



Standardized procedures are based on a dilution method (broth or agar) or equivalent with standardized inoculum concentrations and standardized concentrations of amikacin powder. The MIC values should be interpreted according to the criteria provided in Table 1.

#### Diffusion Technique

Quantitative methods that require measurement of zone diameters also provide reproducible estimates of the susceptibility of bacteria to antimicrobial compounds. One such standardized procedure requires the use of standardized inoculum concentrations and paper disks impregnated with 30 mcg of amikacin.<sup>2,3</sup> The disk diffusion values should be interpreted according to the criteria provided in Table 1.

**Table 1: Susceptibility Interpretive Criteria for Amikacin**

Pathogen	Susceptibility Interpretive Criteria					
	Minimal Inhibitory Concentration (mcg/mL)			Zone Diameter (mm)		
	S	I	R	S	I	R

<i>Enterobacteriaceae</i> <sup>a</sup>	≤ 16	32	≥ 64	≥ 17	15 to 16	≤ 14
<i>Pseudomonas</i>	≤ 16	32	≥ 64	≥ 17	15 to 16	≤ 14
<i>Acinetobacter</i> spp.	≤ 16	32	≥ 64	≥ 17	15 to 16	≤ 14
Other Non- <i>Enterobacteriaceae</i>	≤ 16	32	≥ 64	-	-	-
<i>Staphylococcus</i> spp. <sup>b</sup>	≤ 16	32	≥ 64	≥ 17	15 to 16	≤ 14

S = Susceptible, I = Intermediate, R = Resistant

<sup>a</sup> For *Salmonella* and *Shigella* spp., aminoglycosides may appear active *in vitro* but are not effective clinically; the results should not be reported as susceptible

<sup>b</sup> For *Staphylococci* that test susceptible, aminoglycosides are used only in combination with other active agents that test susceptible

A report of "Susceptible" indicates that the antimicrobial is likely to inhibit growth of the pathogen if the antimicrobial compound reaches the concentration at the infection site necessary to inhibit growth of the pathogen. A report of "Intermediate" indicates that the result should be considered equivocal, and if the microorganism is not fully susceptible to alternative clinically feasible drugs, the test should be repeated. This category implies possible clinical applicability in body sites where the drug is physiologically concentrated. This category also provides a buffer zone that prevents small uncontrolled technical factors from causing major discrepancies in interpretation. A report of "Resistant" indicates that the antimicrobial is not likely to inhibit growth of the pathogen if the antimicrobial compound reaches the concentrations usually achievable at the infection site; other therapy should be selected.

#### Quality Control

Standardized susceptibility test procedures require the use of laboratory controls to monitor and ensure the accuracy and precision of supplies and reagents used in the assay, and the techniques of the individuals performing the test.<sup>1,2,3</sup> Standard amikacin powder should provide the following range of MIC values provided in Table 2. For the diffusion technique using the 30-mcg amikacin disk the criteria provided in Table 2 should be achieved.

**Table 2: Acceptable Quality Control Ranges for Susceptibility Testing**

Quality Control Organism	Minimum Inhibitory Concentrations	Zone Diameter
<i>Escherichia coli</i> ATCC 25922	0.5 to 4	19 to 26
<i>Pseudomonas aeruginosa</i>	1 to 4	18 to 26
<i>Staphylococcus aureus</i> ATCC 25923	Not Applicable	20 to 26
<i>Staphylococcus aureus</i> ATCC 29213	1 to 4	Not Applicable
<i>Enterococcus faecalis</i> ATCC 29212	64 to 256	Not Applicable

#### INDICATIONS AND USAGE:

Amikacin sulfate injection, USP is indicated in the short-term treatment of serious infections due to susceptible strains of Gram-negative bacteria, including *Pseudomonas* species, *Escherichia coli*, species of indole-positive and indole-negative *Proteus*, *Providencia* species, *Klebsiella* species, *Enterobacter* species, *Serratia* species, and *Acinetobacter* species.

To reduce the development of drug-resistant bacteria and maintain the effectiveness of amikacin and other antibacterial drugs, amikacin should be used only to treat or prevent infections that are proven or strongly suspected to be caused by susceptible bacteria. When culture and susceptibility information are available, they should be considered in selecting or modifying antibacterial therapy. In the absence of such data, local epidemiology and susceptibility patterns may contribute to the empiric selection of therapy.

