**Digoxin**  
*(dih-JOX-in)*

**Classification:**  
Cardiac glycoside

**Pregnancy Category:** A  
(Rx) Digitek, Digoxin Injection Pediatric, Lanoxicaps, Lanoxin  
(Rx) Digoxin Injection C.S.D., Digoxin Pediatric Injection C.S.D.

**Action/Kinetics:** Digoxin increases the force and velocity of myocardial contraction (positive inotropic effect) by increasing the refractory period of the AV node and increasing total peripheral resistance. This effect is due to inhibition of sodium/potassium–ATPase in the sarcolemmal membrane, which alters excitation–contraction coupling. Inhibiting sodium/potassium–ATPase results in increased calcium influx and increased release of free calcium ions within the myocardial cells, which then potentiate the contractility of cardiac muscle fibers. Digoxin also decreases the rate of conduction and increases the refractory period of the AV node due to an increase in parasympathetic tone and a decrease in sympathetic tone. Clinical effects are not seen until steady-state plasma levels are reached. The initial dose of digoxin is larger (loading dose) and is traditionally referred to as the digitalizing dose; subsequent doses are referred to as maintenance doses. **Onset:** PO, 0.5–2 hr; **time to peak effect:** 2–6 hr. **Duration:** Over 24 hr. **Onset:** IV, 5–30 min; **time to peak effect:** 1–4 hr. **Duration:** 6 days. **t½:** 30–40 hr. **Therapeutic serum level:** 0.5–2.0 ng/mL. From 20% to 25% is protein bound. Serum levels above 2.5 ng/mL indicate toxicity. Fifty percent to 70% is excreted unchanged by the kidneys. Bioavailability depends on the dosage form: tablets (60–80%), capsules (90–100%), and elixir (70–85%). Thus, changing dosage forms may require dosage adjustments.

**Uses:** (1) CHF, including that due to venous congestion, edema, dyspnea, orthopnea, and cardiac arrhythmia. May be drug of choice for CHF because of rapid onset, relatively short duration, and ability to be administered PO or IV. (2) Control of rapid ventricular contraction rate in clients with atrial fibrillation or flutter. (3) Slow HR in sinus tachycardia due to CHF. (4) SVT. (5) Prophylaxis and treatment of recurrent paroxysmal atrial tachycardia with paroxysmal AV junctional rhythm. (6) Cardiogenic shock (value not established).

**Contraindications:** Ventricular fibrillation or tachycardia (unless congestive failure supervenes after protracted episode not due to digitalis), in presence of digoxin toxicity, hypersensitivity to cardiac glycosides, beriberi heart disease, certain cases of hypersensitive carotid sinus syndrome.

**Special Concerns:** Use with caution in clients with ischemic heart disease, acute myocarditis, hypertrophic subaortic stenosis, hypoxic or myxedematous states, Adams-Stokes or carotid sinus syndromes, cardiac amyloidosis, or cyanotic heart and lung disease, including emphysema and partial heart block. Those with carditis associated with rheumatic fever or viral myocarditis are especially sensitive to digoxin-induced disturbances in rhythm. Electric pacemakers may sensitize the myocardium to cardiac glycosides. Also use with caution and at reduced dosage in elderly, debilitated clients, pregnant women and nursing mothers, and newborn, term, or premature infants who have immature renal and hepatic function and in reduced renal and/or hepatic function.

The half-life of digoxin is prolonged in the elderly; anticipate smaller drug doses. Be especially alert to cardiac arrhythmias in children. This sign of toxicity occurs more frequently in children than in adults.

**Side Effects:** Digoxin is extremely toxic and has caused death even in clients who have received the drug for long periods of time. There is a narrow margin of safety between an effective therapeutic dose and a toxic dose. Overdosage caused by the cumulative effects of the drug is a constant danger in therapy. Digoxin toxicity is characterized by a wide variety of symptoms, which are hard to differentiate from those of the cardiac disease itself.

