

ECG RESIDENT REVIEW

Emergency Medicine | Cardiac Arrhythmias · Ischemia · Metabolic · Syndromes

40 CASES · QUESTION & ANSWER FORMAT

Jose A. Rubero MD, FACEP
Professor in Emergency Medicine

RHYTHMS

15 cases

ISCHEMIA / MI

9 cases

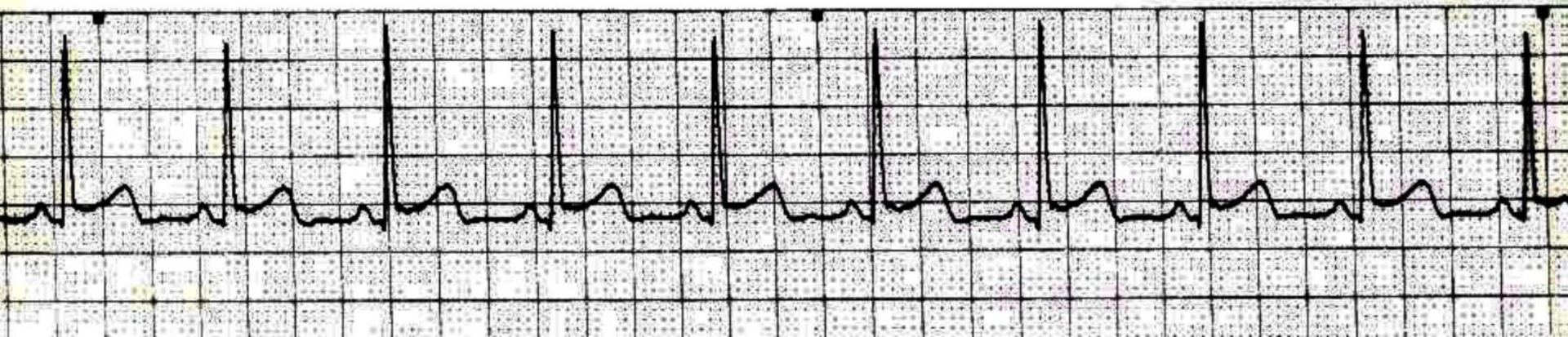
METABOLIC

7 cases

SYNDROMES

9 cases

A 35-year-old woman with routine pre-op evaluation. No complaints. BP 118/76, HR 72.

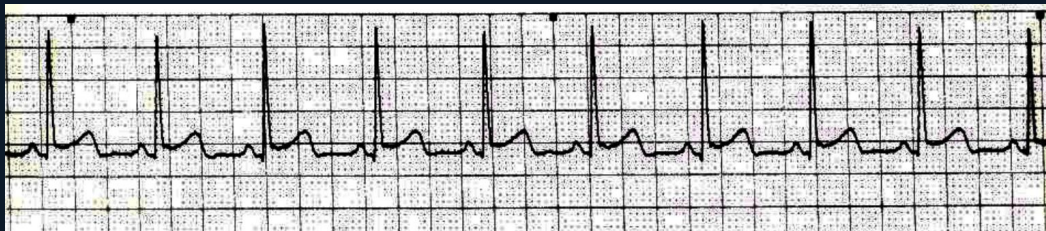


INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



NORMAL SINUS RHYTHM



KEY FINDINGS

- Rate 72 bpm (60–100 normal)
- Regular rhythm
- Upright P waves in II (before every QRS)
- Normal PR interval (120–200 ms)
- Narrow QRS < 120 ms

CLINICAL PEARL

NSR criteria: rate 60–100, regular, P before every QRS, normal PR/QRS. Commit this baseline to memory — every abnormality is a deviation from it.

A 35-year-old woman with routine pre-op evaluation. No complaints. BP 118/76, HR 72.

A 28-year-old woman in the ED with fever 39.2°C, HR 115, BP 104/68. Diaphoretic.



INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



SINUS TACHYCARDIA



KEY FINDINGS

- Rate >100 bpm (here ~115)
- Regular rhythm
- Normal P waves precede every QRS
- PR and QRS normal
- P waves may be closer to preceding T wave

CLINICAL PEARL

Sinus tach is almost always a sign of something else: fever, pain, hypovolemia, PE, hyperthyroidism, anemia. Treat the cause, not the rate.

A 28-year-old woman in the ED with fever 39.2°C, HR 115, BP 104/68. Diaphoretic.

A 72-year-old woman presenting with collapse. HR 38, BP 82/54.



INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



SINUS BRADYCARDIA



KEY FINDINGS

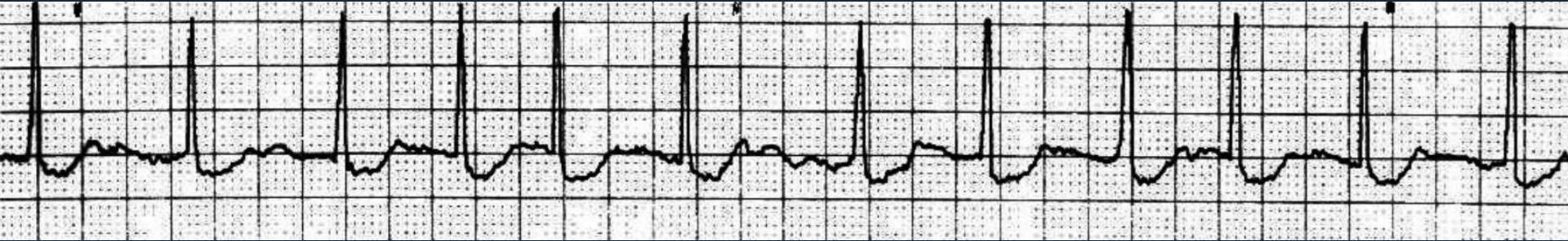
- Rate < 60 bpm (here ~38)
- Regular rhythm
- Normal P waves before every QRS
- Normal PR and QRS intervals
- Symptomatic → treat

CLINICAL PEARL

Causes: athletes (normal), medications (beta-blockers, digoxin), hypothyroidism, sick sinus syndrome, inferior MI (RCA → SA node). Symptomatic → atropine 0.5 mg IV, then pacing.

A 72-year-old woman presenting with collapse. HR 38, BP 82/54.

A 58-year-old woman with palpitations and mild dyspnea. HR 130, BP 108/72. Irregular.



INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



ATRIAL FIBRILLATION WITH RAPID VENTRICULAR RESPONSE



KEY FINDINGS

- Irregularly irregular rhythm (hallmark)
- No organized P waves
- Fibrillatory (chaotic) baseline
- Narrow QRS (unless aberrant conduction)
- Rate > 100 = rapid ventricular response

CLINICAL PEARL

AF is the most common sustained arrhythmia. CHA₂DS₂-VASc score guides anticoagulation. Rate control: beta-blocker or diltiazem. Duration < 48 h or hemodynamic instability → consider cardioversion.

A 58-year-old woman with palpitations and mild dyspnea. HR 130, BP 108/72. Irregular.

A 45-year-old man with sudden palpitations and mild SOB. HR 150, BP 118/76, regular.



INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



ATRIAL FLUTTER WITH 2:1 BLOCK



KEY FINDINGS

- Regular rhythm at ~150 bpm
- Sawtooth flutter waves (best in II, III, aVF)
- Atrial rate ~300 bpm
- 2:1 AV block → ventricular rate 150
- Narrow QRS

CLINICAL PEARL

Atrial rate always ~300. 2:1 block = ventricular rate ~150. If you see a regular tachycardia at 150, think flutter until proven otherwise. Vagal maneuvers/adenosine unmask flutter waves.

A 45-year-old man with sudden palpitations and mild SOB. HR 150, BP 118/76, regular.

A 40-year-old woman from husband's funeral. Anxious, HR 160, regular, BP 122/80.

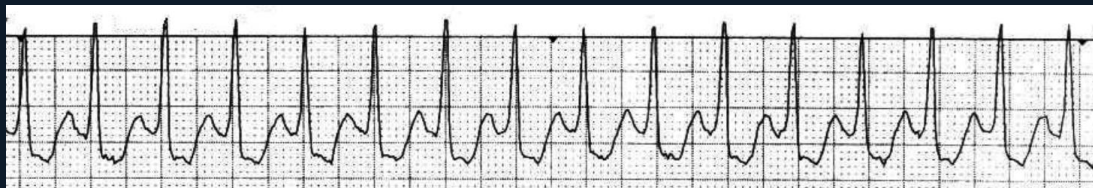


INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



SUPRAVENTRICULAR TACHYCARDIA (AVNRT)



KEY FINDINGS

- Rate 150–220 bpm
- Strictly regular
- No visible P waves (buried in QRS)
- Narrow QRS complex
- Abrupt onset and termination

CLINICAL PEARL

SVT: vagal maneuvers (Valsalva, carotid massage) → adenosine 6 mg rapid IV push (12 mg if no response). If SVT with aberrancy or uncertain → procainamide (avoid adenosine in WPW-related SVT).

A 40-year-old woman from husband's funeral. Anxious, HR 160, regular, BP 122/80.

A 55-year-old man with palpitations. "Skipped beats." HR 72 overall.



INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



NORMAL SINUS RHYTHM WITH PACS



KEY FINDINGS

- Underlying NSR
- Early beat with different P wave morphology
- Narrow QRS (same as sinus)
- Incomplete compensatory pause
- Can cause ABRUPT narrow-complex irregularity

CLINICAL PEARL

PACs are usually benign. High PAC burden (>10,000/day) can precipitate AF. If symptomatic: reduce caffeine/alcohol, beta-blockers. No anticoagulation needed.

A 55-year-old man with palpitations. "Skipped beats." HR 72 overall.

A 60-year-old man with hypertension. Feels "extra beats." Bigeminy pattern.



INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



NSR WITH PVCS (BIGEMINY)



KEY FINDINGS

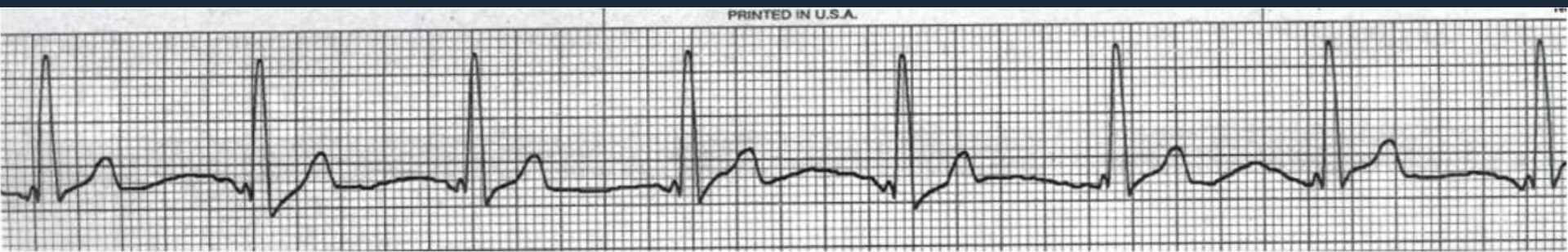
- Wide bizarre QRS (> 120 ms)
- No preceding P wave
- T wave in opposite direction to QRS
- Full compensatory pause after PVC
- Bigeminy = PVC after every sinus beat

CLINICAL PEARL

Occasional PVCs in a structurally normal heart are benign. High burden (>10 – 15% of beats) $\rightarrow$ evaluate for cardiomyopathy. PVC in VT context = different situation entirely.

A 60-year-old man with hypertension. Feels "extra beats." Bigeminy pattern.

A 68-year-old woman post-cardiac surgery. HR 48, BP 92/60. Narrow QRS, no P waves.

