ECG Quiz 27

CASSA
CARDIAC ARRHYTHMIA SOCIETY OF SOUTHERN AFRICA
A SPECIAL INTEREST GROUP OF SA HEART ASSOCIATION

ANSWER

Systematic analysis of the ECG:

1. **Rate and regularity:** Rates in a standard 12-lead ECG are best calculated by counting the number of beats in the 10 second recording and multiplying these by 6 to give the rate per minute. Obviously, heart rate refers to ventricular rate.

   The rhythm strip of lead II at the bottom of this ECG shows regular electrical activity: 17 positive waves x 6 = 102 per minute. One could be forgiven for choosing this as the correct answer if it weren't for the remainder of the ECG.

   If one looks at the 12 leads, displayed above the rhythm strip in a 3 by 4 arrangement, and counts this electrical activity, a number of things can be noticed:

   - There are 16 beats between the beginning and the end of the ECG recording or 4 per lead; multiplied by 6 = 96;
   - The beats are not fully regular: After every 4 beats there is a longer interval between these waves;
   - The longer interval always coincides with a change in the recorded lead, e.g. from Lead III to aVF, to V3 and to V6; and
   - The first 4 waves in the first set of 3 leads, I, II and III, coincide with those in the bottom rhythm strip. None of the waves in subsequent vertical set of 3 leads: aVR, aVL, and aVF, nor in the 2 following sets headed by V1 and then V4, coincide simultaneously with the activity in the rhythm strip. Simultaneous activity is best tested by dropping a vertical line on the ECG recording.

2. **Atrial activity:** Analysis of leads III, V1, shows that the waves that were discussed above seem to be quite compatible with P-waves. If this is the case then:

   - The P-wave axis is almost 90 degrees or slightly less because the 4th P-wave in lead I is clearly positive. These are still most likely to be of sinus node origin which more typically has an axis of 15-75 degrees; and
   - The P-wave morphology is abnormal: Tall in lead II and predominantly negative in V1: probable bi-atrial enlargement or abnormality (which is the preferred term).

3. **QRS complexes:** It should be noted:

   - In the top line/tracing with leads I, aVR, V1 and V4, there are 4 QRS complexes;
   - In the 2nd line with leads II, aVL, V2, V5, there appear to be 3 QRSs;
   - In the bottom tracing, the rhythm strip, there are no obvious QRSs;
   - The duration of the QRS is almost 120ms;
   - The axis of the QRS is minus 30°; and
   - Superficially there appears to be a relationship/association between P and QRS: 4:1.

4. **T-waves and QT**

   - V3 shows that there is a very wide T-wave. The QT therefore measures: 3.5 x 0.2sec (big blocks) = 700ms which is enormously prolonged;
   - It is important to spot that at the beginning of the lead V3 tracing, there is a deflection, not an artefact, which is the latter half of a T-wave (see Figure 1). Careful analysis of each of the other 11 leads shows that each starts with a similar termination of a T-wave;
   - The lead II tracing and rhythm strip have this partially recorded T-wave at the beginning and another immediately after the 3rd P-wave; this despite no QRS being visible in this lead; and
   - Measurement of the T-to-T-interval in lead II by using callipers or by marking this on a piece of paper allows one to map further intervals on the rhythm strip and make the observation that there are T-waves occurring perfectly regularly: 7 in total = rate of 42 (see Figure 2).

IN SUMMARY

The ECG shows an atrial rhythm, sinus tachycardia at a rate of 102 per minute, and a completely dissociated ventricular escape rhythm at 42 bpm, i.e. complete heart block.

Correct answer: d.

FURTHER DISCUSSION

Display or arrangement of the printed 12 lead ECG does not follow a standard or convention and is determined usually by the machine/computer manufacturer and occasionally by the user. Assumptions or being unfamiliar with the variations may lead to difficulties and ECG misinterpretation.

Commonly, the rhythm strip is a 10 second recording at the bottom of the page; most frequently lead II or V1 are used. The 12 leads may be displayed in a 3 by 4, 6 by 2, or occasionally 12 by 1 arrangement above the rhythm tracing. In the most commonly used 3 by 4 pattern the tracing of each of the 4 leads (each 2.5 seconds long) in a line may either be:

- Sequential (i.e. leads I, II, and III are of the first 2.5s; aVR, aVL and aVF of the second 2.5s; V1,V2 and V3 are from the 5 to 7.5s mark, etc. and coinciding vertically with the rhythm tracing.) or
- Simultaneous (i.e. all recorded in the same 2.5s and just displayed in the conventional manner).