#### CONTRAINDICATIONS:

A history of hypersensitivity to amikacin is a contraindication for its use. A history of hypersensitivity or serious toxic reactions to aminoglycosides may contraindicate the use of any other aminoglycoside because of the known cross-sensitivities of patients to drugs in this class.

#### WARNINGS:

See **BOXED WARNINGS**.

Aminoglycosides can cause fetal harm when administered to a pregnant woman. Aminoglycosides cross the placenta and there have been several reports of total irreversible, bilateral congenital deafness in children whose mothers received streptomycin during pregnancy. Although serious side effects to the fetus or newborns have not been reported in the treatment of pregnant women with other aminoglycosides, the potential for harm exists. Reproduction studies of amikacin have been performed in rats and mice and revealed no evidence of impaired fertility or harm to the fetus due to amikacin. There are no well controlled studies in pregnant women, but investigational experience does not include any positive evidence of adverse effects to the fetus. If this drug is used during pregnancy, or if the patient becomes pregnant while taking this drug, the patient should be apprised of the potential hazard to the fetus.

Contains sodium metabisulfite, a sulfite that may cause allergic-type reactions including anaphylactic symptoms and life-threatening or less severe asthmatic episodes in certain susceptible people. The overall prevalence of sulfite sensitivity in the general population is unknown and probably low. Sulfite sensitivity is seen more frequently in asthmatic than nonasthmatic people.

*Clostridium difficile* associated diarrhea (CDAD) has been reported with use of nearly all antibacterial agents, including amikacin sulfate injection, and may range in severity from mild diarrhea to fatal colitis. Treatment with antibacterial agents alters the normal flora of the colon leading to overgrowth of *C. difficile*.

*C. difficile* produces toxins A and B which contribute to the development of CDAD. Hypertoxin producing strains of *C. difficile* cause increased morbidity and mortality, as these infections can be refractory to antimicrobial therapy and may require colectomy. CDAD must be considered in all patients who present with diarrhea following antibiotic use. Careful medical history is necessary since CDAD has been reported to occur over two months after the administration of antibacterial agents.

If CDAD is suspected or confirmed, ongoing antibiotic use not directed against *C. difficile* may need to be discontinued. Appropriate fluid and electrolyte management, protein supplementation, antibiotic treatment of *C. difficile*, and surgical evaluation should be instituted as clinically indicated.

#### PRECAUTIONS:

##### General

Prescribing amikacin in the absence of a proven or strongly suspected bacterial infection or a prophylactic indication is unlikely to provide benefit to the patient and increases the risk of the development of drug-resistant bacteria.

Aminoglycosides are quickly and almost totally absorbed when they are applied topically, except to the urinary bladder, in association with surgical procedures. Irreversible deafness, renal failure, and death due to neuromuscular blockade have been reported following irrigation of both small and large surgical fields with an aminoglycoside preparation.

Amikacin sulfate injection is potentially nephrotoxic, ototoxic and neurotoxic. The concurrent or serial use of other ototoxic or nephrotoxic agents should be avoided either systemically or topically because of the potential for additive effects. Increased nephrotoxicity has been reported following concomitant parenteral



administration of aminoglycoside antibiotics and cephalosporins. Concomitant cephalosporins may spuriously elevate creatinine determinations.

Since amikacin is present in high concentrations in the renal excretory system, patients should be well hydrated to minimize chemical irritation of the renal tubules. Kidney function should be assessed by the usual methods prior to starting therapy and daily during the course of treatment.

If signs of renal irritation appear (casts, white or red cells, or albumin), hydration should be increased. A reduction in dosage (see **DOSAGE AND ADMINISTRATION**) may be desirable if other evidence of renal dysfunction occurs such as decreased creatinine clearance; decreased urine specific gravity; increased BUN, creatinine, or oliguria. If azotemia increases or if a progressive decrease in urinary output occurs, treatment should be stopped.

**Note: When patients are well-hydrated and kidney function is normal the risk of nephrotoxic reactions with amikacin is low if the dosage recommendations (see DOSAGE AND ADMINISTRATION) are not exceeded.**

Elderly patients may have reduced renal function which may not be evident in routine screening tests such as BUN or serum creatinine. A creatinine clearance determination may be more useful. Monitoring of renal function during treatment with aminoglycosides is particularly important.

Aminoglycosides should be used with caution in patients with muscular disorders such as myasthenia gravis or parkinsonism since these drugs may aggravate muscle weakness because of their potential curare-like effect on the neuromuscular junction.