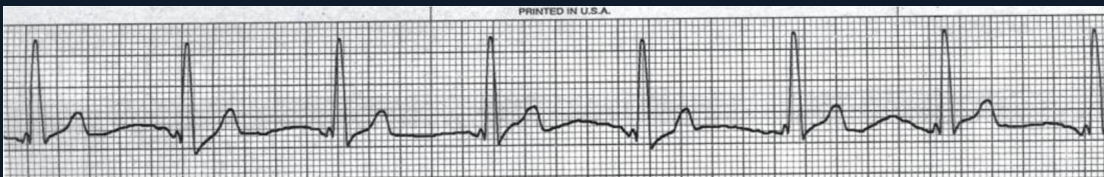


INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



JUNCTIONAL ESCAPE RHYTHM



KEY FINDINGS

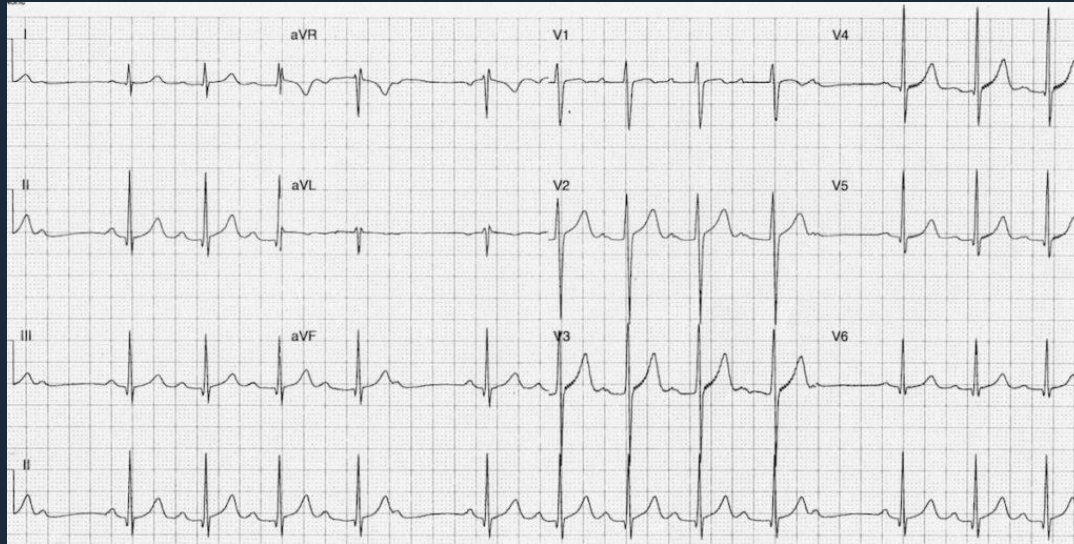
- Rate 40–60 bpm (escape rate)
- Regular rhythm
- Absent or retrograde P waves (before, during, or after QRS)
- Narrow QRS (conducted normally through His-Purkinje)
- Often a marker of SA node failure

CLINICAL PEARL

Junctional rhythm is a safety escape. Ask WHY the sinus node failed: increased vagal tone, ischemia (inferior MI), drugs, sick sinus syndrome. Symptomatic → atropine or pacing.

A 68-year-old woman post-cardiac surgery. HR 48, BP 92/60. Narrow QRS, no P waves.

A 70-year-old man with dizziness and pre-syncope. HR ~55, grouping of beats.



INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



2ND DEGREE AV BLOCK, MOBITZ I (WENCKEBACH)



KEY FINDINGS

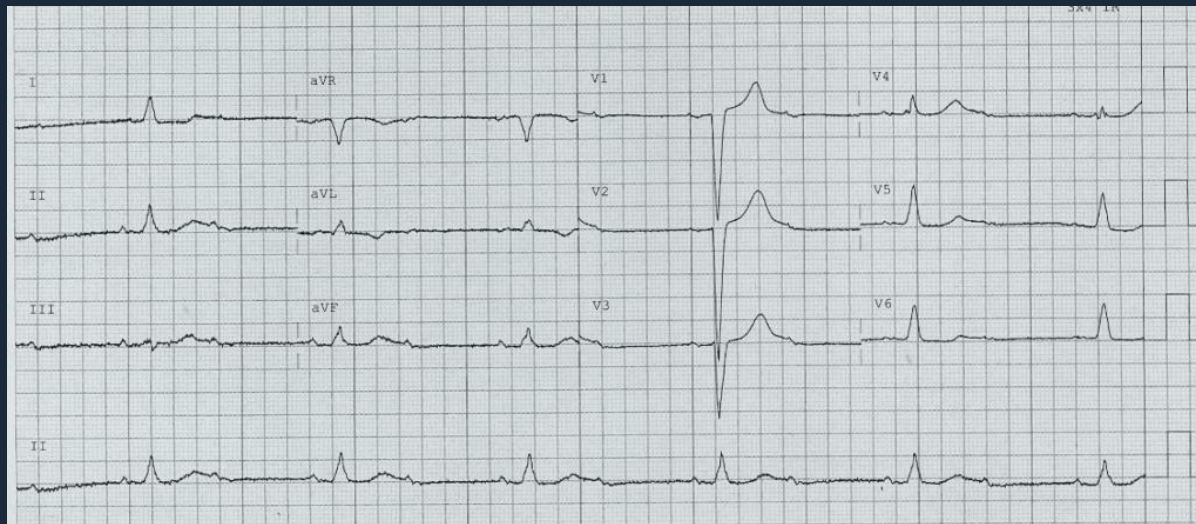
- Progressive PR lengthening
- Dropped QRS (non-conducted P wave)
- Group beating: 3:2 or 4:3 ratio common
- Rate slows just before the dropped beat
- Narrow QRS (block at AV node)

CLINICAL PEARL

Wenckebach = AV nodal level. Often benign, seen in athletes and inferior MI. Symptomatic → atropine. Mobitz II (fixed PR, sudden drop) = infranodal → pacing required.

A 70-year-old man with dizziness and pre-syncope. HR ~55, grouping of beats.

A 65-year-old man with syncope. Fixed PR, sudden dropped beats. Wide QRS.



INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



2ND DEGREE AV BLOCK, MOBITZ II



KEY FINDINGS

- FIXED PR interval (does NOT change)
- Sudden dropped QRS without warning
- Wide QRS (infranodal block)
- Can progress to complete heart block
- Requires permanent pacemaker

CLINICAL PEARL

Mobitz II is always infranodal (bundle of His or below). High risk of sudden complete AV block. Unlike Mobitz I, it does NOT respond to atropine. Requires PACING.

A 65-year-old man with syncope. Fixed PR, sudden dropped beats. Wide QRS.

A 78-year-old woman, AMS, HR 38, BP 76/50. P waves and QRS are independent.



INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



COMPLETE (3RD DEGREE) AV BLOCK



KEY FINDINGS

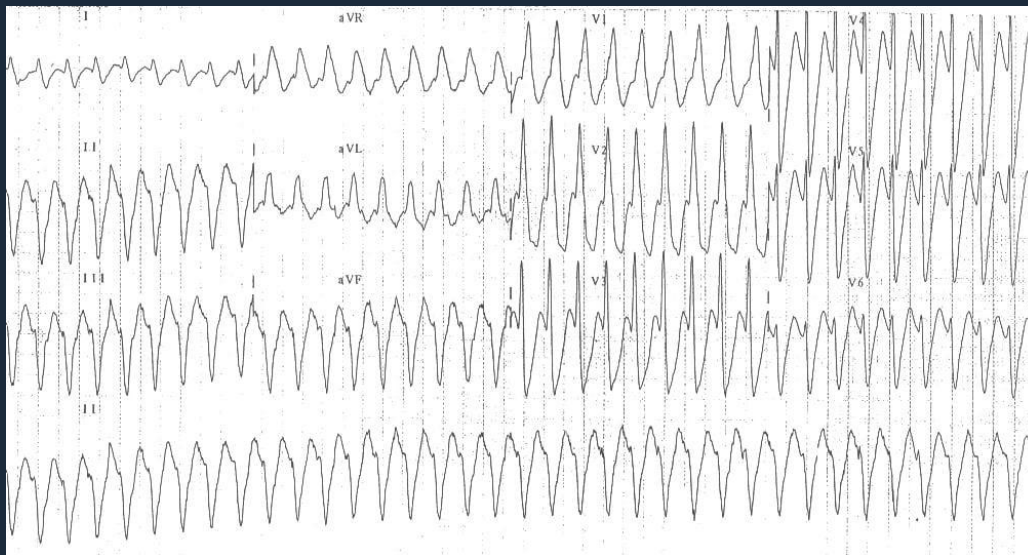
- P waves and QRS march out completely independently (AV dissociation)
- Atrial rate > ventricular rate
- Slow ventricular escape rhythm (junctional 40–60 or ventricular 20–40)
- Wide QRS if ventricular escape
- Hemodynamic compromise

CLINICAL PEARL

Complete AV block = no conduction from atria to ventricles. Ventricular escape keeps the patient alive. EMERGENT pacing. Causes: inferior MI (often reversible), anterior MI (permanent pacemaker), Lyme disease, drugs.

A 78-year-old woman, AMS, HR 38, BP 76/50. P waves and QRS are independent.

A 65-year-old man with prior MI, now pulseless. Wide complex tachycardia, HR 165.

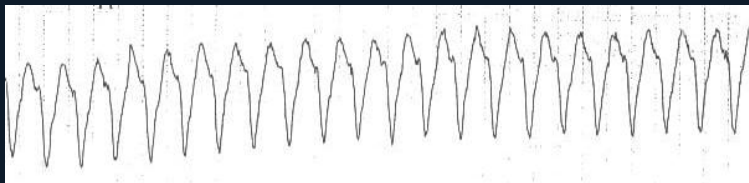


INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



VENTRICULAR TACHYCARDIA (PULSELESS)



KEY FINDINGS

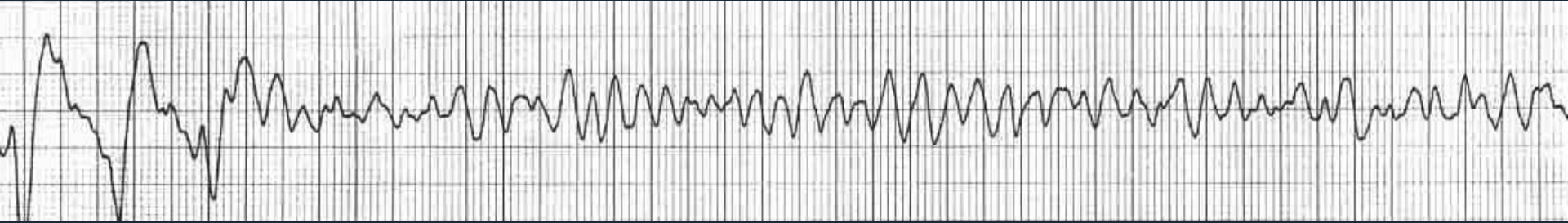
- Wide QRS > 120 ms
- Rate 100–250 bpm
- AV dissociation (P waves independent if visible)
- Fusion beats or capture beats (pathognomonic)
- No P waves visible typically
- There is a RBBB-like pattern in V1 with a taller left rabbit ear – this is very specific for VT
- Tall monophasic R wave in V1 with an rS complex in V6 (small R wave, big S wave) — this pattern is also very specific for VT

CLINICAL PEARL

Pulse present → stable: amiodarone or procainamide. Unstable: synchronized cardioversion. Pulseless: treat as VFib → defibrillate 200 J biphasic + CPR. Brugada criteria help differentiate VT from SVT with aberrancy.

A 65-year-old man with prior MI, now pulseless. Wide complex tachycardia, HR 165.

A 58-year-old man collapses mid-ECG. Pulseless, apneic. Chaotic ECG.



INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



VENTRICULAR FIBRILLATION



KEY FINDINGS

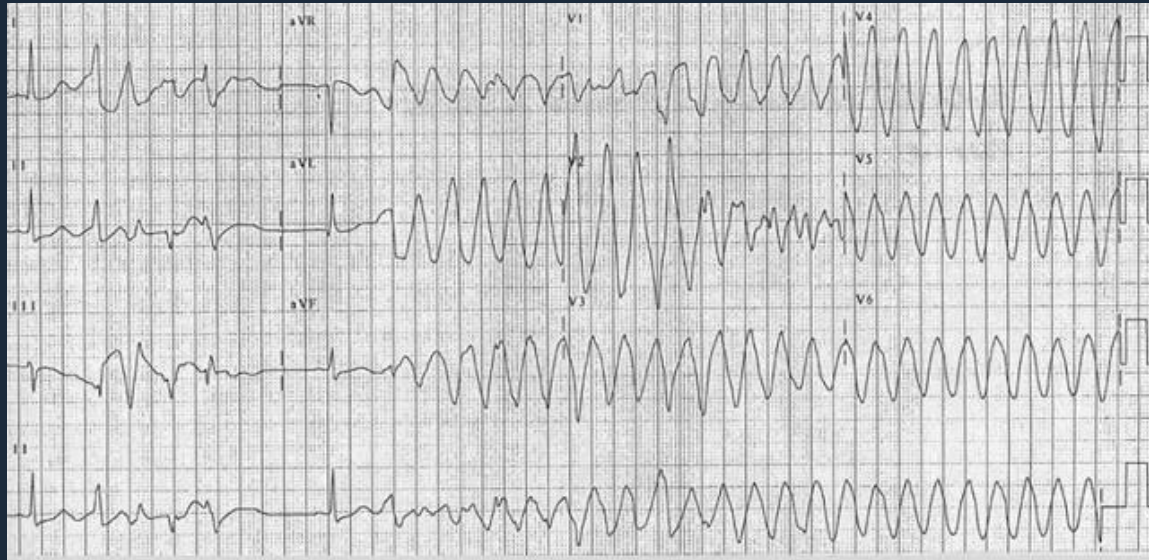
- Chaotic, disorganized electrical activity
- No recognizable P, QRS, or T waves
- Amplitude and rate vary chaotically
- No cardiac output
- SHOCKABLE rhythm

CLINICAL PEARL

VFib = cardiac arrest. DEFIBRILLATE IMMEDIATELY (200 J biphasic). CPR between shocks. Epinephrine 1 mg IV every 3–5 min. Amiodarone 300 mg after 3rd shock. Identify and treat reversible causes (4 H's and 4 T's).

A 58-year-old man collapses mid-ECG. Pulseless, apneic. Chaotic ECG.

A 55-year-old on sotalol and azithromycin. Recurrent syncope. QTc 560 ms.



INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



TORSADES DE POINTES



KEY FINDINGS

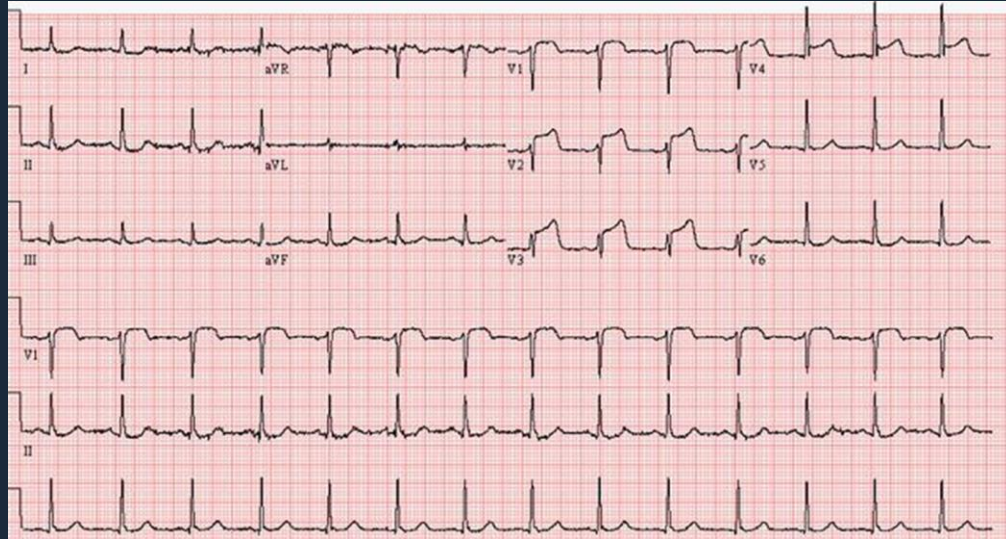
- Polymorphic VT with twisting axis
- Occurs on background of prolonged QTc
- Rate 150–250 bpm
- Often self-terminating, can degenerate to VFib
- Precede by a "long-short" R-R initiating sequence

CLINICAL PEARL

Magnesium 2 g IV (regardless of serum Mg level) is first-line. Increase heart rate (isoproterenol infusion or overdrive pacing) to shorten QT. STOP causative drugs (QT-prolonging). Correct K^+ and Mg^{2+} .

A 55-year-old on sotalol and azithromycin. Recurrent syncope. QTc 560 ms.

A 60-year-old man, chest pain radiating to left arm × 1 hour. Diaphoretic. BP 100/70.

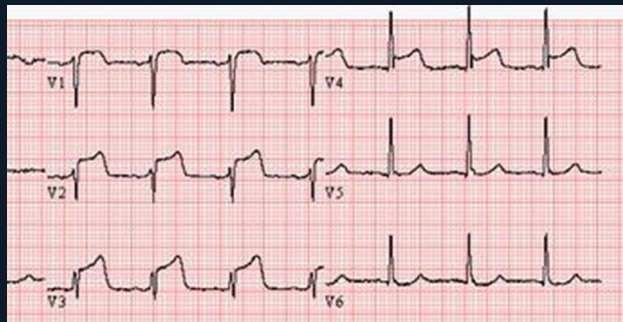


INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



ANTERIOR STEMI (PROXIMAL LAD OCCLUSION)



KEY FINDINGS

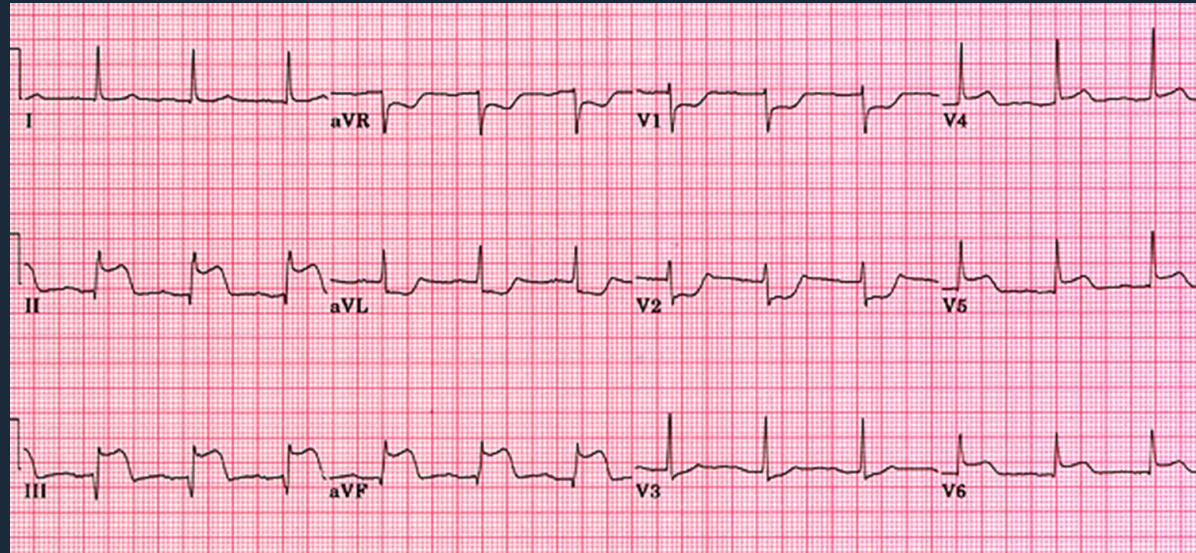
- STE ≥ 1 mm in V2–V4 (or V1–V6 for extensive anterior)
- Hyperacute T waves early
- Reciprocal ST depression in II, III, aVF
- Q waves developing (if late)
- New LBBB equivalent

CLINICAL PEARL

Activate cath lab immediately. Door-to-balloon < 90 min. Aspirin + P2Y12 inhibitor + anticoagulation. Avoid unnecessary delays for further workup. "Time is muscle."

A 60-year-old man, chest pain radiating to left arm $\times$ 1 hour. Diaphoretic. BP 100/70.

A 70-year-old woman, crushing chest pain to jaw × 2 hours. HR 55, BP 90/60.

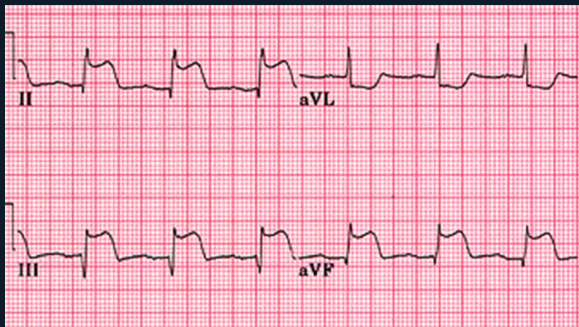


INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



INFERIOR STEMI (RCA OCCLUSION)



KEY FINDINGS

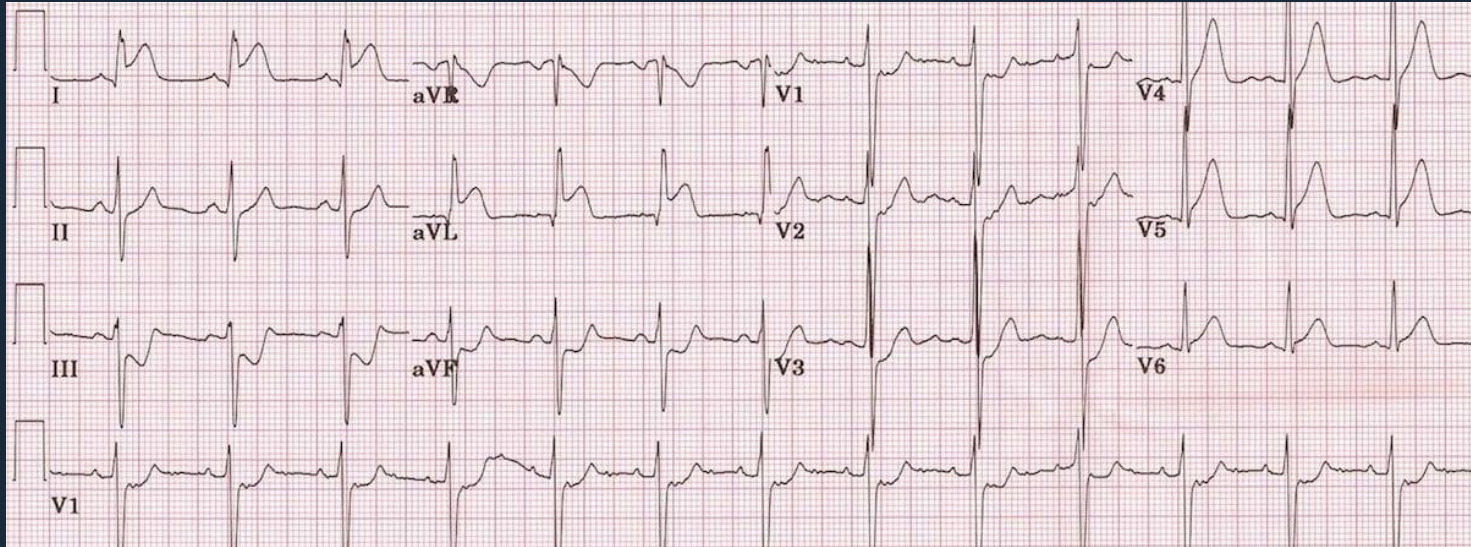
- STE in II, III, aVF
- Reciprocal ST depression in I, aVL
- Bradycardia common (RCA → SA node)
- Get right-sided leads: V3R/V4R
- RV involvement if STE in V4R

CLINICAL PEARL

RCA occlusion → inferior MI + possible RV MI. RV infarct: hypotension + JVD + clear lungs. AVOID nitrates (preload-dependent). Give IV fluids. RV infarct complicates ~40% of inferior STEMIs.

A 70-year-old woman, crushing chest pain to jaw × 2 hours. HR 55, BP 90/60.

A 55-year-old man with chest pain. STE noted in lateral leads. BP 124/78, HR 90.

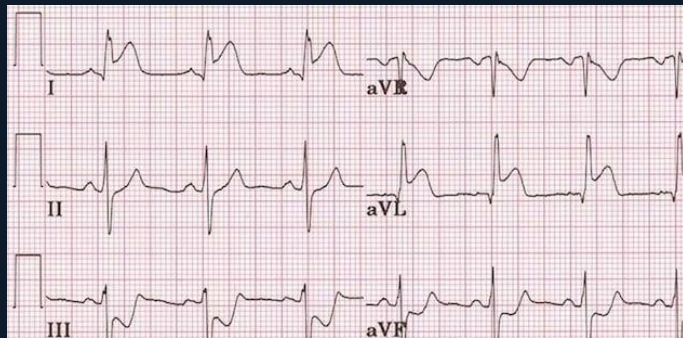


INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



LATERAL STEMI (LCX OCCLUSION)



KEY FINDINGS

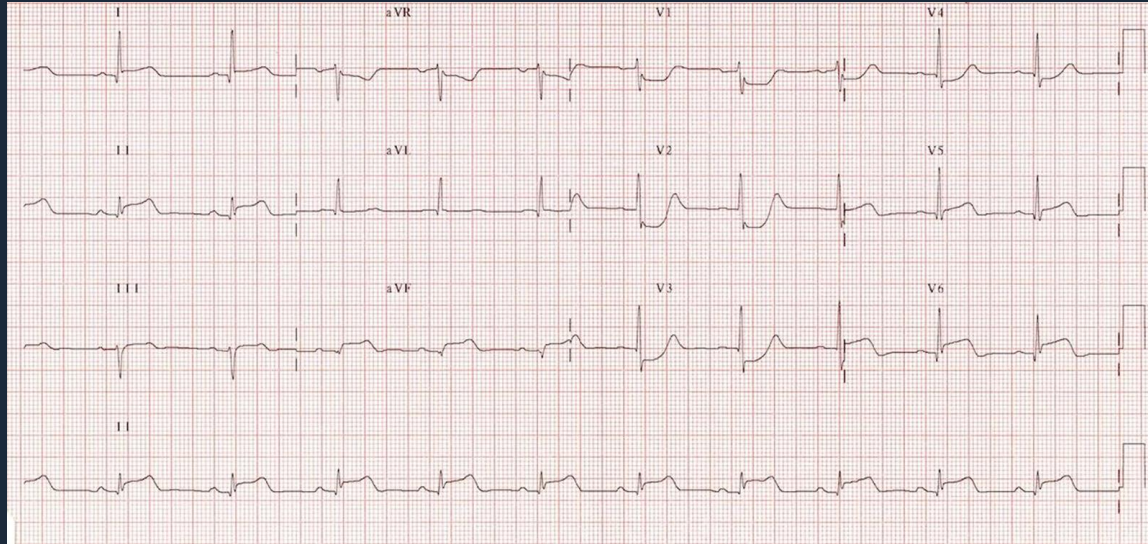
- STE in I, aVL (high lateral) and/or V5–V6 (low lateral)
- Reciprocal depression in II, III, aVF
- LCx occlusion often subtler on ECG
- May be missed (LCx is "ECG-silent artery")
- Consider posterior leads V7–V9

CLINICAL PEARL

LCx is often the "silent" culprit — ECG may appear subtle or normal. High clinical suspicion + troponin + posterior leads. Any STE in lateral leads warrants urgent cath lab activation.