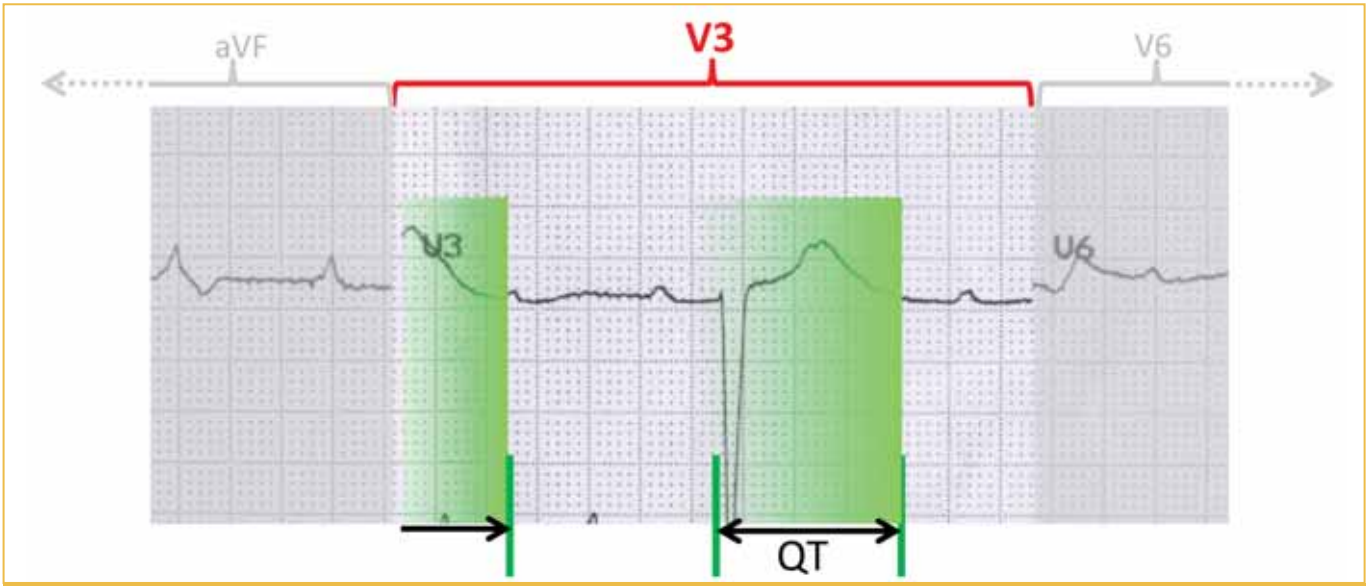

FIGURE 1: V3 segment from ECG #27.
Note the wide QRS with a LBBB-like morphology and a QT that measures 700ms. The deflection at the start of this V3 segment is not an artefact but the end of a T-wave. Dissociated P-waves are also visible.

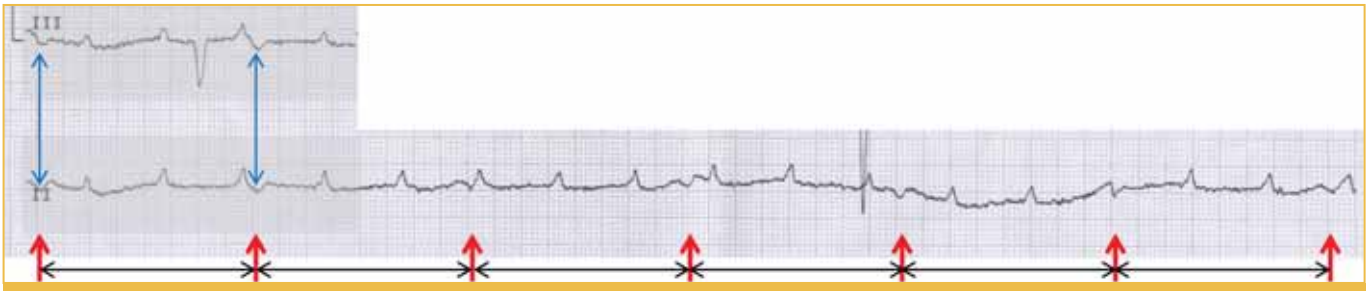

FIGURE 2: The Lead II rhythm strip of ECG #27.
The rhythm strip shows absolutely regular deflections, marked with the red arrows, and dissociated from the P-waves. These deflections are T-waves because the first 2 coincide with the T-waves in the simultaneous recording in Lead III. In Lead II no QRS complexes are visible.

The latter is how ECG #27 was recorded and only the first 2.5s of the rhythm strip is in synchrony with the traces above. Multi-channel simultaneous recordings are best for the analysis of arrhythmias and wave morphologies: The 12 by 1 over 10sec recording is probably the best but is not often available (see Figures 3&4).

