Deadly Misdiagnoses in ECGs:

Subtle Findings of Cardiac Ischemia

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Copyright Issues

1. ECGs for the Emergency Physician Volume 1 & 2 (Mattu and Brady)
2. Electrocardiography in Emergency Medicine (Mattu, Tabas, and Barish)

Disclosure

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Case 1

- 24 yo. man presents c/o 45 minute episode of chest pain and diaphoresis
  - Now asymptomatic
  - CRFs — 1/2 ppd. smoker, lupus
  - Exam normal
  - ECG interpreted as normal (EP and cardiologist)
Case 1

- PMD “agrees” to admit patient
- Patient rules out for MI
- Discharged next morning
- Returns 4 days later with worsening pain
  - Cardiac enzymes positive
  - ECG...

Case 1 — 4 Days Later

Case 1 — Initial ECG
Case 2

- 63 yo. man presents c/o 30 minute episode of severe right arm and hand pain 2 hours prior to arrival
  - Brief diaphoresis
  - CRFs — hypertension, hypercholesterolemia
  - Exam normal
  - ECG interpreted as normal

Baseline ECG

- Multiple labs (including cardiac enzymes) are normal
- Patient is discharged
- Waits in WR 45 minutes while friend tries to find the car
- In WR, patient has recurrent pain, diaphoresis, lightheadedness, and...
Case 2

- Multiple labs (including cardiac enzymes) are normal
- Patient is discharged
- Waits in WR 45 minutes while friend tries to find the car
- In WR, patient has recurrent pain, diaphoresis, lightheadedness, and... vomits!

Case 2 — Initial ECG
Case 3

- 87 yo. man became nauseous, diaphoretic, and pale while in church
  - No chest pain or dyspnea
  - “Funny feeling under my chest”
  - ECG interpreted as normal in ED
  - Cardiologist reads “NSC from previous ECG” (4 years earlier)

Baseline ECG

- Patient’s nausea is treated with antiemetics
- Pallor resolves with IVF
- SL NTG has no effect on “funny feeling” in chest
  - No further interventions/treatment
- Plans are made for admission for “dehydration”
Case 3

- One hour later “funny feeling” still persists
- Pallor recurs, patient becomes diaphoretic
- Repeat ECG is obtained…

Case 3 — Initial ECG

Outline

- Wellens’ Syndrome
- Loss of precordial T-wave balance (NTTV1)
- Early reciprocal changes in lead aVL
Wellens’ Syndrome

- De Zwann C, Bar FW, Wellens HJJ (Am Heart J, 1982)
  - Pattern of ECG T-wave abnormality in mid-precordial leads (V2-V3, ± V4)
  - Highly specific for critical obstruction in proximal LAD
  - High risk for extensive anterior MI, death
  - 2 patterns...

Wellens’ Syndrome

- Warnings...
  - Type 2 pattern often misdiagnosed as “non-specific T-wave pattern” or “normal”
  - ST changes are often absent
  - ECG abnormality usually present in pain-free state
  - Cardiac biomarkers often normal initially

Wellens’ Syndrome

- Outline
  - Wellens’ Syndrome
  - Loss of precordial T-wave balance (NTTV1)
  - Early reciprocal changes in lead aVL

Wellens’ Syndrome

- Type 1
- Type 2
Wellens’ Syndrome

Warnings...
- Patients are best evaluated and managed with catheterization/PCI
  - Stress testing may precipitate AMI
  - Medical management usually ineffective for proximal LAD lesions
  - Natural history:

  - Wellens: 75% of patients developed AMI within weeks if medically managed

Wellens’ Syndrome (pain-free)
Wellens’ Syndrome Case 1

- 47 yo. man presents with right sided chest pain after using cocaine
  - Prior history of anterior wall MI
  - Pain is mild, completely reproducible
  - No response to SL NTG
  - Pain resolves with morphine

Baseline ECG
Wellens’ Syndrome Case 1

- ECG: “Old anteroseptal MI, NSC from prior ECG” (EP and cardiology)
- CPEC level 4
  - Patient rules out, no changes on ECG
  - Discharged still pain free
- Returns next day with recurrent right sided chest pain
  - Denies repeat cocaine use
Wellens’ Syndrome Case 2

54 yo. man presents with chest pain and belching
- History of smoking, hypertension, GERD
- *Some* relief with antacids
- This episode…

Wellens’ Syndrome Case 2

54 yo. man presents with chest pain and belching
- History of smoking, hypertension, GERD
- *Some* relief with antacids
- This episode…diaphoresis!