A 55-year-old man with chest pain. STE noted in lateral leads. BP 124/78, HR 90.

A 58-year-old smoker, epigastric pain and diaphoresis. Deep ST depression V1–V3 only.

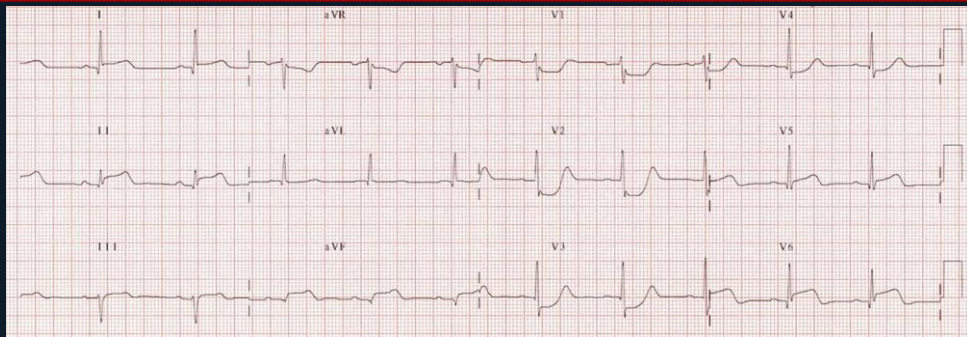


INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



POSTERIOR MI (RCA OR LCX OCCLUSION)



KEY FINDINGS

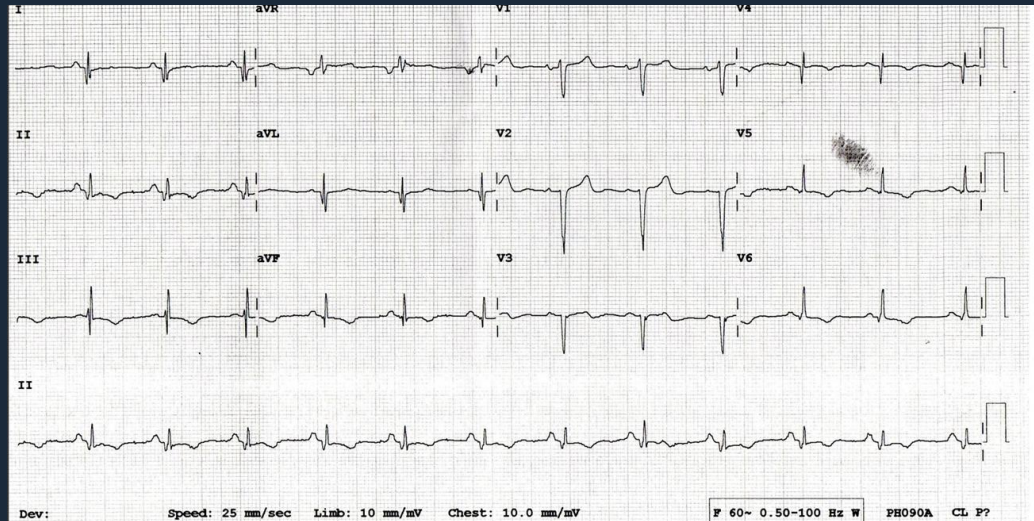
- Tall R waves in V1–V2 (reciprocal Q waves)
- Horizontal ST depression in V1–V3
- Upright tall T waves anteriorly (reciprocal)
- Confirmed by posterior leads V7–V9 (STE ≥ 0.5 mm)
- Often concurrent with inferior STEMI

CLINICAL PEARL

Posterior MI is the "hidden STEMI." Mirror image in V1–V3. Always get posterior leads (V7–V9) in any inferior STEMI or unexplained anterior ST depression. STE ≥ 0.5 mm in V7–V9 = posterior STEMI.

A 58-year-old smoker, epigastric pain and diaphoresis. Deep ST depression V1–V3 only.

A 62-year-old woman, chest pressure × 3 hours, diaphoretic. ECG shows no STE but dynamic changes.

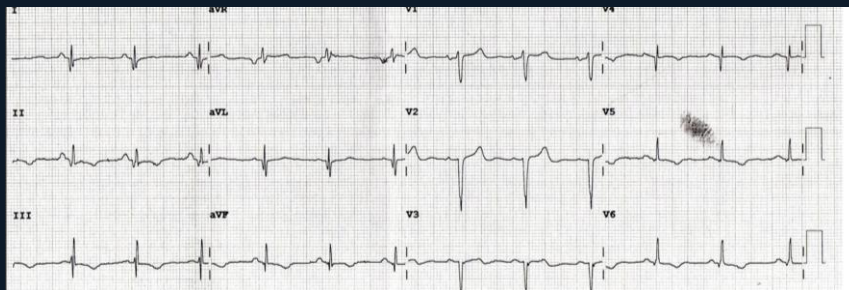


INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



NSTEMI (ST DEPRESSION + T WAVE INVERSION)



KEY FINDINGS

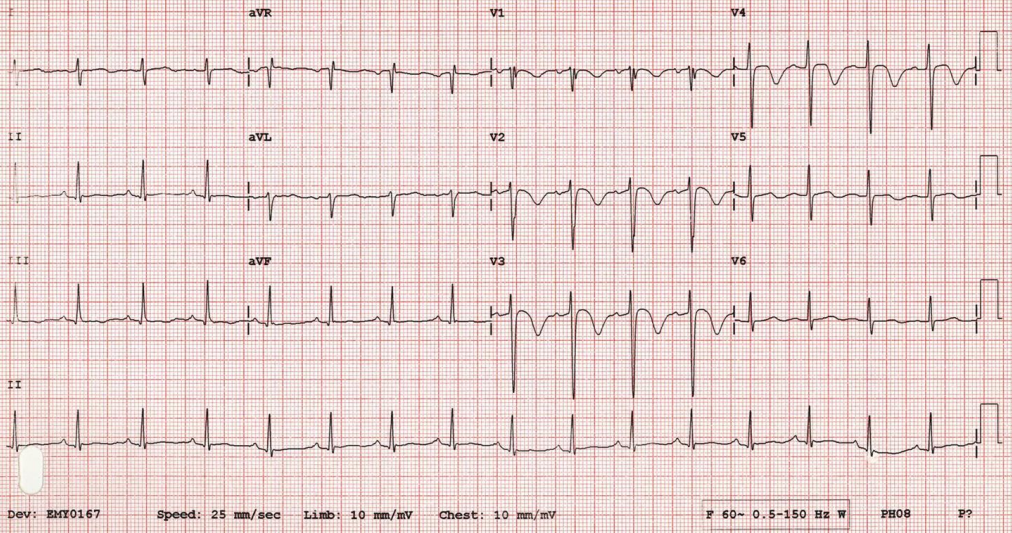
- Horizontal or downsloping ST depression
- T wave inversion (new or dynamic)
- No ST elevation
- Troponin elevated (NSTEMI) or normal (UA)
- May have reciprocal changes

CLINICAL PEARL

NSTEMI vs UA = troponin. Both managed with antiplatelets, anticoagulation, and risk stratification. High-risk features (ongoing pain, dynamic ECG, hemodynamic instability) → early invasive strategy.

A 62-year-old woman, chest pressure × 3 hours, diaphoretic. ECG shows no STE but dynamic changes.

A 55-year-old man, chest pain resolved 2 hours ago. Now pain-free. Biphasic T waves V2–V3.

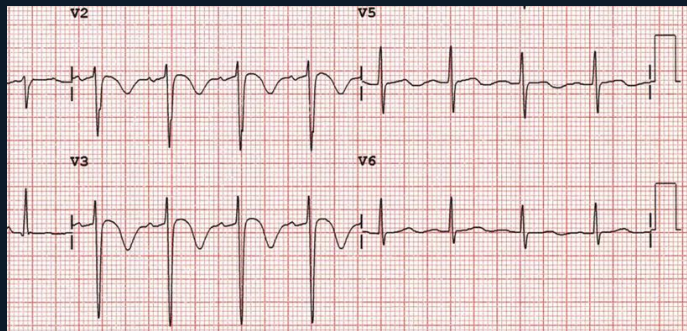


INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



WELLENS SYNDROME (PROXIMAL LAD CRITICAL STENOSIS)



KEY FINDINGS

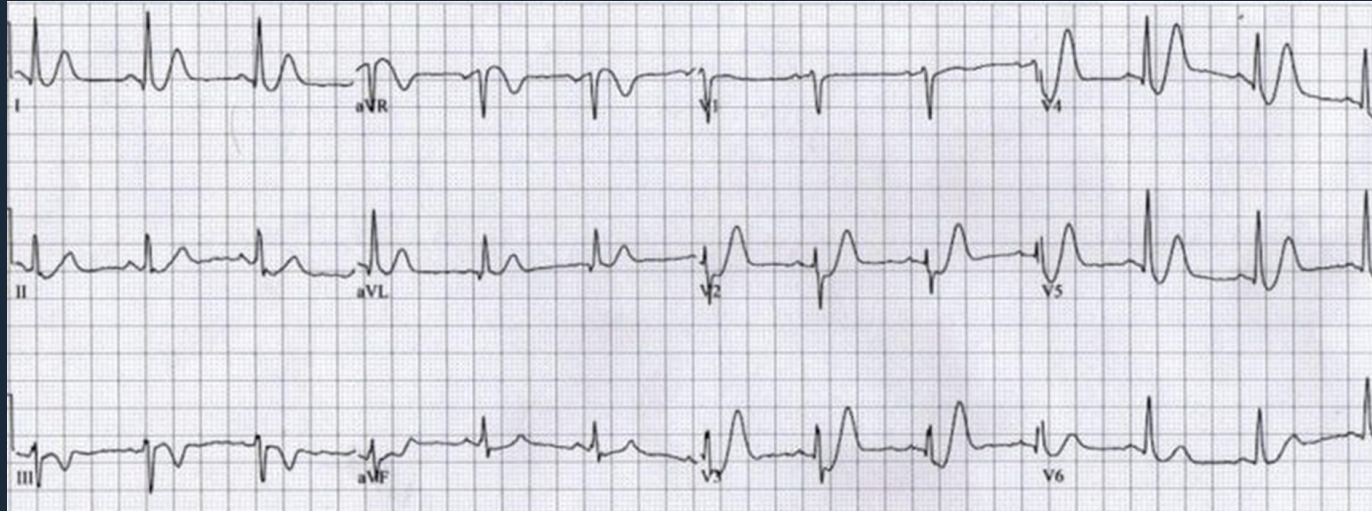
- Biphasic T waves V2–V3: up then down (type A/B)
- Occurs DURING PAIN-FREE INTERVAL
- No STE at time of ECG
- Normal or minimally elevated troponin early
- High risk for massive anterior STEMI

CLINICAL PEARL

DO NOT stress test Wellens patients — can precipitate massive anterior MI. Admit immediately, urgent cardiology consult, cardiac catheterization. The pain-free ECG is a warning, not reassurance.

A 55-year-old man, chest pain resolved 2 hours ago. Now pain-free. Biphasic T waves V2–V3.

A 48-year-old man, acute chest pain. ECG shows upsloping ST depression at J-point + tall T waves in V1–V6.

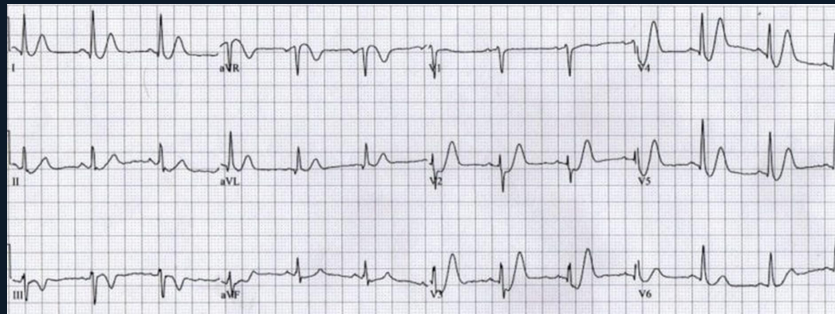


INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



DE WINTER PATTERN (LAD STEMI EQUIVALENT)



KEY FINDINGS

- Upsloping ST depression at J-point in V1–V6
- Tall, symmetric, peaked T waves anteriorly
- ST elevation in aVR (common)
- NO classic ST elevation in precordial leads
- STEMI equivalent — activate cath lab

CLINICAL PEARL

de Winter pattern is present in ~2% of LAD occlusions. It does NOT evolve to classic STE. Because it lacks the classic STE pattern, it is frequently missed. Treat as anterior STEMI.

A 48-year-old man, acute chest pain. ECG shows upsloping ST depression at J-point + tall T waves in V1–V6.

Unconfirmed report.

