should be considered to ensure adequate drug absorption, without excessive accumulation, and to assist in avoiding toxicity.</p> <p>Data currently are not available for patients receiving peritoneal dialysis. Until data become available, begin with doses recommended for patients receiving hemodialysis and verify adequacy of dosing, using serum concentration monitoring.</p> <p>* The appropriateness of 250-mg daily doses has not been established. There should be careful monitoring for evidence of neurotoxicity.</p> <p>† No adjustment in dose is needed for those with low creatinine clearance or those on hemodialysis. No adjustment in dosing frequency is needed, but it may be given three times a week to facilitate administration.</p>		

- **Rifampin** and **isoniazid** are metabolized by the liver, so conventional dosing may be used in the setting of renal insufficiency.
- Supplemental dosing is not necessary for **isoniazid**, **rifampin**, or **ethambutol**. If **pyrazinamide** is given after hemodialysis, supplemental dosing is not required.
- A longer interval between doses with three times a week administration is recommended for **pyrazinamide** and **ethambutol**.
- Doses of **streptomycin**, **kanamycin**, **amikacin**, and **capreomycin** must be adjusted in patients with renal failure, and the dosing interval should be increased. In general, the dose should not be reduced because the drugs exhibit concentration dependent bactericidal action, and smaller doses may reduce drug efficacy.
- **Ethionamide** requires no dose adjustment.
- Twice daily dosing (4 g) of **p-Aminosalicylic acid (PAS)** should be adequate if the granule formulation is used. Its metabolite, acetyl-PAS, is substantially removed by hemodialysis.
- **Cycloserine** requires an increase in the dosing interval to avoid accumulation between hemodialysis sessions, and the drug should be given after hemodialysis to avoid underdosing.
- The **fluoroquinolones** undergo some degree of renal clearance that varies from drug to drug. For example, levofloxacin undergoes greater renal clearance than moxifloxacin. It should be noted that the fluoroquinolone dosing recommendations for end-stage renal disease provided by the manufacturers were developed for treating pyogenic bacterial infections. These recommendations may not be applicable to the treatment of tuberculosis in patients with end-stage renal disease.

### **Administration of Drugs Immediately After Hemodialysis**

Antituberculosis drugs exhibit concentration dependent bactericidal action, and smaller doses may reduce drug efficacy. Administration of all antituberculosis drugs immediately following hemodialysis will require DOT three times per week and avoid premature removal of the drugs.

### **Monitoring of Serum Drug Concentrations**

It is important to monitor serum drug concentrations in persons with renal insufficiency who are taking cycloserine, ethambutol, or any of the injectable agents to minimize dose-related toxicity, while providing effective doses.

Clinicians also should be aware that patients with end-stage renal disease may have additional clinical conditions, such as diabetes mellitus with gastroparesis, that may affect the absorption of the antituberculosis drugs, or they may be taking concurrent medications that interact with these drugs. Under these circumstances a careful clinical and pharmacologic assessment is necessary, and, in selected cases, serum drug

concentration measurements may be used to assist in determining the optimum dose of the antituberculosis drugs.

Finally, data currently do not exist for patients receiving peritoneal dialysis. Because the drug removal mechanisms differ between hemodialysis and peritoneal dialysis, it cannot be assumed that all of the recommendations in Table 1 will apply to peritoneal dialysis. Such patients may require close monitoring, including measurements of the serum concentrations of the antituberculosis drugs.<sup>51</sup>

## Resources



- ATS, CDC, IDSA. “Treatment of Tuberculosis” (*MMWR* 2003;52[No. RR-11]:10–11, 63–65). Available at: <http://www.cdc.gov/mmwr/PDF/rr/rr5211.pdf>
- Francis J. Curry National Tuberculosis Center and California Department of Public Health “Drug-Resistant Tuberculosis: A Survival Guide for Clinicians, 2<sup>nd</sup> edition” (chapter 5) Available at: <http://www.nationaltbcenter.edu/drtb/>

## Tuberculosis Associated with Tumor Necrosis Factor-Alpha Antagonists

TB is a potential consequence of treatment with tumor necrosis factor-alpha (TNF- $\alpha$ ) antagonists such as the following:

- Infliximab (Remicade<sup>®</sup>)
- Etanercept (Enbrel<sup>®</sup>)
- Adalimumab (Humira<sup>®</sup>)