One of the most serious side effects of digoxin is hypokalemia. This may lead to cardiac arrhythmias, muscle weakness, hypotension, and respiratory distress. Other agents causing hypokalemia reinforce this effect and increase the chance of digitalis toxicity. Such reactions may occur in clients who have been on digoxin maintenance for a long time. **CV:** Changes in the rate, rhythm, and irritability of the heart and the mechanism of the heartbeat. Extrasystoles, bigeminal pulse, coupled rhythm, ectopic beat, and other forms of arrhythmias have been noted. Death most often results from ventricular fibrillation. Discontinue digoxin in adults when pulse rate falls below 60 beats/min. All cardiac changes are best detected by the ECG, which is also most useful in clients suffering from intoxication. **GI:** Anorexia, N&V, excessive salivation, epigastric distress, abdominal pain, diarrhea, bowel necrosis. Clients on digoxin therapy may experience two vomiting stages. The first is an early sign of toxicity and is a direct effect of digoxin on the GI tract. Late vomiting indicates stimulation of the vomiting center of the brain, which occurs after the heart muscle has been saturated with digoxin. **CNS:** Headaches, fatigue, lassitude, irritability, malaise, muscle weakness, insomnia, stupor. Psy-
chotomimetic effects (especially in elderly or arteriosclerotic clients or neonates) including disorientation, confusion, depression, aphasia, delirium, hallucinations, and, rarely, convulsions. Neuromuscular: Neurologic pain involving the lower third of the face and lumbar areas, paresthesia. Visual disturbances: Blurred vision, flickering dots, white halos, borders around dark objects, diplopia, ambylopia, color perception changes. Hypersensitivity (5–7 days after starting therapy): Skin reactions (urticaria, fever, pruritus, facial and angioneurotic edema). Other: Chest pain, coldness of extremities.

Laboratory Test Considerations:
May ↓ PT. Alters tests for 17-ketosteroids and 17-hydroxycorticosteroids.

OD Overdose Management: The relationship of digoxin levels to symptoms of toxicity varies significantly from client to client; thus, it is not possible to identify digoxin levels that would define toxicity accurately. Symptoms (Toxicity): GI: Anorexia, N&V, diarrhea, abdominal discomfort, or pain. CNS: Blurred, yellow, or green vision and halo effect; headache, weakness, drowsiness, mental depression, apathy, restlessness, disorientation, confusion, seizures, EEG abnormalities, delirium, hallucinations, neuralgia, psychosis. CV: VT, unifocal or multiform PVCs (especially in bigeminal or trigeminal patterns), paroxysmal/nonparoxysmal nodal rhythms, AV dissociation, accelerated junctional rhythm, excessive slowing of the pulse, AV block (may proceed to complete block), atrial fibrillation, ventricular fibrillation (most common cause of death). Children: Visual disturbances, headache, weakness, apathy, and psychosis occur but may be difficult to recognize. CV: Conduction disturbances, supraventricular tachyarrhythmias (e.g., AV block), atrial tachycardia with or without block, nodal tachycardia, unifocal or multiform ventricular premature contractions, ventricular tachycardia, sinus bradycardia (especially in infants). Treatment in Adults:

- Discontinue drug, admit to ICU for continuous ECG monitoring.
- If serum potassium is below normal, KCl should be administered in divided PO doses totaling 3–6 g (40–80 mEq). Potassium should not be used when severe or complete heart block is due to digoxin and not related to tachycardia.
- Atropine: A dose of 0.01 mg/kg IV to treat severe sinus bradycardia or slow ventricular rate due to secondary AV block.
- Cholestyramine, colestipol, activated charcoal: To bind digitalis in the intestine, thus preventing enterohepatic recirculation.
- Digoxin immune FAB: See drug entry. Given in approximate equimolar quantities as digoxin, it reverses S&S of toxicity, often with improvement within 30 min.
- Lidocaine: A dose of 1 mg/kg given over 5 min followed by an infusion of 15–50 mcg/kg/min to maintain normal cardiac rhythm.
- Phenytoin: For atrial or ventricular arrhythmias unresponsive to potassium, can give a dose of 0.5 mg/kg at a rate not exceeding 50 mg/min (given at 1–2 hr intervals). The maximum dose should not exceed 10 mg/kg/day.
- Countershock: A direct-current countershock can be used only as a last resort. If required, initiate at low voltage levels.

