MEDLAB BASICS · STUDY SHEET

# Endocrinology, Drug Monitoring and Toxicology

Thyroid, adrenal, pituitary and parathyroid patterns, stimulation and suppression tests, the hook effect, peak and trough timing, therapeutic ranges, the osmolal gap, acetaminophen, salicylate, lead, carbon monoxide and drug screens

42 sources + more detail
medlabbasics.com/sheets/lab-chemistry-endocrine-tdm-tox.html
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## 1 Thyroid patterns

| CONDITION | TSH | FREE T4 | T3 |
|---|---|---|---|
| **Primary hypothyroidism** | High | Low | Low or normal |
| **Subclinical hypothyroidism** | High | Normal | Normal |
| **Hyperthyroidism (Graves, toxic nodule)** | Low | High | High |
| **T3 toxicosis** | Low | Normal | High |
| **Secondary (pituitary) hypothyroidism** | Low or normal | Low | Low or normal |
| **TSH-secreting adenoma or thyroid hormone resistance (rare)** | Normal or high | High | High |
| **Estrogen or pregnancy (high TBG)** | Normal | Normal | Total T3 and T4 high |
| **Euthyroid sick (nonthyroidal illness)** | Normal, low or high | Normal or low | Low |

EXAM TIP TSH is the first test. A low or normal TSH with a low free T4 is not primary disease: think pituitary. High TBG raises total, not free, hormone.

SAFETY High-dose biotin on a streptavidin-biotin platform reads sandwich assays (TSH) falsely low and competitive assays (free T4) falsely high: a false Graves pattern. Ask about biotin and retest after a washout of at least 72 hours.

## 2 Adrenal, pituitary and parathyroid

| QUESTION | TEST | RESULT THAT ANSWERS IT |
|---|---|---|
| **Cortisol excess (Cushing)?** | 1-mg overnight dexamethasone; late-night salivary cortisol; 24-h urine free cortisol | 8 AM cortisol not suppressed below 1.8 µg/dL (50 nmol/L); late-night cortisol high; UFC high on 2-3 collections |
| **Which source of excess?** | Plasma ACTH | Undetectable: adrenal tumor. High: pituitary or ectopic ACTH |
| **Cortisol deficiency (Addison)?** | Morning cortisol and ACTH; cosyntropin 250 µg, cortisol at 0, 30, 60 min | Peak below about 18 µg/dL (500 nmol/L), assay-dependent. Primary: ACTH high; secondary: ACTH low |
| **Primary aldosteronism?** | Morning plasma aldosterone and renin activity | Aldosterone high, renin suppressed, ratio above about 20; confirm with saline or salt loading |
| **Pheochromocytoma?** | Plasma free or 24-h urine fractionated metanephrines | Metanephrine or normetanephrine high; normal results while hypertensive make it unlikely |
| **Prolactinoma?** | Prolactin (dilute if the tumor is large) | Usually more than 5 times normal |
| **GH excess (acromegaly)?** | IGF-1 screen; GH after 75-g oral glucose | IGF-1 high; GH fails to fall below 1 ng/mL (0.4 on sensitive assays) |
| **Primary hyperparathyroidism?** | Calcium with intact PTH | Calcium high, phosphate low, PTH inappropriately high (not suppressed) |
| **Vitamin D status?** | 25-hydroxyvitamin D (not 1,25) | Target above 20 ng/mL (50 nmol/L) |

EXAM TIP Test logic: suspect deficiency, stimulate (cosyntropin); suspect excess, suppress (dexamethasone, glucose for GH, saline for aldosterone). A gland that is autonomous ignores the feedback signal.

SAFETY Hook effect: in a one-step sandwich immunoassay, extreme antigen (prolactin in a macroadenoma, hCG in a molar pregnancy) saturates both antibodies and the result reads falsely low or negative. Repeat on a dilution: a hook shows a much higher corrected value.

## 3 Therapeutic drug monitoring

- Trough: drawn just before the next dose (aminoglycosides: within 30 minutes before it).
- Peak: timing varies by drug. Gentamicin: 30 minutes after the end of a 30-minute infusion, or 60 minutes after IM.
- Steady state: about 5 half-lives after starting or changing a dose; drawing earlier underestimates the level.
- Digoxin: at least 6-8 hours after the dose, after distribution; earlier samples read falsely high.
- A level is useless without the time of the last dose and the time of collection.