I AUR U1 U4

II AUL U2 U5

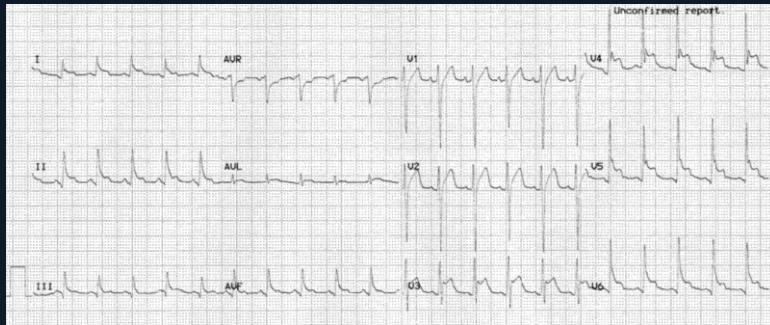
III AUF U3 U6

20 Sep 2005 15:14:57 25mm/s 10mm/mV ADS 50Hz 0.08 - 40Hz 3_F1_R Automatic U5_21 M121 (1)

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



PERICARDITIS



KEY FINDINGS

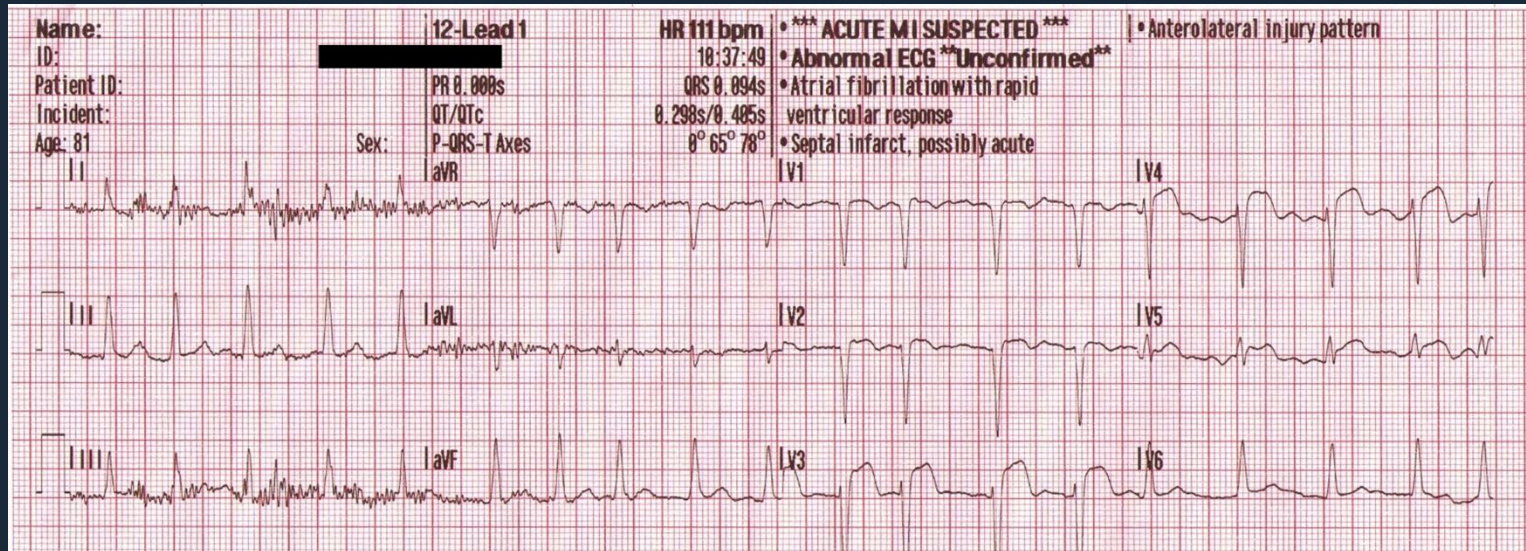
- Widespread saddle-shaped (concave) ST elevation
- PR depression (most prominent in II and aVF)
- NO reciprocal ST depression (unlike STEMI)
- Diffuse pattern — not in one vascular territory
- Normal QRS

CLINICAL PEARL

4 ECG stages: (1) diffuse STE + PR depression, (2) ST normalizes, (3) T wave inversion, (4) normalization. NSAIDs + colchicine. Restrict activity for 3 months. Echo to rule out tamponade.

A 29-year-old woman, central CP worse supine, better leaning forward. Recent flu illness.

A 58-year-old anterior-MI (2 weeks ago). Now with recurrent chest pain and persistent STE.

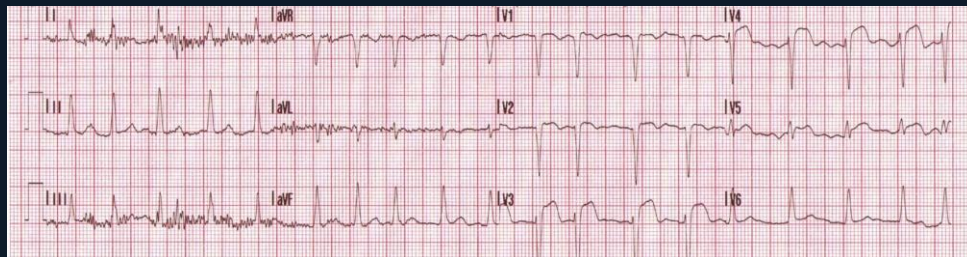


INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



LV ANEURYSM (PERSISTENT ST ELEVATION AFTER MI)



KEY FINDINGS

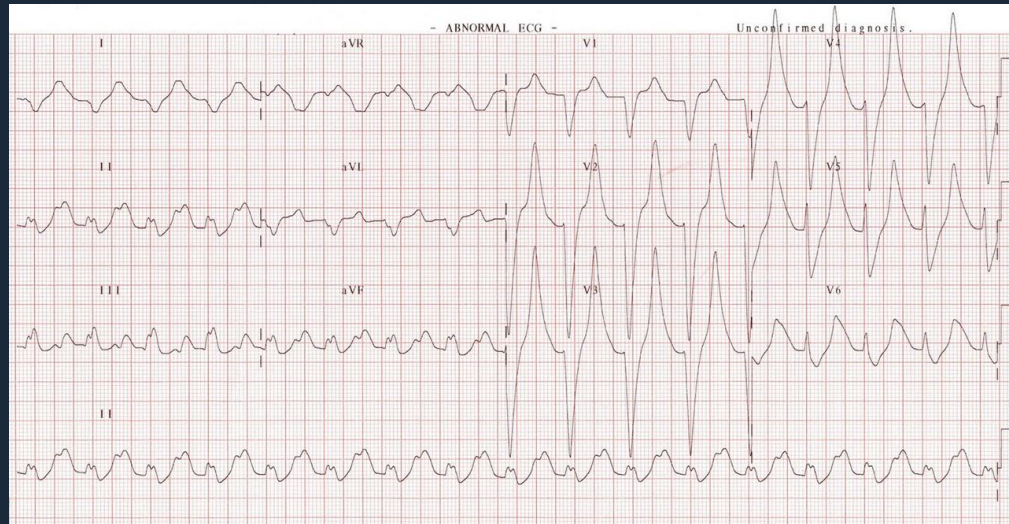
- Persistent STE in V1–V4 (unchanged from prior ECG)
- Deep Q waves in the same territory
- STE is CONCAVE or STRAIGHT (not hyperacute)
- No PR depression (vs pericarditis)
- Echocardiogram shows wall motion abnormality + aneurysm

CLINICAL PEARL

Key differentiator from acute STEMI: compare with prior ECGs. LV aneurysm STE is chronic and UNCHANGED. New or evolving STE = treat as STEMI. Echo confirms diagnosis.

A 58-year-old post-MI (anterior, 1 year ago). Now with recurrent chest pain and persistent STE.

A 68-year-old ESRD patient, missed 1 dialysis. $K^+ = 5.8 \text{ mEq/L}$. Feeling weak.

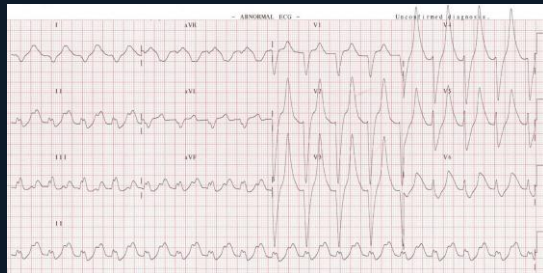
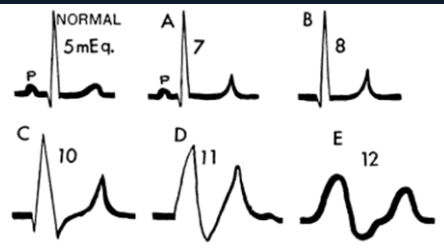


INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



EARLY HYPERKALEMIA (PEAKED T WAVES)



KEY FINDINGS

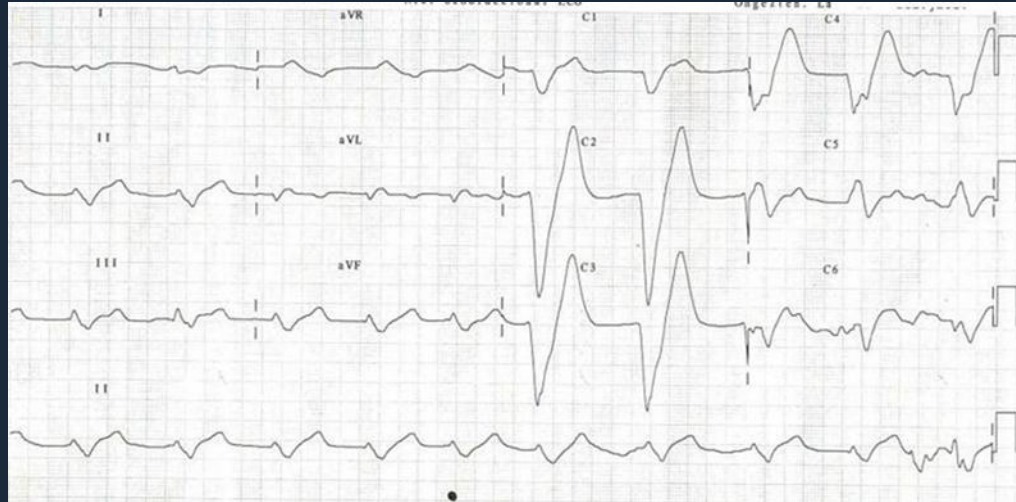
- Tall, narrow, peaked ("tent-shaped") T waves
- T wave amplitude > R wave amplitude in some leads
- Normal P waves and QRS (at this stage)
- Symmetric T waves (vs normal asymmetric)
- Portends further ECG deterioration if untreated

CLINICAL PEARL

ECG changes in hyperkalemia are progressive: peaked T → PR prolongation → P wave loss → QRS widening → sine wave → VFib. Treat early. ECG does NOT reliably predict K^+ level — clinical context essential.

A 68-year-old ESRD patient, missed 1 dialysis. $K^+ = 5.8$ mEq/L. Feeling weak.

A 71-year-old ESRD patient, missed 2 dialysis sessions. $K^+ = 7.2$ mEq/L. Lethargic.

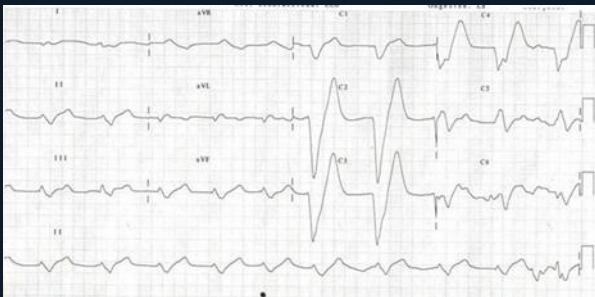


INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



SEVERE HYPERKALEMIA — SINE WAVE PATTERN



KEY FINDINGS

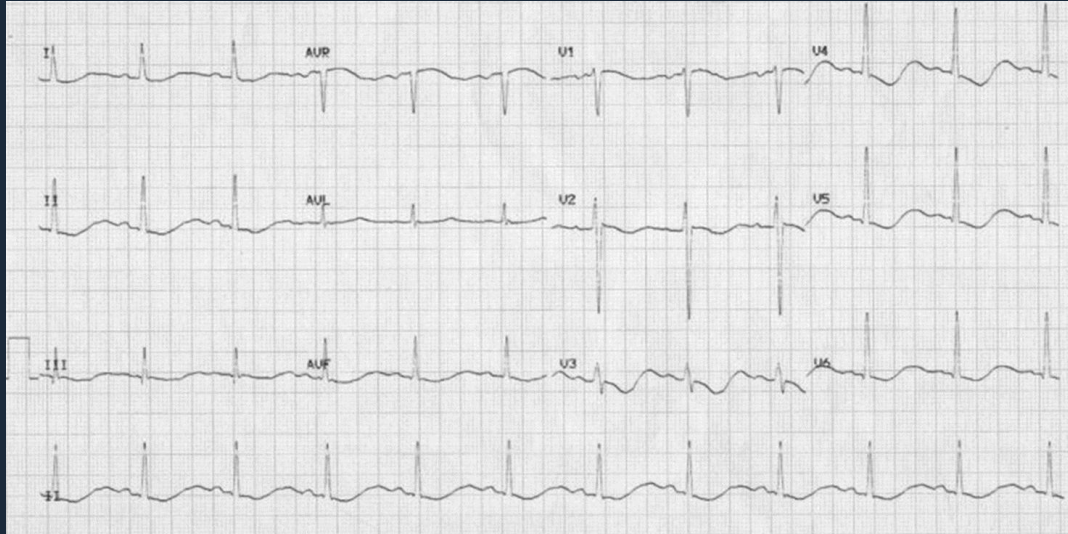
- Sine wave pattern (merging of QRS and T wave)
- No identifiable P waves
- Markedly widened QRS
- Rate ~60–80 with bizarre morphology
- Immediately life-threatening → treat NOW

CLINICAL PEARL

TREAT NOW: (1) Ca^{2+} gluconate 1g IV (membrane stabilization, works in minutes). (2) Insulin 10U + D50W (shifts K^+ in 30–60 min). (3) Albuterol nebulizer. (4) Furosemide/kayexalate/dialysis (remove K^+). Do NOT wait for labs if ECG looks like this.