These drugs work by blocking TNF- $\alpha$ , an inflammatory cytokine, and are approved for treating rheumatoid arthritis and other selected autoimmune diseases. Blocking TNF- $\alpha$  can allow TB disease to emerge from latent TB infection (LTBI). Healthcare providers should take steps to prevent TB in immunocompromised patients and remain vigilant for TB as a cause of unexplained febrile illness.<sup>52</sup>



Patients should be screened for risk factors for *M. tuberculosis* infection and tested for infection before initiating immunosuppressive therapies, including TNF- $\alpha$  antagonists.<sup>53</sup>

## Resources



- CDC. “Tuberculosis Associated with Blocking Agents against Tumor Necrosis Factor-Alpha—California, 2002–2003” (*MMWR* 2004;53[No. 30]:83–686). Available at: <http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5330a4.htm> .

## Culture-Negative Pulmonary Tuberculosis

A diagnosis of TB should not be ruled out if *M. tuberculosis* cannot be isolated from persons suspected of having pulmonary TB on the basis of clinical features and chest radiographic examination. Alternative diagnoses should be carefully considered and further appropriate diagnostic studies undertaken in persons with apparent culture-negative TB.<sup>54</sup>

A diagnosis of culture-negative pulmonary TB can be made if all the following conditions are met:

- Initial acid-fast bacilli (AFB) smears and cultures are negative.
- Clinical or radiographic response occurs within two months of initiation of therapy.
- No other diagnosis has been established.<sup>55</sup>

After the initial phase (first 2 months), continue treatment with an additional 2 months of isoniazid and rifampin during the continuation phase to complete a total of four months of treatment.<sup>56</sup> However, HIV-infected patients with culture-negative pulmonary TB should be treated for a minimum of six months.<sup>57</sup>



### Resources

- ATS, CDC, IDSA. "Treatment of Tuberculosis" (*MMWR* 2003;52[No. RR-11]:10, 61). Available at: <http://www.cdc.gov/mmwr/PDF/rr/rr5211.pdf>

## Extrapulmonary Tuberculosis

The basic principles for treating pulmonary TB also apply to extrapulmonary forms of the disease. The addition of corticosteroids is recommended for patients with TB pericarditis and TB meningitis. Recommendations concerning duration of therapy are as follows:

- Use a six-month course of therapy for TB involving any site.<sup>58</sup> **Exceptions:** For bone or joint TB, use a six- to nine-month regimen.<sup>59</sup> For the meninges, use a 9- to 12-month regimen.<sup>60</sup>
- Consider prolonging therapy for patients with TB in any site that is slow to respond.<sup>61</sup>

**Note:** Affected lymph nodes may enlarge while patients are receiving appropriate therapy or after treatment has ended without any evidence of bacteriological relapse. On occasion, new nodes can appear during or after treatment as well.<sup>62</sup>



## Resources

- ATS, CDC, IDSA. "Treatment of Tuberculosis" (*MMWR* 2003;52[No. RR-11]:10, 56–61). Available at: <http://www.cdc.gov/mmwr/PDF/rr/rr5211.pdf>
- Division of Tuberculosis Elimination. *Fact Sheets* (Division of Tuberculosis Elimination Web site; accessed February 2007). Available at: <http://www.cdc.gov/tb/pubs/TBfactsheets.htm>
- CDC. *Self-Study Modules on Tuberculosis* (Division of Tuberculosis Elimination Web site; 2008). Available at: <http://www.cdc.gov/tb/education/ssmodules/default.htm>

## Pregnancy and Breastfeeding

Because of the risk of TB to the fetus, treatment in pregnant women should be initiated whenever the probability of maternal disease is moderate to high. The initial treatment regimen should consist of isoniazid (INH), rifampin (RIF), and ethambutol (EMB). As pyrazinamide (PZA) generally is not included in the initial treatment regimen, the minimum duration of therapy is nine months. Although these drugs cross the placenta, they do not appear to have teratogenic effects.