Wellens’ Syndrome Case 2

- ECG interpreted as normal (EP and cardiology)
- Patient discharged
- Died ~ 2 weeks later
  - Autopsy confirmed large proximal LAD lesion and anterior wall MI
- Lawsuit filed…settlement reached
Wellens’ Syndrome Case 3

- 43 yo. woman presents 20 minute episode of chest pain, diaphoresis
  - No prior history or cardiac risk factors
  - Normal exam, now asymptomatic
  - ECG…

Wellens’ Syndrome Case 3

- ECG interpreted as non-specific ST/T wave pattern (EP and cardiologist)
- Patient admitted to chest pain center
  - “Level 4,” ruled out by enzymes, no ECG changes, no stress test
  - Discharged
- Next week, symptoms recurred
  - Cath at local hospital → 100% LAD lesion

Wellens’ Syndrome

- Beware biphasic T-waves in mid-precordial leads!
  - Suggests proximal LAD stenosis
  - High risk for AMI in short-term
  - Best treated with invasive therapy (PCI)
“My psychiatrist told me I was crazy and I said I want a second opinion. He said okay, you’re ugly, too.”

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Outline

- Wellens’ Syndrome
- Loss of precordial T-wave balance (NTTV1)
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Normal ECG
The normal ECG has a flat or inverted T-wave in lead V1.

- In other patients, upright TV1 should be considered abnormal:
  - Especially if “tall” (TTV1)
  - Especially if new (NTTV1)

What does an upright TV1 signify?

- ECG literature...
  - Suggests significant underlying CAD
  - Suggests acute ischemia if new (NTTV1)
  - TV1 > TV6 is especially concerning, abnormal
  - NTTV1 may precede other expected ECG changes
61 yo. woman presents c/o substernal chest pressure and shortness of breath
- Symptoms improve with NTG
- ECG initially interpreted as showing “NSSTT wave abnls.”

Symptoms recur
- Serial ECGs are done
78 yo. man presents complaining of "poking sensation" on left chest for several hours
- No other complaints
- Normal exam
- ECG...
**NTTV1 — Case 2**

- Disposition...???
- "As you know..."

**NTTV1 — Case 2**

- "Admit to medicine.. I'll see him in the morning."
- Poking sensation recurs overnight.
- Repeat ECG overnight...

**NTTV1 — Case 2**

- 89 yo. woman presents for evaluation of 10 minute episode of slurred speech
- History of hypertension, diabetes
- Patient is admitted for workup of TIA
- Initial ECG shows sinus bradycardia and LVH
Patient develops brief episode of chest pain during the night
- Repeat ECG is done
- Interpreted by cardiology as showing no significant change
**NTTV1 — Case 3**

- No inpatient workup for chest pain
- Patient’s workup for TIA is negative
  - Discharged
- Few days later, patient returns after collapsing in her bathroom
  - ECG…

**NTTV1 — Case 4**

- 54 yo. man presents with substernal burning, belching, dyspepsia, diaphoresis
  - History of hypertension and diabetes
  - No other symptoms
  - Normal exam
  - Resident gives patient Maalox, symptoms resolve prior to ECG
  - ECG appears normal
Attending decides to observe patient
- Get 2 sets of cardiac enzymes and repeat ECG before discharge
  - Both sets of cardiac enzymes are normal
  - Patient has recurrence of “indigestion”
  - Repeat ECG is done...
NTTV1 — Case 4 (next morning)