A 71-year-old ESRD patient, missed 2 dialysis sessions. K^+ = 7.2 mEq/L. Lethargic.

A 61-year-old on furosemide + vomiting × 3 days. $K^+ = 2.4$ mEq/L. QTc 520 ms.



INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



HYPOKALEMIA (PROMINENT U WAVES + PROLONGED QTc)



KEY FINDINGS

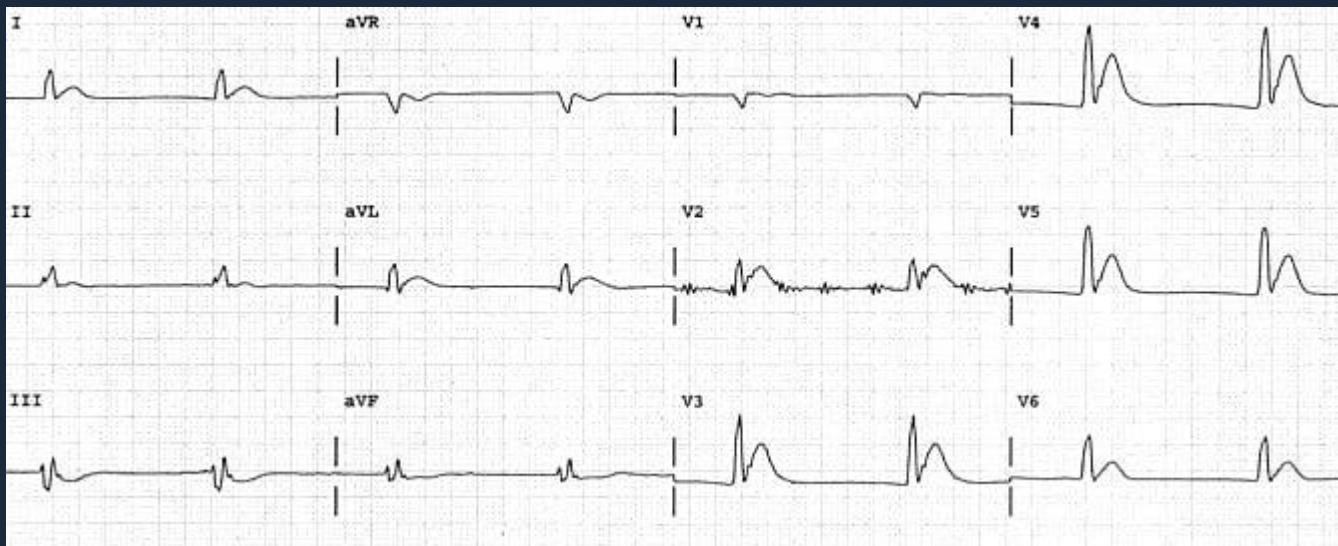
- Prominent U waves (positive deflection AFTER T wave)
- T wave flattening or inversion
- ST depression
- Prolonged QTc (risk of torsades)
- Apparent QTc may be QU interval

CLINICAL PEARL

Hypokalemia U waves: DOWN-UP (T goes down, U goes up) — differentiates from Wellens (UP-DOWN). Replace K^+ to > 4 mEq/L. Always check Mg^{2+} — hypomagnesemia perpetuates renal K^+ wasting.

A 61-year-old on furosemide + vomiting $\times$ 3 days. $K^+ = 2.4$ mEq/L. QTc 520 ms.

A 65-year-old with metastatic lung cancer. $\text{Ca}^{2+} = 13.2 \text{ mg/dL}$. Confusion and constipation.

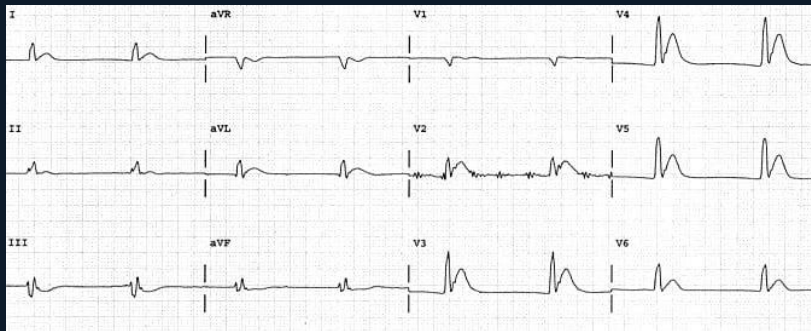


INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



HYPERCALCEMIA (SHORT QT + SHORT ST SEGMENT)



KEY FINDINGS

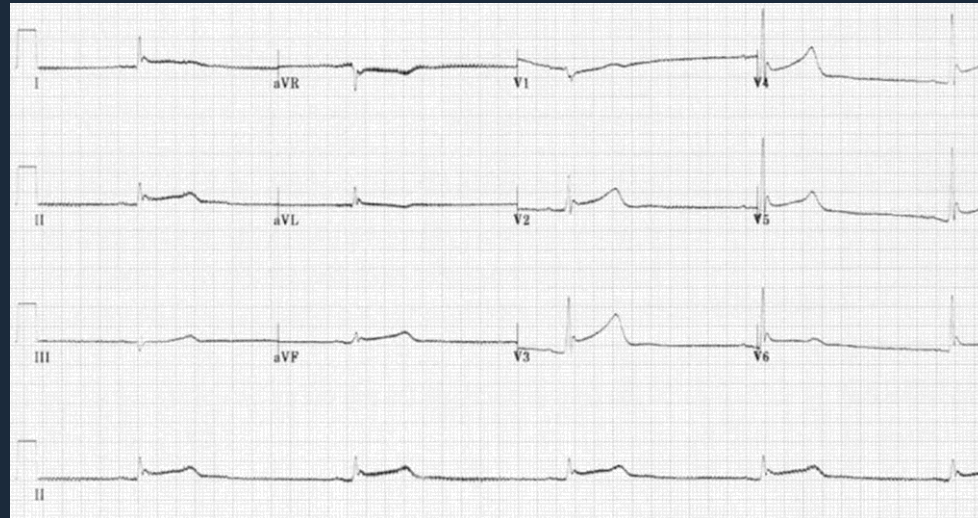
- Shortened QT interval (QTc < 340 ms)
- Shortened or absent ST segment
- QRS transitions directly into T wave
- Mild T wave changes
- Severe hypercalcemia can cause PR prolongation and wide QRS

CLINICAL PEARL

Causes of short QT: hypercalcemia, digoxin effect, congenital short QT syndrome. Treatment: IV saline + furosemide (loop diuretics), bisphosphonates for malignant hypercalcemia. Severe → calcitonin.

A 65-year-old with metastatic lung cancer. $\text{Ca}^{2+} = 13.2 \text{ mg/dL}$. Confusion and constipation.

A man found outdoors in January. GCS 9, temp 28°C. ECG shows Osborne waves.



INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



HYPOTHERMIA — OSBORNE J WAVES

Osborne Waves or “J-Waves”



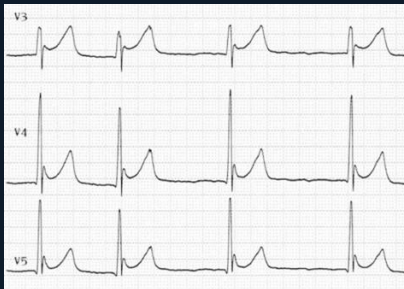
Here we see the Osborn waves of severe hypothermia (blue arrows).

The rhythm is atrial fibrillation.

Bradycardia is present.

The QT/QTc is prolonged.

The patient's core temperature was measured at 76°F (24°C).



KEY FINDINGS

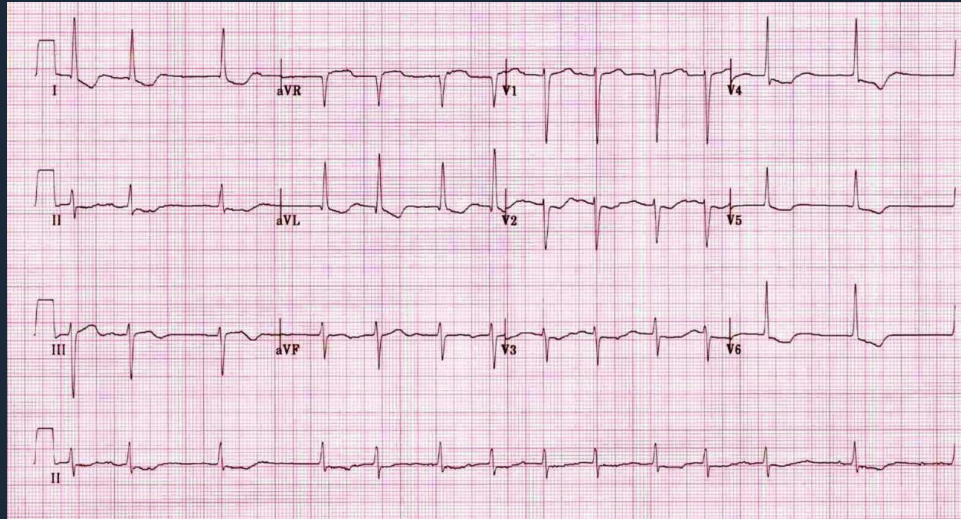
- Osborne (J) wave: positive deflection at QRS-ST junction
- Best seen in V3–V6 and inferior leads
- Bradycardia
- QTc prolongation
- At < 30°C: risk of VFib from movement or intubation

CLINICAL PEARL

J waves also occur in hypercalcemia and early repolarization. Hypothermia ECG: "everything slows down." Gentle rewarming — avoid unnecessary stimulation. Active rewarming for temp < 30°C or hemodynamic instability.

A man found outdoors in January. GCS 9, temp 28°C. ECG shows Osborne waves.

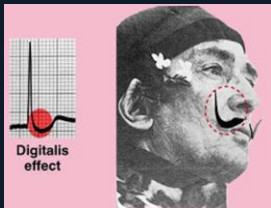
A 74-year-old on digoxin for AF. Rate controlled, but classic ECG changes present.



INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?

DIGOXIN EFFECT (SALVADOR DALI MUSTACHE SIGN)



KEY FINDINGS

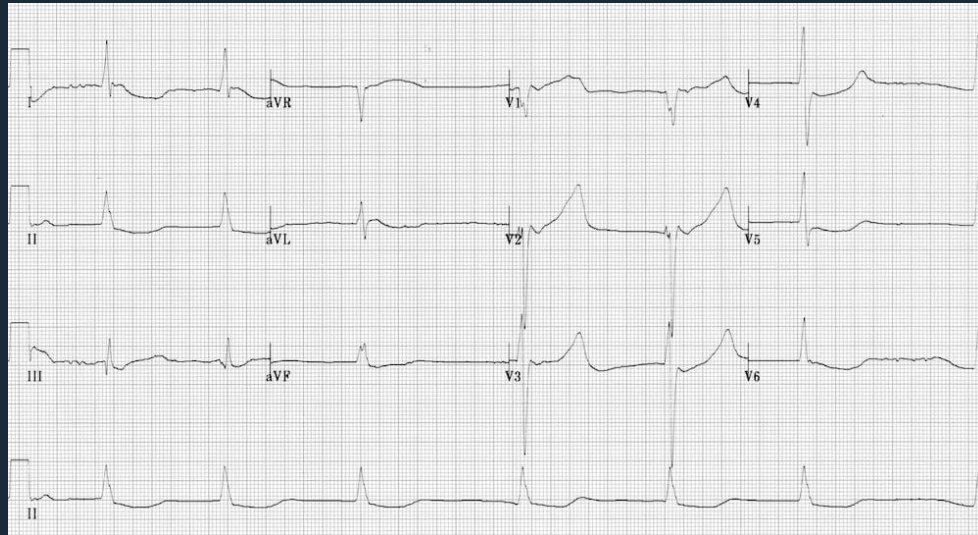
- Scooped / sagging ST segment ("reverse tick" or mustache shape)
- Shortened QT interval
- Flattened or inverted T waves
- Slow ventricular rate (if AF present)
- NOT the same as digoxin toxicity (which causes arrhythmias)

CLINICAL PEARL

Digoxin effect (therapeutic) $\neq$ digoxin toxicity. Toxicity: AV block, junctional tachycardia, bidirectional VT, yellow-green visual halos, N/V. Digoxin level, K^+ , and clinical picture guide management. Antidote: Digibind.