Breastfeeding should not be discouraged in women being treated with first-line antituberculosis agents because the small concentrations of drugs in breast milk do not produce toxicity in the nursing newborn. Conversely, drugs in breast milk should not be considered an effective treatment for TB in a nursing infant.<sup>63</sup>

Pyridoxine supplementation (25 mg/day) is recommended for all women taking INH who are either pregnant or breastfeeding.<sup>64</sup>



## Resources

- ATS, CDC, IDSA. "Treatment of Tuberculosis" (*MMWR* 2003;52[No. RR-11]:11, 62–63). Available at: <http://www.cdc.gov/mmwr/PDF/rr/rr5211.pdf>
- CDC. *Self-Study Modules on Tuberculosis* (Division of Tuberculosis Elimination Web site; 2008). Available at: <http://www.cdc.gov/tb/education/ssmodules/default.htm>
- American Academy of Pediatrics. In: Pickering LK, Baker CJ, Long SS, McMillan JA, eds. *Red Book: 2006 Report of the Committee on Infectious Diseases*. 27th ed. Elk Grove Village, IL: American Academy of Pediatrics; 2006 (Red Book® Online Web site). Available at: <http://www.aapredbook.org>

## Tuberculosis in Children

A pediatric patient is a person below eighteen (18) years of age.



Because of the high risk of disseminated TB in infants and children younger than 5 years of age, treatment should be started as soon as the diagnosis of TB is suspected (the window period).<sup>65</sup>

The following recommendations have been developed for children:

- Regimens recommended for infants, children, and adolescents with TB are generally the same as those for adults.  
**Exception:** Ethambutol (EMB) is not used routinely in children.<sup>66</sup>
- Duration of treatment in children is six months.  
**Exception:** For disseminated disease and TB meningitis, use a 9- to 12- month regimen.<sup>67</sup> For other exceptions, refer to “Duration of Treatment” in the “Treatment Regimens and Dosages” topic in this section.
- DOT should always be used in treating children.<sup>68</sup>

Due to the difficulty of isolating *M. tuberculosis* in a child with pulmonary TB, the choice of drugs for the child is frequently guided by the drug susceptibility test results of the presumed source case. If drug-resistant TB is suspected or the source case isolate is not available, specimens for microbiological evaluation should be obtained via early morning gastric aspiration, bronchoalveolar lavage, or biopsy.<sup>69</sup>



### Resources

- ATS, CDC, IDSA. “Treatment of Tuberculosis” (*MMWR* 2003;52[No. RR-11]:9–10, 55–56). Available at: <http://www.cdc.gov/mmwr/PDF/rr/rr5211.pdf>
- CDC. *Self-Study Modules on Tuberculosis* (Division of Tuberculosis Elimination Web site; 2008). Available at: <http://www.cdc.gov/tb/education/ssmodules/default.htm>
- Francis J. Curry National Tuberculosis Center. *Pediatric Tuberculosis: An Online Presentation* (Francis J. Curry National Tuberculosis Center Web site; 2007). Available at: [http://www.nationaltbcenter.edu/pediatric\\_tb/](http://www.nationaltbcenter.edu/pediatric_tb/)
- American Academy of Pediatrics. In: Pickering LK, Baker CJ, Long SS, McMillan JA, eds. *Red Book: Pediatrics, 2006 Report of the Committee on Infectious Diseases*. 27th ed. Elk Grove Village, IL: American Academy of Pediatrics; 2006 (Red Book® Online Web site). Available at: <http://www.aapredbook.org>

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# Resources and References

## Resources

- ATS, CDC, IDSA. "Treatment of Tuberculosis" (*MMWR* 2003;52[No. RR-11]). Available at: <http://www.cdc.gov/mmwr/PDF/rr/rr5211.pdf>.
- CDC. *Core Curriculum on Tuberculosis (2000)* [Division of Tuberculosis Elimination Web site]. November 2001. Available at <http://www.cdc.gov/tb/pubs/corecurr/default.htm>.
- CDC. *Self-Study Modules on Tuberculosis* (Division of Tuberculosis Elimination Web site; 1999). Available at: <http://www.phppo.cdc.gov/phtn/tbmodules/Default.htm>.
- Saukkonen, J. Et Al. An Official ATS Statement: Hepatotoxicity of Antituberculosis Therapy. *Am J Respir Crit Care Med* 2006. 174:935-952. Available at <http://ajrccm.atsjournals.org/cgi/reprint/174/8/935.pdf>.
- Francis J. Curry National Tuberculosis Center. *Pediatric Tuberculosis: An Online Presentation* (Francis J. Curry National Tuberculosis Center Web site; 2007). Available at: [http://www.nationaltbcenter.ucsf.edu/pediatric\\_tb/http://www.nationaltbcenter.edu/pediatric\\_tb/](http://www.nationaltbcenter.ucsf.edu/pediatric_tb/http://www.nationaltbcenter.edu/pediatric_tb/).