Treatment in Children: Give potassium in divided doses totaling 1–1.5 mEq/kg (if correction of arrhythmia is urgent, a dose of 0.5 mEq/kg/hr can be used) with careful monitoring of the ECG. The potassium IV solution should be dilute to avoid local irritation although IV fluid overload must be avoided. Digoxin immune FAB may also be used.

Digoxin is not removed effectively by dialysis, by exchange transfusion, or during cardiopulmonary bypass as most of the drug is found in tissues rather than the circulating blood.

Drug Interactions:
The following drugs increase serum digoxin levels, leading to possible toxicity: Aminoglycosides, amiodarone, anticholinergics, atorvastatin, benzodiazepines, captopril, diltiazem, dipyridamole, erythromycin, esmolol, flecainide, hydroxychloroquine, ibuprofen, indomethacin, itraconazole, nifedipine, quinidine, quinine, telmisartan, tetracyclines, tolbutamide, verapamil.

- Albuterol / Digoxin binding to skeletal muscle
- H Aloe / Potential for digoxin effect R/T aloe-induced hypokalemia
- Amiloride / Digoxin inotropic effects

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Digoxin effect R/T GI tract absorption

• Aminosalicylic acid / Digoxin effect R/T GI tract absorption
• Amphotericin B / K depletion caused by digoxin; risk of digitalis toxicity
• Antacids / Digoxin effect R/T GI tract absorption
• Beta blockers / Complete heart block possible
• Buckthorn bark/berry / Potential for digoxin effect R/T to buckthorn-induced hypokalemia
• Calcium preparations / Cardiac arrhythmias following parenteral calcium
• Cascara sagrada bark / Potential for digoxin effect R/T to cascara-induced hypokalemia
• Chlorthalidone / K and Mg loss with chance of digitalis toxicity
• Cholestyramine / Binds digoxin in the intestine and its absorption
• Colestipol / Binds digoxin in the intestine and its absorption
• Disopyramide / May alter effect of digoxin
• Ephedra / Chance of cardiac arrhythmias
• Ephedrine / Chance of cardiac arrhythmias
• Epinephrine / Chance of cardiac arrhythmias
• Ethacrynic acid / K and Mg loss with chance of digitalis toxicity
• Fluoxetine / Possible serum digoxin levels
• Furosemide / K and Mg loss with chance of digoxin toxicity
• German chamomile flower / Potential for digoxin effect R/T to chamomile-induced hypokalemia
• Ginseng / Digoxin levels
• Glucose infusions / Large infusions of glucose may cause in serum potassium and chance of digoxin toxicity
• Grapefruit juice / Digoxin bioavailability; do not take digoxin with grapefruit juice
• Hawthorn / Potentiation of digoxin effect
• Hypoglycemic drugs / Effect of digitalis glycosides due to breakdown by liver
• Iceland moss / Potential for digoxin effect R/T to iceland moss-induced hypokalemia
• Indian snakeroot / Risk of bradycardia
• Ivy leaf / Potential for digoxin effect R/T to ivy leaf-induced hypokalemia
• Levothyroxine / Serum levels and therapeutic digoxin effect
• Licorice / Potential for digoxin effect R/T to licorice-induced hypokalemia
• Marshmallow root / Potential for digoxin effect R/T to marshmallow root-induced hypokalemia
• Methimazole / Chance of toxic effects of digitalis

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• Metoclopramide / ↓ Digoxin effect R/T ↓ GI tract absorption
• Muscle relaxants, nondepolarizing / ↑ Risk of cardiac arrhythmias
• Penicillamine / ↓ Serum digoxin levels.
• Propranolol / Potentiates digitalis-induced bradycardia
• Rhubarb root / Potential for ↑ digoxin effect R/T to rhubarb root-induced hypokalemia
• St. John's wort / ↓ Digoxin plasma levels R/T ↑ renal excretion
• Sarsaparilla root / Potential for ↑ absorption of digoxin
• Senna pod/leaf / Potential for ↑ digoxin effect R/T to senna-induced hypokalemia
• Spironolactone / Either ↑ or ↓ toxic effects of digoxin
• Succinylcholine / ↑ Chance of cardiac arrhythmias
• Sulfasalazine / ↓ Digoxin effect of R/T ↓ GI tract absorption
• Sympathomimetics / ↑ Chance of cardiac arrhythmias
• Thiazides / ↑ K and Mg loss with ↑ chance of digoxin toxicity
• Thioamides / ↑ Effect and toxicity of digoxin
• Thyroid / ↓ Digoxin effect
• Triamterene / ↑ Digoxin effects