A 74-year-old on digoxin for AF. Rate controlled, but classic ECG changes present.

A 32-year-old woman with recurrent syncope on exertion. QTc 530 ms on routine ECG.

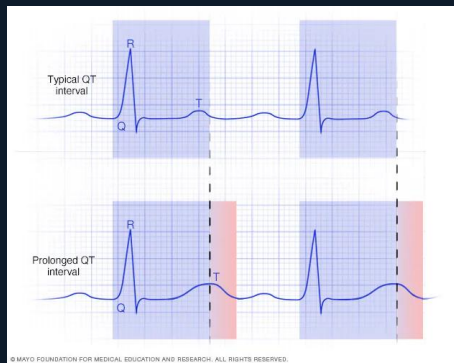


INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



LONG QT SYNDROME (CONGENITAL OR ACQUIRED)



KEY FINDINGS

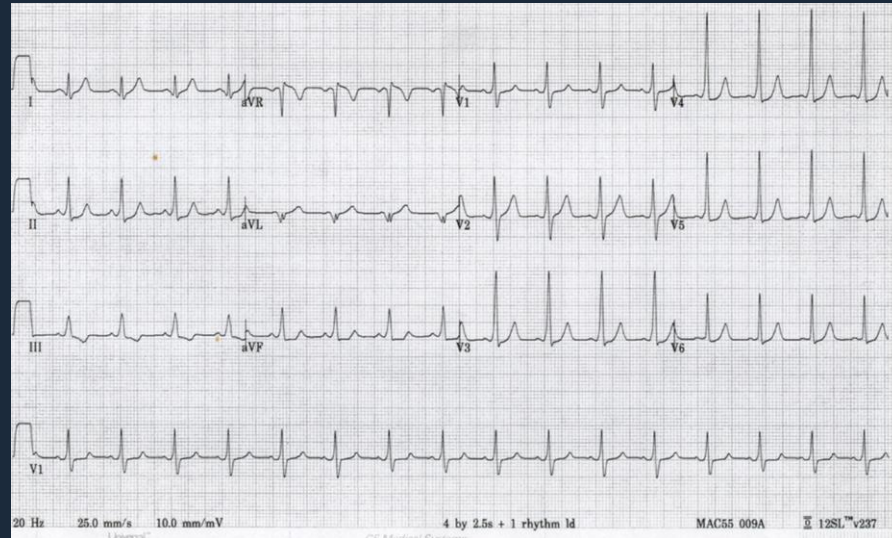
- QTc > 450ms (men) or > 470ms (women) — pathologic > 500ms
- Prolonged from end of QRS to end of T wave
- May have T wave notching or bifid T waves
- Triggers: exercise, sudden noise, emotional stress (congenital)
- Medications: check QTdrugs.org

CLINICAL PEARL

Congenital LQTS (LQT1 = exercise triggers; LQT2 = auditory triggers; LQT3 = sleep). Acquired: drugs (QT-prolonging), electrolyte disturbances, myocarditis. Treatment: beta-blockers, ICD for high-risk, avoid QT-prolonging drugs.

A 32-year-old woman with recurrent syncope on exertion. QTc 530 ms on routine ECG.

A 25-year-old athlete with exertional syncope. Short PR, slurred QRS upstroke.

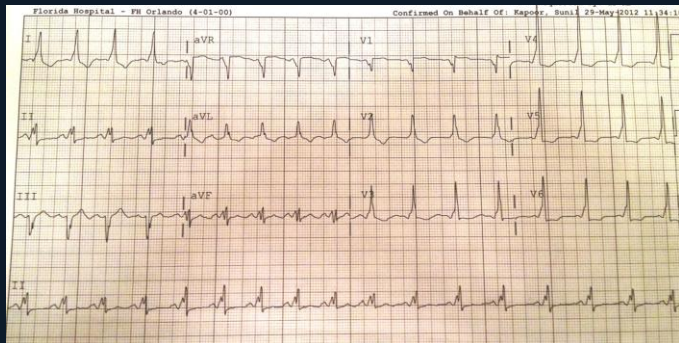


INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



WOLFF-PARKINSON-WHITE (WPW) SYNDROME



KEY FINDINGS

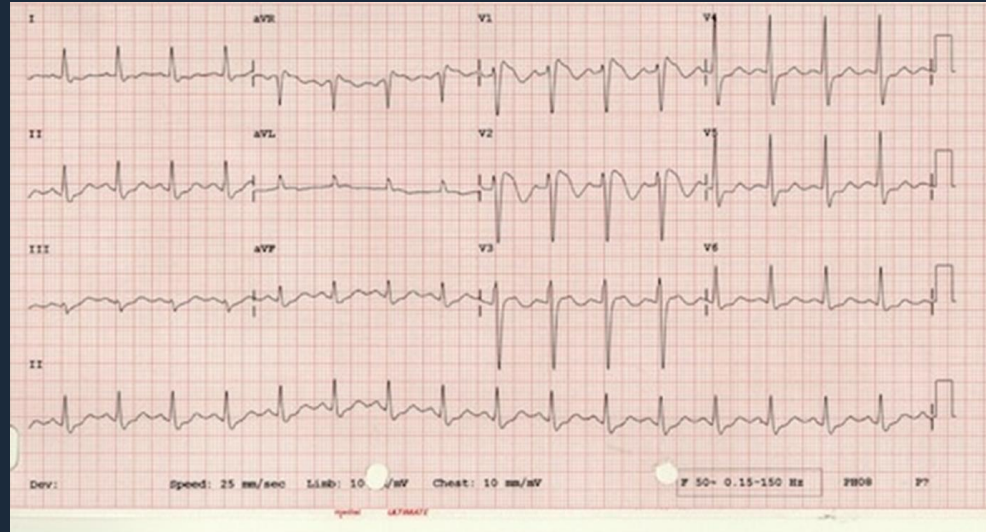
- Short PR interval (< 120 ms)
- Delta wave (slurred initial QRS upstroke)
- Widened QRS (> 120 ms)
- Secondary ST-T changes (discordant)
- At risk for AF $\rightarrow$ VFib via rapid accessory pathway conduction

CLINICAL PEARL

WPW + AF is potentially lethal: accessory pathway conducts AF very rapidly $\rightarrow$ VFib. If WPW-related tachycardia: use procainamide or cardioversion. AVOID: adenosine, beta-blockers, CCBs, digoxin (all can accelerate accessory pathway conduction). Refer for EP study and catheter ablation.

A 25-year-old athlete with exertional syncope. Short PR, slurred QRS upstroke.

A 30-year-old Asian male with syncope during sleep. Family history of sudden death.

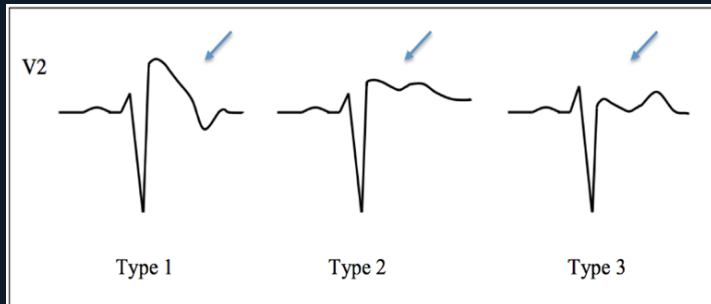


INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



BRUGADA SYNDROME TYPE I



KEY FINDINGS

- Coved-type STE > 2mm in V1–V3 (type I pattern)
- T wave inversion in V1–V3
- RBBB-like pattern
- Spontaneous or drug-induced (Na channel blockers)
- High risk of sudden cardiac death

CLINICAL PEARL

Brugada Type I: coved pattern. Type II/III (saddle-back) = Brugada pattern, not diagnostic. Fever can unmask/worsen the pattern. Test with Na channel blocker challenge (flecainide) if spontaneous type I absent. Treatment: ICD. Avoid QT-prolonging drugs and fever.

A 30-year-old Asian male with syncope during sleep. Family history of sudden death.

A 45-year-old woman with pleuritic chest pain after long flight. RBBB noted — was it pre-existing?

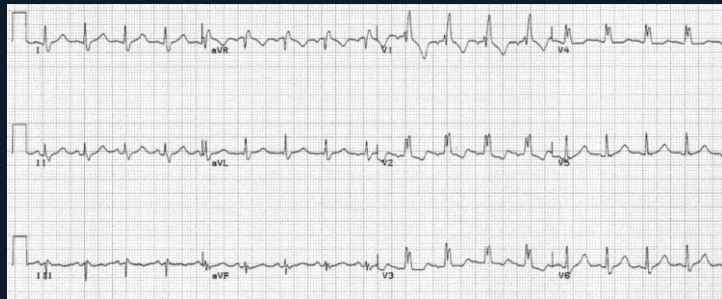


INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



RIGHT BUNDLE BRANCH BLOCK (RBBB)



KEY FINDINGS

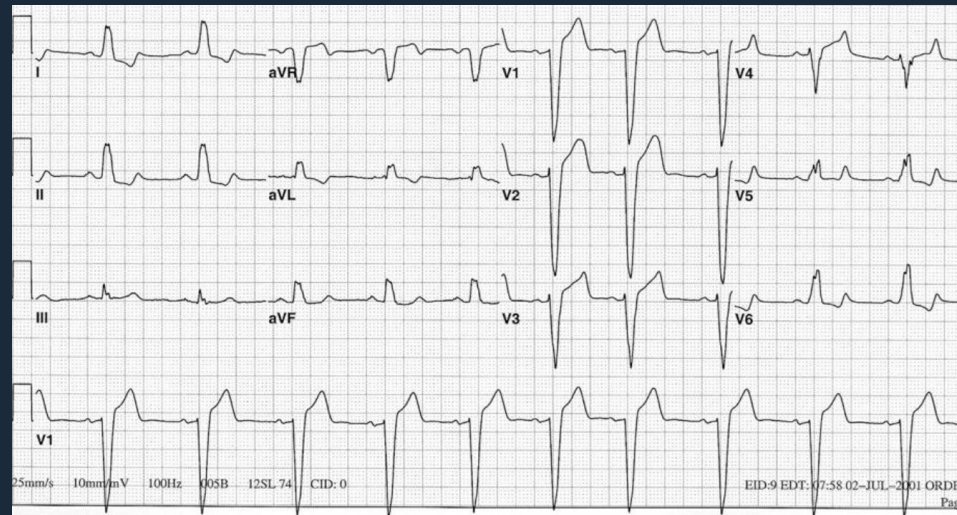
- QRS ≥ 120 ms
- RSR' pattern in V1 ("rabbit ears")
- Wide, slurred S wave in I, V5, V6
- Discordant T waves in V1–V3
- New RBBB in PE: right heart strain pattern

CLINICAL PEARL

"MaRRoW": M-shape in V1, W-shape in V5 for RBBB (opposite of LBBB WiLLiaM). RBBB is often incidental. NEW RBBB with chest pain and clinical risk factors for PE: get CTPA. RBBB does NOT invalidate STEMI diagnosis (check initial STE in V1–V3).

A 45-year-old woman with pleuritic chest pain after long flight. RBBB noted — was it pre-existing?

A 65-year-old man with new LBBB and chest pain. Admitted as STEMI equivalent.