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# Endocrinology, Drug Monitoring and Toxicology



## 3 Therapeutic drug monitoring CONTINUED

| DRUG | USUAL RANGE | LAB POINT |
|---|---|---|
| **Gentamicin** | Conventional: peak 5-8, trough under 2 µg/mL. Once daily: peak 15-20, trough under 1 µg/mL | Nephrotoxic and ototoxic; trough tracks toxicity |
| **Vancomycin** | AUC 400-600 mg·h/L (trough-only 15-20 target no longer recommended) | Post-distribution level plus trough, or Bayesian software |
| **Digoxin** | 0.8-2.0 ng/mL (1.0-2.6 nmol/L) lab range; 0.5-0.8 in heart failure | Low K or Mg, high Ca and renal failure cause toxicity at 'normal' levels |
| **Phenytoin** | Total 10-20 µg/mL (40-79 µmol/L); free 1-2 µg/mL | About 10% free; measure free when albumin is low or in renal failure |
| **Valproic acid** | 50-100 µg/mL (347-693 µmol/L) | Trough 12 h after the last dose (24 h for once-daily forms) |
| **Carbamazepine** | 4-12 µg/mL (17-51 µmol/L) | Trough 12 h after dose |
| **Lithium** | 0.6-1.2 mmol/L; maintenance often 0.6-1.0 | 12 ± 1 h after the last dose; never a lithium heparin tube |
| **Tacrolimus** | Trough set by the transplant program (often 3-10 µg/L) | Whole blood, not serum or plasma |
| **Cyclosporine** | Trough (C0) or 2-h (C2) targets set by program and assay | Whole blood; methods not interchangeable |
| **Methotrexate (high dose)** | Timed levels after infusion (24, 36, 42, 48 h) in µmol/L | Delayed clearance guides rescue; immunoassay overreads after glucarpidase |

⚠ **SAFETY** Lithium drawn into a lithium heparin tube can read in the toxic range in a patient who is not toxic, worst when the tube is underfilled. Recollect in a tube without lithium.

## 4 Toxicology

Calculated osmolality = 2 × Na + glucose/18 + BUN/2.8 + ethanol/4.6 (glucose, BUN and ethanol in mg/dL). Osmolal gap = measured − calculated; over 10 mOsm/kg points to an unmeasured osmole. See the Osmolality and Osmolar Gap calculators.

| POISON | KEY LABORATORY FINDING |
|---|---|
| **Methanol** | Osmolal gap early; high anion gap acidosis later (formic acid) |
| **Ethylene glycol** | Osmolal gap early; anion gap acidosis (glycolic acid); calcium oxalate crystals; falsely high lactate on lactate oxidase analyzers |
| **Isopropanol** | Osmolal gap and acetone (ketones) without acidosis |
| **Acetaminophen** | Level at 4 h or later plotted on the nomogram (150 µg/mL [990 µmol/L] at 4 h); AST and ALT peak at 72-96 h |
| **Salicylate** | Respiratory alkalosis first, then anion gap metabolic acidosis; serial levels (therapeutic 10-20 mg/dL) |
| **Lead** | Whole blood lead; 3.5 µg/dL (0.17 µmol/L) or more needs action; basophilic stippling, microcytic anemia |
| **Carbon monoxide** | Carboxyhemoglobin by co-oximetry (venous is fine); pulse oximetry and calculated saturation look normal |

💡 **EXAM TIP** A gap that the measured ethanol does not explain is a co-ingested toxic alcohol until proven otherwise. A normal gap late after ingestion does not rule one out: the parent alcohol has already become acid.

## 5 Drug screens

- Screen: immunoassay with a cutoff; reports a class by cross-reactivity with the calibrator drug.
- Confirm: a different principle with mass spectrometric identification (GC-MS, LC-MS, LC-MS/MS) at a lower, analyte-specific cutoff.
- Opiate screens are built on morphine: they miss fentanyl and methadone and may miss oxycodone and buprenorphine. Order specific tests.
- Forensic (workplace) testing adds chain of custody, a temperature check (32-38 °C within 4 minutes) and specimen validity testing.

| CLASS (HHS URINE PANEL) | SCREEN CUTOFF | CONFIRMATION CUTOFF |
|---|---|---|
| **Marijuana metabolite (THCA)** | 50 ng/mL | 15 ng/mL |
| **Cocaine metabolite (benzoylecgonine)** | 150 ng/mL | 100 ng/mL |
| **Codeine/morphine** | 2,000 ng/mL | 2,000 codeine; 4,000 morphine |
| **6-Acetylmorphine (heroin)** | 10 ng/mL | 10 ng/mL |
| **Amphetamine/methamphetamine** | 500 ng/mL | 250 ng/mL each |
| **Fentanyl** | 1 ng/mL | 1 ng/mL fentanyl or norfentanyl |

## MORE Toxicology in depth

| STEP | WORKED EXAMPLE: NA 138, GLUCOSE 90, BUN 14, ETHANOL 230 MG/DL, MEASURED 366 MOSM/KG |
|---|---|
| **2 × Na** | 276 |
| **Glucose/18 + BUN/2.8** | 5 + 5 = 10 |
| **Ethanol/4.6** | 50 |
| **Calculated osmolality** | 336 mOsm/kg |
| **Gap** | 366 − 336 = 30: ethanol does not explain it; request specific methanol and ethylene glycol levels |


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