## References

- <sup>1</sup> ATS, CDC, IDSA. Controlling tuberculosis in the United States: recommendations from the American Thoracic Society, CDC, and the Infectious Diseases Society of America. *MMWR* 2005;54(No. RR-12):15.
- <sup>2</sup> CDC. Regimens—pulmonary TB. In: Chapter 7: treatment of TB disease. *Core Curriculum on Tuberculosis (2000)* [Division of Tuberculosis Elimination Web site]. Updated November 2001. Available at: Accessed June 25, 2009.
- <sup>3</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):3.
- <sup>4</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):4.
- <sup>5</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):5.
- <sup>6</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):5.
- <sup>7</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):57.
- <sup>8</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):57.
- <sup>9</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):6–7.
- <sup>10</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):52.
- <sup>11</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):6.
- <sup>12</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):43.
- <sup>13</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):43.
- <sup>14</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):43.
- <sup>15</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):43.
- <sup>16</sup> California Department of Health Services(CDHS)/California Tuberculosis Controllers Association(CTCA). TB case management—core components. *CDHS/CTCA Joint Guidelines* [CTCA Web site]. 1998:9. Available at: <http://www.ctca.org/guidelines/index.html> . Accessed July 11, 2006.
- <sup>17</sup> CDC. Targeted tuberculin testing and treatment of latent tuberculosis infection. *MMWR* 2000;49(No. RR-6):26–29, 38–39.
- <sup>18</sup> CDC. Module 4: treatment of tuberculosis and tuberculosis infection. *Self-Study Modules on Tuberculosis* [Division of Tuberculosis Elimination Web site]. 1999:8–9, 15–17. Available at: <http://www.cdc.gov/tb/pubs/ssmodules/default.htm> . Accessed July 3, 2006.
- <sup>19</sup> CDC. Update: adverse event data and revised American Thoracic Society/CDC recommendations against the use of rifampin and pyrazinamide for treatment of latent tuberculosis infection—United States. *MMWR* 2003;52(No. 31): 735–736.