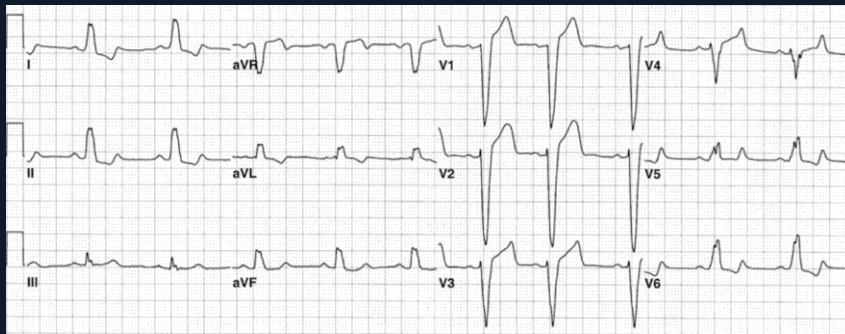


INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



LEFT BUNDLE BRANCH BLOCK (NEW / PRESUMABLY NEW)



KEY FINDINGS

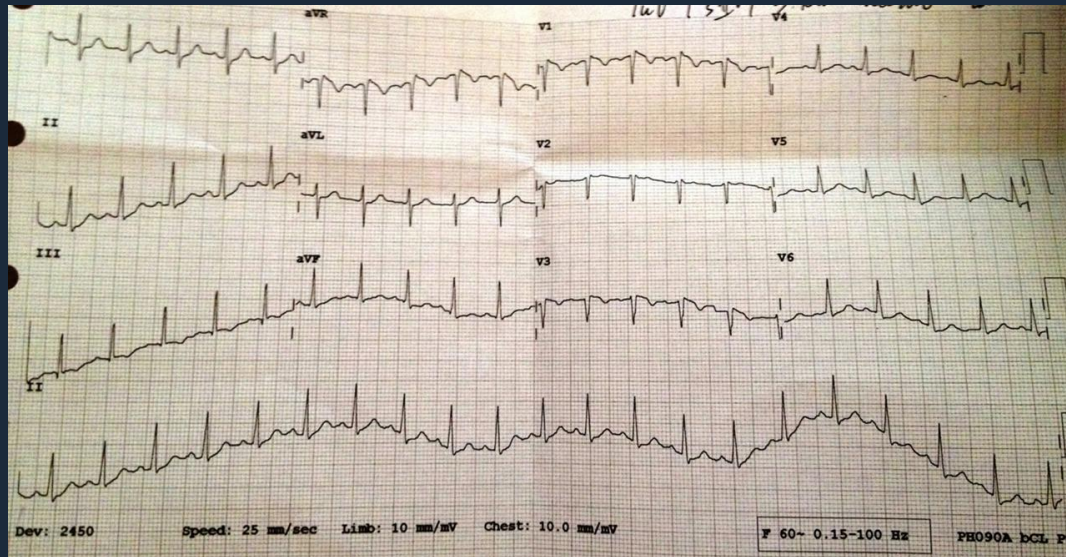
- QRS ≥ 120 ms
- Broad monophasic R in I, aVL, V5–V6 (notched)
- Deep S in V1–V3
- Absence of septal Q waves in lateral leads
- Discordant ST-T changes expected

CLINICAL PEARL

"WiLLiaM": W in V1, M in V5 for LBBB. New LBBB with ischemic symptoms = STEMI equivalent. Sgarbossa criteria help identify MI within LBBB: concordant STE ≥ 1 mm, concordant STD ≥ 1 mm in V1–V3, excessive discordant STE ≥ 5 mm (or modified Smith $\geq 25\%$ of S wave).

A 65-year-old man with new LBBB and chest pain. Admitted as STEMI equivalent.

A 45-year-old woman, 14-hour flight, pleuritic chest pain, HR 108, O₂ sat 91%.

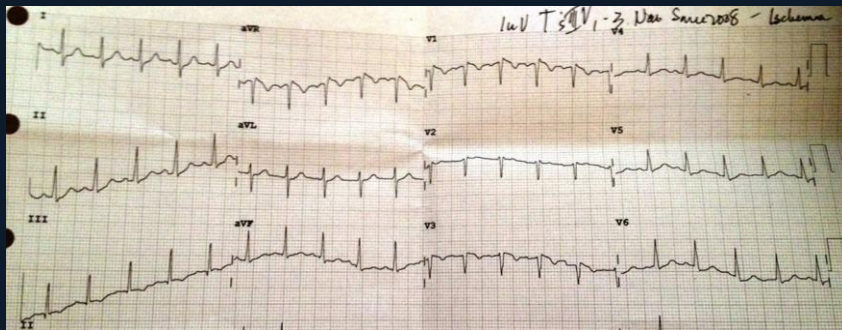


INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



PULMONARY EMBOLISM (S1Q3T3 PATTERN + RBBB)



KEY FINDINGS

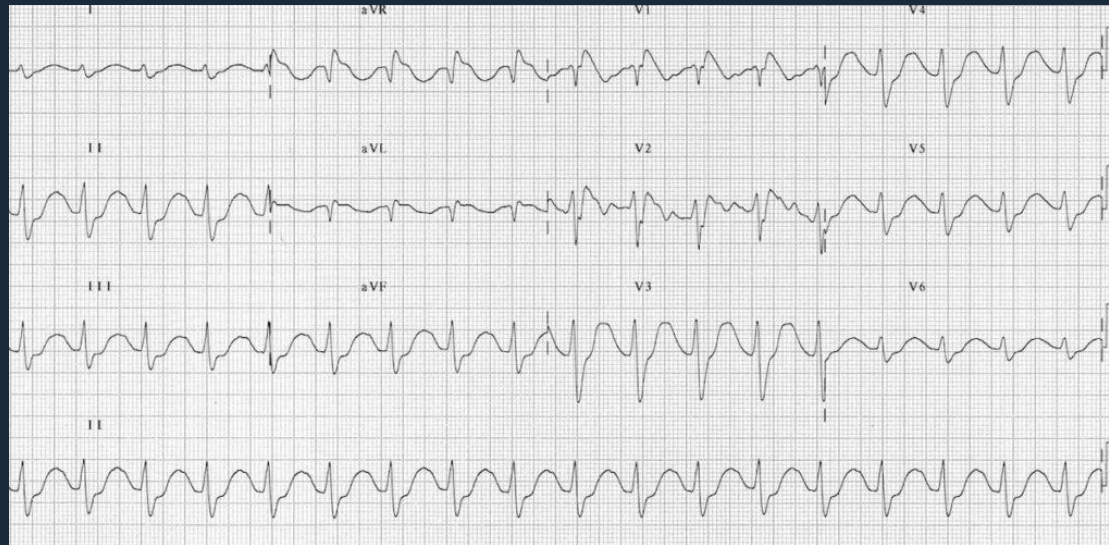
- Sinus tachycardia (most common ECG arrhythmia finding)
- S1Q3T3: deep S in I, Q wave in III, inverted T in III
- RBBB (right heart strain)
- Right axis deviation
- T wave inversion V1–V4 (RV strain pattern)

CLINICAL PEARL

S1Q3T3 is CLASSIC but RARE (occurs in < 20% of PE). Sinus tachycardia alone is most common. ECG cannot diagnose or exclude PE. Wells score + D-dimer (if low-moderate pretest probability) OR CTPA (if high probability). Unstable → bedside echo + empirical thrombolytics.

A 45-year-old woman, 14-hour flight, pleuritic chest pain, HR 108, O₂ sat 91%.

An 18-year-old woman found collapsed, dilated pupils, GCS 10. QRS 140 ms, QTc 560 ms.



INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



TRICYCLIC ANTIDEPRESSANT OVERDOSE



KEY FINDINGS

- Wide QRS > 100 ms (Na channel blockade)
- Prolonged QTc
- Terminal R wave in aVR ≥ 3 mm (or R/S ratio > 0.7 in aVR)
- Sinus tachycardia
- Right axis deviation (rightward terminal 40 ms vector)

CLINICAL PEARL

TCA toxicity: wide QRS is the key danger. QRS > 100 ms → sodium bicarbonate 1–2 mEq/kg IV to alkalinize (target pH 7.45–7.55 and Na loading). QRS > 160 ms → high risk VTach/VFib. Avoid physostigmine. Lipid emulsion therapy for refractory cases.

An 18-year-old woman found collapsed, dilated pupils, GCS 10. QRS 140 ms, QTc 560 ms.

A 13-year-old boy with syncope during a stressful exam. Echo: asymmetric septal hypertrophy.



INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



HYPERTROPHIC CARDIOMYOPATHY (HCM)



KEY FINDINGS

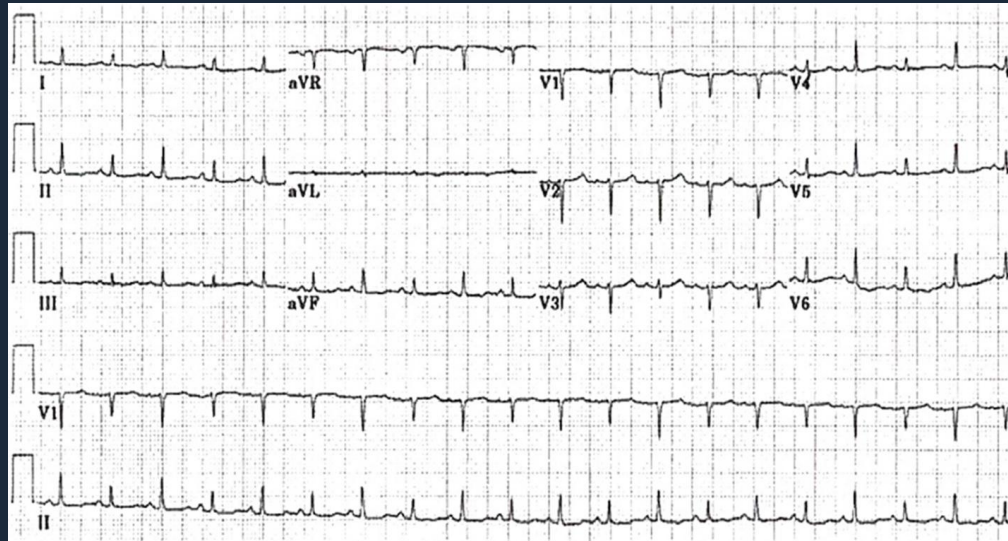
- LVH voltage criteria (Sokolow: $S V1 + R V5/V6 \geq 35$ mm)
- Deep narrow Q waves in I, aVL, V4–V6 (septal hypertrophy)
- ST depression + T wave inversion (strain pattern)
- Short PR
- Asymmetric — does not fit standard ischemic territory

CLINICAL PEARL

HCM is the most common cause of sudden cardiac death in young athletes in the US. Mechanism: LVOTO, arrhythmia, or ischemia. Avoid intense exercise. ICD for high-risk features (family history of SCD, NSVT, massive hypertrophy ≥ 30 mm, syncope, hypotension with exercise).

A 13-year-old boy with syncope during a stressful exam. Echo: asymmetric septal hypertrophy.

A 55-year-old with lung cancer and progressive dyspnea. HR 115, BP 88/60, JVD, muffled heart sounds.

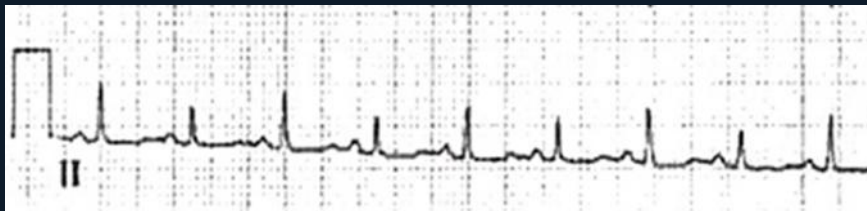


INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



ELECTRICAL ALTERNANS (PERICARDIAL TAMPONADE)



KEY FINDINGS

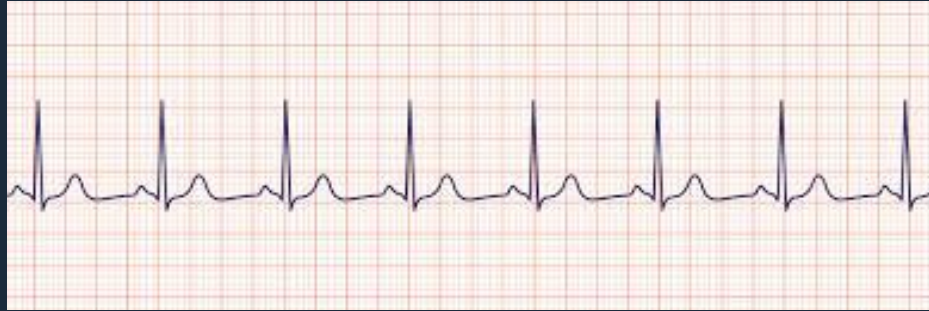
- Alternating QRS amplitude (tall–short–tall–short)
- Sinus tachycardia
- Low voltage (pericardial fluid insulates)
- Electrical alternans = pathognomonic for large pericardial effusion
- Beck's Triad: hypotension + JVD + muffled heart sounds

CLINICAL PEARL

Electrical alternans is nearly pathognomonic for cardiac tamponade. The heart swings back and forth in the fluid, changing its electrical axis beat-to-beat. Bedside POCUS: RV diastolic collapse. Treatment: emergent pericardiocentesis.

A 55-year-old with lung cancer and progressive dyspnea. HR 115, BP 88/60, JVD, muffled heart sounds.

A 65-year-old man found unresponsive. Pulseless. Organized ECG activity present. START CPR.



INTERPRET THIS ECG

What is the rhythm / diagnosis? What are your key findings? What is your immediate management?



PULSELESS ELECTRICAL ACTIVITY (PEA)



KEY FINDINGS

- Organized (or near-organized) electrical activity on ECG
- NO palpable pulse (by definition)
- ECG alone does NOT diagnose PEA — clinical exam essential
- May show: tachycardia, bradycardia, or wide complex
- Treat the CAUSE (4 H's and 4 T's)

CLINICAL PEARL

4 H's: Hypoxia, Hypovolemia, Hypo/Hyperkalemia, Hypothermia. 4 T's: Tension pneumothorax, Tamponade, Thrombosis (PE/MI), Toxins. POCUS is invaluable in PEA: wall motion, pericardial fluid, RV dilation (PE), IVC. CPR + epinephrine + treat reversible causes.

A 65-year-old man found unresponsive. Pulseless. Organized ECG activity present. START CPR.

SESSION COMPLETE

40 cases reviewed

Questions? Discussion?
Any cases you want to revisit?

Continue to review your lecture series and practice with the Banner Health & Oxford Medical Education case banks.

Jose A. Rubero MD, FACEP · Professor in Emergency Medicine