- Normal variants
  - LBBB
  - LVH
  - HLVV

Left Bundle Branch Block

Left Ventricular Hypertrophy
High Left Ventricular Voltage

Loss of Precordial T-Wave Balance

- Beware the upright T-wave in V1!
  - Especially if new,
  - Especially if TV1 > TV6
  - Suggests underlying CAD or acute ischemia

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“I drink too much. The last time I gave a urine sample it had an olive in it.”
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Normal ECG

Early Reciprocal Changes in Lead aVL

- The normal ECG lead aVL
  - Isoelectric ST-segment
  - Upright T-wave

Early Reciprocal Changes in Lead aVL

- The normal ECG lead aVL
  - Isoelectric ST-segment
  - Upright T-wave
- Acute inferior wall MIs
  - Common “reciprocal changes”
    - ST-segment downsloping in aVL
    - T-wave inversion in aVL
Acute Inferior Wall MI

Early Reciprocal Changes in Lead aVL

- Marriott — these reciprocal aVL changes can *precede* the development of inferior lead abnormalities

Early Reciprocal Changes in Lead aVL — Case 1

- 56 yo. man presents c/o "throat burning," nausea, and belching
  - History of hypertension and tobacco use
  - Treated in fast-track with Maalox/viscous lidocaine with mild improvement
  - Patient wants to be discharged
Early Reciprocal Changes in Lead aVL — Case 1

- 30 minutes later symptoms worsen
  - Now with diaphoresis
- ECG is obtained
  - Interpreted as normal (EP and cardiologist)

Baseline ECG

Patient is given Maalox again
- Symptoms persist
- Serial ECGs are then performed with the persistent symptoms...
Early Reciprocal Changes in Lead aVL — First ECG

Early Reciprocal Changes in Lead aVL — Case 1

Early Reciprocal Changes in Lead aVL — Case 1
Early Reciprocal Changes in Lead aVL — Case 2

- 47 yo. man presents c/o of severe reflux symptoms “all day”
  - Belching, substernal burning, nausea
  - History of prior septal MI
  - No prior history of GERD
  - Symptoms improve significantly after Maalox and ranitidine
  - ECG interpreted as “old septal MI, o/w normal”

Baseline ECG

Patient discharged feeling better
- Rx for ranitidine

Patient returns with recurrent symptoms 2 hours later
- ECG...
46 yo. man presents c/o substernal chest burning and diaphoresis after eating chicken soup few hours earlier
- History of severe GERD, but this was worse
- Took prevacid, now feeling better
- ECG interpreted as normal (EP and cardiologist)
Emergency physician decides to observe patient, draw labs
- Pain worsens and serial ECGs demonstrate progressive changes
Early Reciprocal Changes in Lead aVL

- Normal variants
  - LBBB
  - LVH

Left Bundle Branch Block

Left Ventricular Hypertrophy

Early Reciprocal Changes in Lead aVL

- Reciprocal changes in lead aVL may be the first sign of inferior myocardial ischemia
Review of Original Cases

“I could tell that my parents hated me. My bath toys were a toaster and a radio.”

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Case 2
Multiple labs (including cardiac enzymes) are normal
Patient is discharged
Waits in WR 45 minutes while friend tries to find the car
In WR, patient has recurrent pain, diaphoresis, lightheadedness, and vomits
Repeat ECG...
Case 2 — Initial ECG

Case 3

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Case 3

Case 3 — Initial ECG
Summary

- Beware biphasic T-waves in V2-V4!
  - Suggests proximal LAD stenosis
  - Best treated with invasive therapy (PCI)
- Beware the upright T-wave in V1!
  - Especially if new, especially if TV1 > TV6
  - Suggests underlying CAD or acute ischemia
- Reciprocal changes in lead aVL may be the first sign of inferior myocardial ischemia

Remember...

- Just because electrocardiography is a basic skill in EM...
Remember…

- Just because electrocardiography is a basic skill in EM doesn’t mean that our skills should be *basic*.

YOU must be the expert in electrocardiography!

Thanks!