*In vitro* mixing of aminoglycosides with beta-lactam antibiotics (penicillin or cephalosporin) may result in a significant mutual inactivation. A reduction in serum half-life or serum level may occur when an aminoglycoside or penicillin-type drug is administered by separate routes. Inactivation of the aminoglycoside is clinically significant only in patients with severely impaired renal function. Inactivation may continue in specimens of body fluids collected for assay, resulting in inaccurate aminoglycoside readings. Such specimens should be properly handled (assayed promptly, frozen, or treated with beta-lactamase).

Cross-allergenicity among aminoglycosides has been demonstrated.

As with other antibiotics, the use of amikacin may result in overgrowth of nonsusceptible organisms. If this occurs, appropriate therapy should be instituted.

Aminoglycosides should not be given concurrently with potent diuretics (see **BOXED WARNINGS**).

#### **Information for Patients**

Patients should be counseled that antibacterial drugs including amikacin should only be used to treat bacterial infections. They do not treat viral infections (e.g., the common cold). When amikacin is prescribed to treat a bacterial infection, patients should be told that although it is common to feel better early in the course of therapy, the medication should be taken exactly as directed. Skipping doses or not completing the full course of therapy may (1) decrease the effectiveness of the immediate treatment and (2) increase the likelihood that bacteria will develop resistance and will not be treatable by amikacin or other antibacterial drugs in the future.

Diarrhea is a common problem caused by antibiotics which usually ends when the antibiotic is discontinued. Sometimes after starting treatment with antibiotics, patients can develop watery and bloody stools (with or without stomach cramps and fever) even as late as two or more months after having taken the last dose of the antibiotic. If this occurs, patients should contact their physician as soon as possible.

#### **Carcinogenesis, Mutagenesis, Impairment of Fertility**

Long-term studies in animals to evaluate carcinogenic potential have not been performed, and mutagenicity has not been studied. Amikacin administered subcutaneously to rats at doses up to 4 times the human daily dose did not impair male or female fertility.

#### **Pregnancy**

**Teratogenic Effects: Pregnancy Category D**

See **WARNINGS**.

#### **Nursing Mothers**

It is not known whether amikacin is excreted in human milk. Because many drugs are excreted in human milk and because of the potential for serious adverse reactions in nursing infants from amikacin, a decision should be made whether to discontinue nursing or to discontinue the drug, taking into account the importance of the drug to the mother.

#### **Pediatric Use**

Aminoglycosides should be used with caution in premature and neonatal infants because of the renal immaturity of these patients and the resulting prolongation of serum half-life of these drugs.

#### **ADVERSE REACTIONS:**

All aminoglycosides have the potential to induce auditory, vestibular, and renal toxicity and neuromuscular blockade (see **BOXED WARNINGS**). They occur more frequently in patients with present or past history of renal impairment, of treatment with other ototoxic or nephrotoxic drugs, and in patients treated for longer periods and/or with higher doses than recommended.

#### **Neurotoxicity-Ototoxicity**

Toxic effects on the eighth cranial nerve can result in hearing loss, loss of balance, or both. Amikacin primarily affects auditory function. Cochlear damage includes high frequency deafness and usually occurs before clinical hearing loss can be detected.

#### **Neurotoxicity-Neuromuscular Blockade**

Acute muscular paralysis and apnea can occur following treatment with aminoglycoside drugs.

#### **Nephrotoxicity**

Elevation of serum creatinine, albuminuria, presence of red and white cells, casts, azotemia, and oliguria have been reported. Renal function changes are usually reversible when the drug is discontinued. As would be expected with any aminoglycoside, reports of toxic nephropathy and acute renal failure have been received during postmarketing surveillance.

#### **Other**

In addition to those described above, other adverse reactions which have been reported on rare occasions are skin rash, drug fever, headache, paresthesia, tremor, nausea and vomiting, eosinophilia, arthralgia, anemia, hypotension and hypomagnesemia. Macular infarction sometimes leading to permanent loss of vision has been reported following intravitreal administration (injection into the eye) of amikacin.

#### **OVERDOSAGE:**

In the event of overdose or toxic reaction, peritoneal dialysis or hemodialysis will aid in the removal of amikacin from the blood. In the newborn infant, exchange transfusion may also be considered.

#### **DOSAGE AND ADMINISTRATION:**

The patient's pretreatment body weight should be obtained for calculation of correct dosage. Amikacin sulfate injection may be given intramuscularly or intravenously.

The status of renal function should be estimated by measurement of the serum creatinine concentration or calculation of the endogenous creatinine clearance rate. The blood urea nitrogen (BUN) is much less reliable for this purpose. Reassessment of renal function should be made periodically during therapy.