**How Supplied:** Capsule: 0.05 mg, 0.1 mg, 0.2 mg; Elixir, Pediatric: 0.05 mg/mL; Injection: 0.1 mg/mL, 0.25 mg/mL; Tablet: 0.125 mg, 0.25 mg

**Dosage**

- **Capsules**
- **Digitalization:** Rapid.

**Adults:** 0.4–0.6 mg initially followed by 0.1–0.3 mg q 6–8 hr until desired effect achieved.
- **Digitalization:** Slow.

**Adults:** A total of 0.05–0.35 mg/day divided in two doses for a period of 7–22 days to reach steady-state serum levels. **Pediatric.** Digitalizing dosage is divided into three or more doses with the initial dose being about one-half the total dose; doses are given q 4–8 hr. **Children, 10 years and older:** 0.008–0.012 mg/kg. **5–10 years:** 0.015–0.03 mg/kg. **2–5 years:** 0.025–0.035 mg/kg. **1 month–2 years:** 0.03–0.05 mg/kg. **Neonates, full-term:** 0.02–0.03 mg/kg. **Neonates, premature:** 0.015–0.025 mg/kg.
- **Maintenance.**

**Adults:** 0.05–0.35 mg once or twice daily. **Premature neonates:** 20–30% of total digitalizing dose divided and given in two to three daily doses. **Neonates to 10 years:** 25–35% of the total digitalizing dose divided and given in two to three daily doses.
- **Elixir, Tablets**
- **Digitalization:** Rapid.

**Adults:** A total of 0.75–1.25 mg divided into two or more doses each given at 6–8-hr intervals.
- **Digitalization:** Slow.

**Adults:** 0.125–0.5 mg/day for 7 days. **Pediatric.** (Digitalizing dose is divided into two or more doses and given at 6–8-hr intervals.) **Children, 10 years and older, rapid or slow:** Same as adult dose. **5–10 years:** 0.02–0.035 mg/kg. **2–5 years:** 0.03–0.05 mg/kg. **1 month–2 years:** 0.035–0.06 mg/kg. **Premature and newborn infants to 1 month:** 0.02–0.035 mg/kg.
Maintenance.

Adults: 0.125–0.5 mg/day. Pediatric: One-fifth to one-third the total digitalizing dose daily. NOTE: An alternate regimen (referred to as the “small-dose” method) is 0.017 mg/kg/day. This dose causes less toxicity.

- IV
- Digitalization.

Adults: Same as tablets. Maintenance: 0.125–0.5 mg/day in divided doses or as a single dose. Pediatric: Same as tablets.

Nursing Considerations

Administration/Storage:

1. Measure liquids precisely, using a calibrated dropper or syringe.
2. Obtain written parameters indicating the pulse rates, both high and low, at which cardiac glycosides are to be held; changes in rate or rhythm may indicate toxicity.
3. Lanoxicaps gelatin capsules are more bioavailable than tablets. Thus, the 0.05-mg capsule is equivalent to the 0.0625-mg tablet; the 0.1-mg capsule is equivalent to the 0.125-mg tablet, and the 0.2-mg capsule is equivalent to the 0.25-mg tablet.
4. Differences in bioavailability have been noted between products; monitor clients when changing from one product to another.
5. If switching from tablets or elixir to liquid filled capsules or parenteral route expect reduction in dosage as the absorption if much higher with the capsules and parenteral form.
6. Protect from light.
7. IV Give IV injections over 5 min (or longer) either undiluted or diluted fourfold or greater with sterile water for injection, 0.9% NaCl, RL injection, or D5W.