- <sup>20</sup> CDC. Response to treatment. In: Chapter 7: treatment of TB disease. *Core Curriculum on Tuberculosis (2000)* [Division of Tuberculosis Elimination Web site]. Updated November 2001. Available at: <http://www.cdc.gov/tb/pubs/corecurr/default.htm>. Accessed November 20, 2006.
- <sup>21</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):6–7.
- <sup>22</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):8.
- <sup>23</sup> CDC. Response to treatment. In: Chapter 7: treatment of TB disease. *Core Curriculum on Tuberculosis (2000)* [Division of Tuberculosis Elimination Web site]. Updated November 2001. Available at: <http://www.cdc.gov/tb/pubs/corecurr/default.htm>. Accessed November 20, 2006.
- <sup>24</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):68–69.
- <sup>25</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):68–69.
- <sup>26</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):68–69.
- <sup>27</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):51.
- <sup>28</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):51.
- <sup>29</sup> CDC. Targeted tuberculin testing and treatment of latent tuberculosis infection. *MMWR* 2000;49(No. RR-6):10.
- <sup>30</sup> Brudkey K, Dobkin J. Resurgent tuberculosis in New York City. *Am Rev Respir Dis* 1991;144:745-749; In: Isake, L. Introduction to the symposium. Alcoholism and tuberculosis: an overview. *Alcohol Clin Exp Res* February 1995;19(1):1–2.
- <sup>31</sup> Saukkonen, JJ, Cohn, DL, Jasmer, RM, Schenker, S, Jereb, JA, Nolan, CM, Peloquin, CA, et al. An official ATS statement: hepatotoxicity of antituberculosis therapy. *Am J Respir Crit Care Med* 2006;174:937.
- <sup>32</sup> Saukkonen, JJ, Cohn, DL, Jasmer, RM, Schenker, S, Jereb, JA, Nolan, CM, Peloquin, CA, et al. An official ATS statement: hepatotoxicity of antituberculosis therapy. *Am J Respir Crit Care Med* 2006;174:947.
- <sup>33</sup> Saukkonen, JJ, Cohn, DL, Jasmer, RM, Schenker, S, Jereb, JA, Nolan, CM, Peloquin, CA, et al. An official ATS statement: hepatotoxicity of antituberculosis therapy. *Am J Respir Crit Care Med* 2006;174:935.
- <sup>34</sup> CDC. Targeted tuberculin testing and treatment of latent tuberculosis infection. *MMWR* 2000;49(No. RR-6):16-18.
- <sup>35</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):20-21.
- <sup>36</sup> Saukkonen, JJ, Cohn, DL, Jasmer, RM, Schenker, S, Jereb, JA, Nolan, CM, Peloquin, CA, et al. An official ATS statement: hepatotoxicity of antituberculosis therapy. *Am J Respir Crit Care Med* 2006;174:937.
- <sup>37</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):24.
- <sup>38</sup> Saukkonen, JJ, Cohn, DL, Jasmer, RM, Schenker, S, Jereb, JA, Nolan, CM, Peloquin, CA, et al. An official ATS statement: hepatotoxicity of antituberculosis therapy. *Am J Respir Crit Care Med* 2006;174:935.
- <sup>39</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):10.
- <sup>40</sup> Brudkey K, Dobkin J. Resurgent tuberculosis in New York City. *Am Rev Respir Dis* 144:745-749, 1991. In: Isake, L. Introduction to the symposium. Alcoholism and tuberculosis: an overview. *Alcohol Clin Exp Res* February 1995;19(1):1–2.
- <sup>41</sup> Gelmanova, IY, Keshavjee S, Golubchikova VT, Berezina VI, Strelis AK, Yanova GV, Atwoodr S, Murray M. Barriers to successful tuberculosis treatment in Tomsk, Russian Federation: non-adherence, default and the acquisition of multidrug resistance. *Bulletin of the World Health Organization* September 2007;85(9):647–732. Accessed June 25, 2009 Available at: <http://www.who.int/bulletin/volumes/85/9/06-038331/en/index.html>
- <sup>42</sup> Gelmanova, IY, Keshavjee S, Golubchikova VT, Berezina VI, Strelis AK, Yanova GV, Atwoodr S, Murray M. Barriers to successful tuberculosis treatment in Tomsk, Russian Federation: non-adherence, default and the acquisition of multidrug resistance. *Bulletin of the World Health Organization* September 2007;85(9):647–732. Accessed June 25, 2009. Available at: <http://www.who.int/bulletin/volumes/85/9/06-038331/en/index.html>
- <sup>43</sup> CDC. Approaches to improving adherence to antituberculosis therapy – South Carolina and New York, 1986-1991. *MMWR* 1993;42(04):74–75, 81.
- <sup>44</sup> Saukkonen, JJ, Cohn, DL, Jasmer, RM, Schenker, S, Jereb, JA, Nolan, CM, Peloquin, CA, et al. An official ATS statement: hepatotoxicity of antituberculosis therapy. *Am J Respir Crit Care Med* 2006;174:943.
- <sup>45</sup> Saukkonen, JJ, Cohn, DL, Jasmer, RM, Schenker, S, Jereb, JA, Nolan, CM, Peloquin, CA, et al. An official ATS statement: hepatotoxicity of antituberculosis therapy. *Am J Respir Crit Care Med* 2006;174:935.
- <sup>46</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):65.
- <sup>47</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):11.
- <sup>48</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):63–64.
- <sup>49</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):63.
- <sup>50</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):64.
- <sup>51</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):64.
- <sup>52</sup> CDC. Tuberculosis associated with blocking agents against tumor necrosis factor-alpha—California, 2002–2003. *MMWR* 2004;53(No. 30):683.
- <sup>53</sup> CDC. Tuberculosis associated with blocking agents against tumor necrosis factor-alpha—California, 2002–2003. *MMWR* 2004;53(No. 30):685.
- <sup>54</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):61.
- <sup>55</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):61.
- <sup>56</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):6, 61.
- <sup>57</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):52.
- <sup>58</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):10.
- <sup>59</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):57.
- <sup>60</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):10, 57, 58–59.
- <sup>61</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):10.
- <sup>62</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):57.
- <sup>63</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):62–63.



- 
- <sup>64</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):11.
- <sup>65</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):55.
- <sup>66</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):55–56.
- <sup>67</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):56.
- <sup>68</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):56.
- <sup>69</sup> ATS, CDC, IDSA. Treatment of tuberculosis. *MMWR* 2003;52(No. RR-11):55.