Whenever possible, amikacin concentrations in serum should be measured to assure adequate but not excessive levels. It is desirable to measure both peak and trough serum concentrations intermittently during therapy. Peak concentrations (30 to 90 minutes after injection) above 35 micrograms per mL and trough concentrations (just prior to the next dose) above 10 micrograms per mL should be avoided. Dosage should be adjusted as indicated.

#### **Intramuscular Administration for Patients with Normal Renal Function**

The recommended dosage for adults, children and older infants (see **BOXED WARNINGS**) with normal renal function is 15 mg/kg/day divided into 2 or 3 equal doses administered at equally-divided intervals, i.e., 7.5 mg/kg q12h or 5 mg/kg q8h. Treatment of patients in the heavier weight classes should not exceed 1.5 gram/day.

When amikacin is indicated in newborns (see **BOXED WARNINGS**), it is recommended that a loading dose of 10 mg/kg be administered initially to be followed with 7.5 mg/kg every 12 hours.

The usual duration of treatment is 7 to 10 days. It is desirable to limit the duration of treatment to short term whenever feasible. The total daily dose by all routes of administration should not exceed 15 mg/kg/day. In difficult and complicated infections where treatment beyond 10 days is considered, the use of amikacin should be re-evaluated. If continued, amikacin serum levels, and renal, auditory, and vestibular functions should be monitored. At the recommended dosage level, uncomplicated infections due to amikacin-sensitive organisms should respond in 24 to 48 hours. If definite clinical response does not occur within 3 to 5 days, therapy should be stopped and the antibiotic susceptibility pattern of the invading organism should be rechecked. Failure of the infection to respond may be due to resistance of the organism or to the presence of septic foci requiring surgical drainage.

When amikacin is indicated in uncomplicated urinary tract infections, a dose of 250 mg twice daily may be used.

DOSAGE GUIDELINES ADULTS AND CHILDREN WITH NORMAL RENAL FUNCTION				
Patient Weight		Dosage		
lbs	kg	7.5 mg/kg q12h	OR	5 mg/kg q8h
99	45	337.5 mg		225 mg
110	50	375 mg		250 mg
121	55	412.5 mg		275 mg
132	60	450 mg		300 mg
143	65	487.5 mg		325 mg
154	70	525 mg		350 mg
165	75	562.5 mg		375 mg
176	80	600 mg		400 mg
187	85	637.5 mg		425 mg
198	90	675 mg		450 mg
209	95	712.5 mg		475 mg
220	100	750 mg		500 mg

#### **Intramuscular Administration for Patients with Impaired Renal Function**

Whenever possible, serum amikacin concentrations should be monitored by appropriate assay procedures. Doses may be adjusted in patients with impaired renal function either by administering normal doses at prolonged intervals or by administering reduced doses at a fixed interval.

Both methods are based on the patient's creatinine clearance or serum creatinine values since these have been found to correlate with aminoglycoside half-lives in patients with diminished renal function. These dosage schedules must be used in conjunction with careful clinical and laboratory observations of the patient and should be modified as necessary. Neither method should be used when dialysis is being performed.

#### **Normal Dosage at Prolonged Intervals**

If the creatinine clearance rate is not available and the patient's condition is stable, a dosage interval in hours for the normal dose can be calculated by multiplying the patient's serum creatinine by 9, e.g., if the serum creatinine concentration is 2 mg/100 mL, the recommended single dose (7.5 mg/kg) should be administered every 18 hours.

#### **Reduced Dosage at Fixed Time Intervals**

When renal function is impaired and it is desirable to administer amikacin at a fixed time interval, dosage must be reduced. In these patients, serum amikacin concentrations should be measured to assure accurate administration of amikacin and to avoid concentrations above 35 mcg/mL. If serum assay determinations are not available and the patient's condition is stable, serum creatinine and creatinine clearance values are the most readily available indicators of the degree of renal impairment to use as a guide for dosage.

First, initiate therapy by administering a normal dose, 7.5 mg/kg, as a loading dose. This loading dose is the same as the normally recommended dose which would be calculated for a patient with a normal renal function as described above.

To determine the size of maintenance doses administered every 12 hours, the loading dose should be reduced in proportion to the reduction in the patient's creatinine clearance rate:

Maintenance Dose = $\frac{\text{observed CC in mL/min}}{\text{normal CC in mL/min}} \times \text{Calculated loading dose in mg}$
Every 12 Hours
(CC=creatinine clearance rate)

An alternate rough guide for determining reduced dosage at 12-hour intervals (for patients whose steady state serum creatinine values are known) is to divide the normally recommended dose by the patient's serum creatinine.