Assessment:

For clients starting on a digitalizing dose:

1. Document type, onset, and characteristics of symptoms. If administered for heart failure, note causes; ensure that failure not solely related to diastolic dysfunction as drug’s positive inotropic effect may increase cardiac outflow obstruction with hypertrophic cardiomyopathy.
2. Note any drugs prescribed that would adversely interact with digoxin and monitor; diuretics may increase toxicity.
3. Assess for hyper/hypothyroidism; hypothyroid clients are sensitive to glycosides while hyperthyroid clients may require a higher dose of drug.
4. Monitor CBC, serum electrolytes, calcium, Mg, liver and renal function tests. Reduce dose with renal dysfunction.
5. Obtain ECG; note rhythm/rate.
6. Document cardiopulmonary findings; note presence of S3, JVD, HJR, displaced PMI, HR above 100 bpm, rales, peripheral edema, DOE, PND, and echo, MUGA, and/or cardiac catheterization findings. Note NYHA Classification based on client symptoms.
7. Elderly clients must be observed for early S&S of toxicity (N&V, anorexia, confusion, and visual disturbances) because their rate of drug elimination is slower.

Interventions

For clients being digitalized and for clients on a maintenance dose of digoxin

1. During digitalization, monitor closely.
2. Observe monitor for bradycardia and/or arrhythmias, count apical rate for at least 1 min before administering the drug. Obtain written parameters (e.g., HR > 60 bpm) for drug administration.
   * Document adult HR below 50 bpm and hold drug. Report if an arrhythmia (irregular pulse) or any sudden increase or decrease in pulse rate, pulse deficit, and changes in rhythm occurs.
   * If child’s HR is 90–110 bpm or if an arrhythmia is present, withhold drug and report.
3. Anticipate more than once daily dosing in most children (up to age 10) due to higher metabolic activity.

4. With co-worker simultaneously take the apical and radial pulse for 1 min, and report pulse deficit (e.g., the wrist rate is less than the apical rate); may indicate an adverse drug reaction.

5. Monitor weights and I&O. Weight gain may indicate edema. Adequate intake will help prevent cumulative toxic drug effects.

6. If taking non-potassium-sparing diuretics as well as digoxin, will need potassium supplements. Provide the most palatable preparation available. (Liquid potassium preparations are usually bitter.)

7. If gastric distress experienced, use an antacid. Antacids containing Al or Mg and kaolin/pectin mixtures should be given 6 hr before or 6 hr after dose of cardiac glycoside to prevent decreased therapeutic effects.

8. When given to newborns, use a cardiac monitor to identify early evidence of toxicity: excessive slowing of sinus rate, sinoatrial arrest, or prolonged PR interval.

9. Monitor digoxin levels periodically and assess for symptoms of toxicity; draw specimen more than 6 hr after last dose. Have digoxin antidote available (digoxin immune FAB) for severe toxicity.

10. Use caution; digoxin withdrawal may worsen heart failure.

Client/Family Teaching:
1. Take after meals to lessen gastric irritation.

2. Do not take with grapefruit juice.

3. Maintain a written record of pulse rates and weights; review guidelines for withholding medication and reporting abnormal pulse rates.

4. Do not change brands; different preparations have variations in bioavailability and could cause toxicity or loss of effect.

5. Follow directions carefully for taking the medication. If one dose of drug is accidentally missed, do not double up on the next dose.

6. Report any adverse effects or toxic drug symptoms: Anorexia, N&V, abdominal pain and diarrhea are often early symptoms due to the toxic effects on the GI tract and CTZ stimulation. Disorientation, agitation, visual disturbances, changes in color perception, irregular heart beat and hallucinations may also occur.

7. Maintain a sodium-restricted diet. Read labels and review foods low in sodium; consult dietitian for assistance in food selection, meal planning, and preparation.

8. Consult provider before taking any other medications, whether prescribed or OTC, because drug interactions occur frequently with cardiac glycosides.

9. Report any persistent cough, difficulty breathing, or swelling (S&S of CHF).

10. Identify community health agencies to assist in maintaining health.

11. Return for scheduled follow-up visits and lab tests.

Outcomes/Evaluate:
* Stable cardiac rate and rhythm, improved breathing patterns, ↓ severity of S&S of CHF, improved CO, improved activity tolerance, ↓ weight, and improved diuresis

* Serum drug levels within therapeutic range (e.g., digoxin 0.5–2.0 ng/mL)