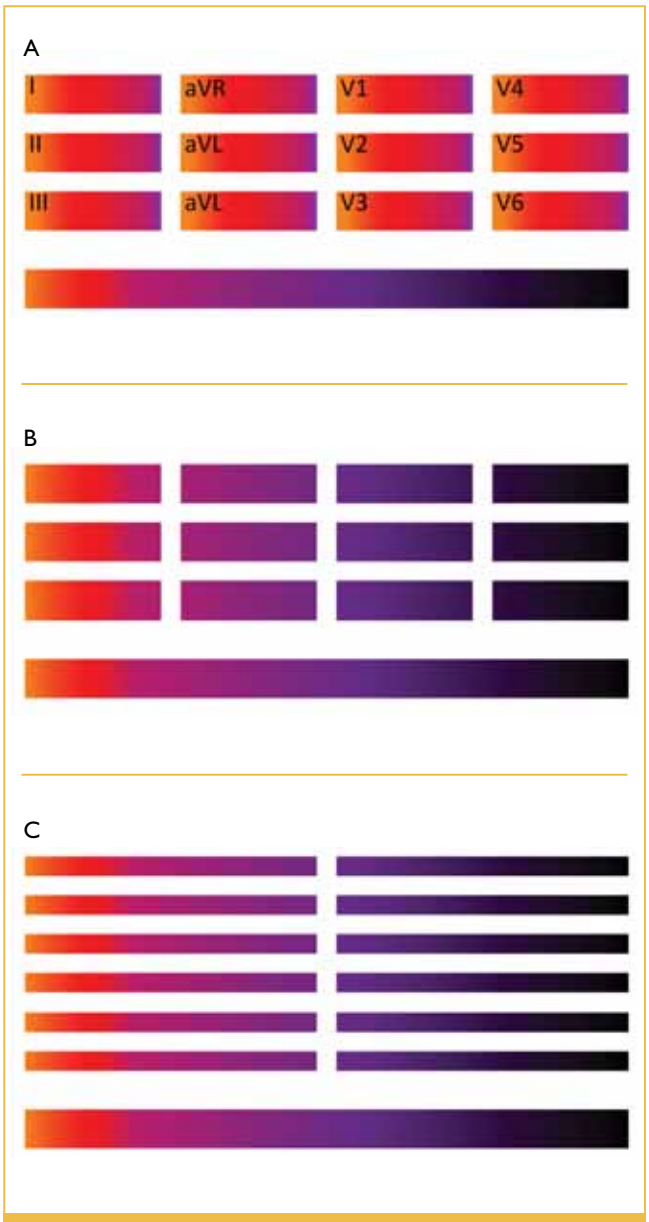

FIGURE 3: Display of the arrangement and timing of 12 lead ECG traces.
A. Simultaneous 3x4 format: In this arrangement of the 12 leads, as in ECG #27, all 12 traces were recorded simultaneously during the first 2.5 seconds and all coincide or are synchronous only with the first quarter of the rhythm strip.
B. Sequential 3x4 format: This is the most frequently used format with each of the leads in each horizontal line following sequentially in time during the 10 second recording.
C. Sequential 6x2 format: Another common format.

As a precaution, one should be aware that ECG monitors and machines may let one down in the setting of ventricular asystole with an underlying atrial rhythm. The auto-gain function of many ECG monitors may increase the apparent size of P-waves to such an extent that they are misinterpreted and counted as QRSs.
Apart from the technical issues, it is necessary to state the obvious:

- There cannot be a T-wave unless there was a ventricular depolarisation or QRS; and,
- Since the QRS complex has a vector and axis, it is possible that each part of the QRS and therefore the whole complex may be exactly perpendicular to one of the bipolar limb leads and may not register a visible deflection in that recording. It does not mean that there is no QRS.

The T-wave can be likened to an aeroplane's vapour trail; even if one may not be able to see the aeroplane as may occur if the observation is from the side as opposed to viewing it from below i.e. in the perpendicular plane when it will be seen in greatest dimension, the presence of the vapour trail confirms its existence.

The most important observation apart from the diagnosis of complete heart block is the prolonged QT interval which, even if corrected for the slow rate, remains worryingly long and may predispose the patient to Torsades-de-Pointes, and the risk of fatal ventricular fibrillation. It must be remembered that the 1-year mortality rate related to complete heart block is over 50%; not all deaths are due to failure of the escape rhythm and asystole, but some are due to "bradycardia-induced-tachycardia". A pacemaker is urgently indicated for this patient.

CONCLUSIONS/LESSONS

- The ECG diagnosis of an arrhythmia should never be based on a single lead. Analysis of multiple simultaneously recorded leads is best. ECG recordings may differ vastly in their arrangements.
- Any visible ECG deflection recorded in a limb lead tracing, whether of a P, QRS, ST or T, is possible only if the vector of the electrical activity is not perpendicular to this lead.
- A QRS can occur without a preceding P-wave; but a T-wave can never occur without a QRS (visible or invisible).
- Bradycardia prolongs QT intervals regardless whether it is due to complete heart block or sinus bradycardia/arrest, and predisposes the patient to the risk of a lethal tachyarrhythmia. This is eliminated by pacing.