The above dosage schedules are not intended to be rigid recommendations but are provided as guides to dosage when the measurement of amikacin serum levels is not feasible.

#### **Intravenous Administration**

The individual dose, the total daily dose, and the total cumulative dose of amikacin sulfate are identical to the dose recommended for intramuscular administration. The solution for intravenous use is prepared by adding the contents of a 500 mg vial to 100 or 200 mL of sterile diluent such as 0.9% sodium chloride injection or 5% dextrose injection or any of the compatible solutions listed below.

The solution is administered to adults over a 30 to 60 minute period. The total daily dose should not exceed 15 mg/kg/day and may be divided into either 2 or 3 equally-divided doses at equally-divided intervals.

In pediatric patients the amount of fluid used will depend on the amount of amikacin ordered for the patient. It should be a sufficient amount to infuse the amikacin sulfate injection over a 30 to 60 minute period. Infants should receive a 1 to 2 hour infusion.

Amikacin should not be physically premixed with other drugs but should be administered separately according to the recommended dose and route.

#### **Stability in IV Fluids**

Amikacin sulfate is stable for 24 hours at room temperature at concentrations of 0.25 and 5 mg/mL in the following solutions:

- 5% Dextrose Injection
- 5% Dextrose and 0.2% Sodium Chloride Injection
- 5% Dextrose and 0.45% Sodium Chloride Injection
- 0.9% Sodium Chloride Injection
- Lactated Ringer's Injection

Normosol® M in 5% Dextrose Injection (or Plasma-Lyte 56 Injection in 5% Dextrose in Water)

Normosol® R in 5% Dextrose Injection (or Plasma-Lyte 148 Injection in 5% Dextrose in Water)

In the above solutions with amikacin sulfate injection concentrations of 0.25 and 5 mg/mL, solutions aged for 60 days at 4°C and then stored at 25°C had utility times of 24 hours.

At the same concentrations, solutions frozen and aged for 30 days at -15°C, thawed, and stored at 25°C had utility times of 24 hours.

Parenteral drug products should be inspected visually for particulate matter and discoloration prior to administration whenever the solution and container permit.

Aminoglycosides administered by any of the above routes should not be physically premixed with other drugs but should be administered separately.

Because of the potential toxicity of aminoglycosides, "fixed dosage" recommendations which are not based upon body weight are not advised. Rather, it is essential to calculate the dosage to fit the needs of each patient.

#### **HOW SUPPLIED:**

Amikacin Sulfate Injection, USP, is supplied as a colorless solution which requires no refrigeration. At times the solution may become a very pale yellow; this does not indicate a decrease in potency.

Product No.	NDC No.	Strength	Fill Volume
381502	63323-815-02	500 mg per 2 mL (250 mg per mL)	2 mL Single-Dose vial in packages of 10.
381504	63323-815-04	1,000 mg per 4 mL (250 mg per mL)	4 mL Single-Dose vial in packages of 10.
381602	63323-816-02	100 mg per 2 mL (50 mg per mL)	2 mL Single-Dose vial in packages of 10.

Store at 20° to 25°C (68° to 77°F) [see USP Controlled Room Temperature].

The container closure is not made with natural rubber latex.

#### **REFERENCES:**

1. Clinical and Laboratory Standards Institute (CLSI). *Methods for Dilution Antimicrobial Susceptibility Tests for Bacteria that Grow Aerobically; Approved Standard – Ninth Edition*. CLSI document M07-A9, Clinical and Laboratory Standards Institute, 950 West Valley Road, Suite 2500, Wayne, Pennsylvania 19087, USA, 2012.
2. Clinical and Laboratory Standards Institute (CLSI). *Performance Standards for Antimicrobial Disk Diffusion Susceptibility Tests; Approved Standard – Eleventh Edition*. CLSI document M02-A11, Clinical and Laboratory Standards Institute, 950 West Valley Road, Suite 2500, Wayne, Pennsylvania 19087, USA, 2012.
3. Clinical and Laboratory Standards Institute (CLSI). *Performance Standards for Antimicrobial Susceptibility Testing; Twenty-third Informational Supplement*. CLSI document M100-S23, Clinical and Laboratory Standards Institute, 950 West Valley Road, Suite 2500, Wayne, Pennsylvania 19087, USA, 2013.

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Made in Austria

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