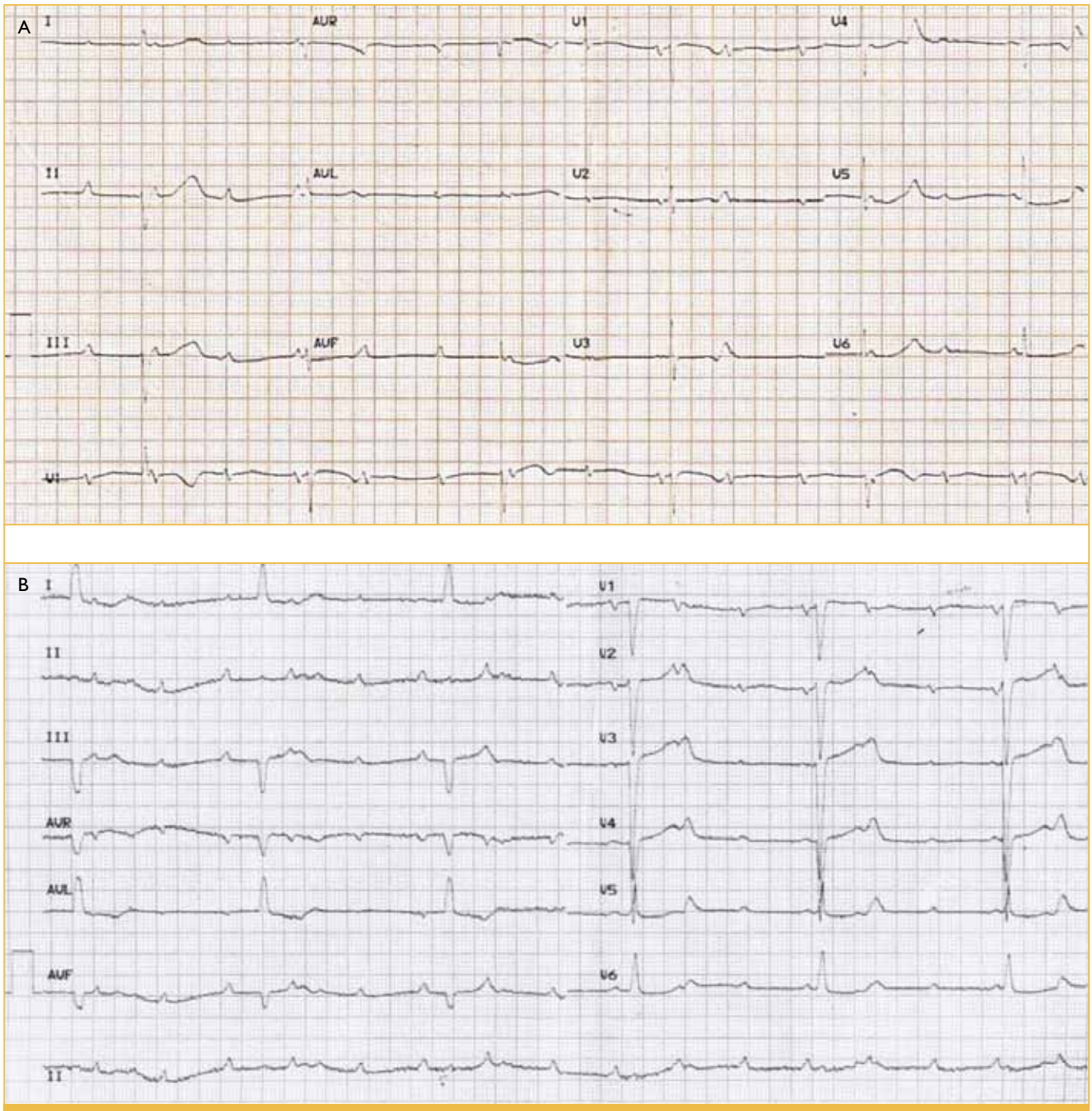

FIGURE 4: Other ECGs of the same patient on different ECG machines.

A. This ECG in the more familiar "sequential 3x4 format" was recorded on arrival at our hospital 2 days after ECG #27. It still shows complete heart block with a ventricular escape rhythm. The V1 rhythm strip at the bottom shows that the first escape beat arises from a different ventricular focus and therefore is now "visible" in Lead II.

B. This ECG in sequential 6x2 format recorded by a different machine in the referring hospital just prior to transfer shows an identical rhythm to ECG #27.

ECG and **QUESTION** on page 118