Artefactual spikes in electrocardiography: a worthwhile introspection

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ABSTRACT Electrical devices, which have become an integral part of our daily life, may influence the electrical recording of the heart. These disturbances from external sources outside of the heart's own activity produce changes in the electrocardiography (ECG) of the patient, simulating rhythmic disturbances of the heart. Understanding these disturbances is essential in order to better interprete the ECG. Common sources of electrical interferences include external devices, such as alternating current and improper earthing, and surgical procedures like diathermy. We report a case of electrical interference in a patient's ECG due to an inserted bladder stimulator. This case report highlights the importance of precise identification of artefacts in the interpretation of ECG, as well as prompt localisation and elimination of the source of interference.

Keywords: artifacts, electrocardiography, implanted neurostimulator
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INTRODUCTION

Electrocardiography (ECG) has become an important tool in the diagnosis of various clinical conditions that require appropriate interpretation skills for meticulous management. At the same time, ruling out the influence of artefacts also plays a major role in avoiding misdiagnosis, thereby conserving health resources. Here, we describe how a patient admitted for a different presentation was incidentally noted to have changes in ECG irrelevant to the presentation, and how retrospective clinical investigations had led to the diagnosis of electrical interference in ECG from a bladder stimulator within the patient.

CASE REPORT

A 59-year-old Caucasian woman presented to the emergency department with an episode of syncope following a strained bowel movement. Her past medical history was significant for chronic obstructive pulmonary disease, diabetes mellitus, coronary artery disease, hypertension, hyperlipidaemia, anxiety, acid reflux and chronic urinary urge incontinence secondary to neurogenic bladder. Her surgical history was significant for appendectomy and implantable neurostimulator device in the bladder for chronic urge incontinence. On admission, her vital signs were stable and no orthostatic changes in blood pressure were noted. Physical examination was normal. Laboratory data, including complete blood count and basic chemistry profile, were also normal. However, an interesting incidental finding was noted in her ECG (Fig. 1).

The patient's ECG revealed a normal sinus rhythm and an old right bundle branch block. No ST-T changes were noted. However, ECG also revealed regularly placed small spikes in the frequency of 14 Hz in all leads, more prominently in the inferior leads II, III and aVF (Fig. 1). This is evident in Fig. 2, which shows 14 up and down wave patterns in a given second (25 squares). As the disturbances were more prominent in the inferior leads, this suggested that the cause of the artefact was closer to the left leg (Table I).

The 12 conventional ECG leads record the differences in potential between the electrodes placed on the surface of the body. They are divided into two groups: six limb leads and six precordial leads. The six extremity leads are further divided into three bipolar leads (leads I, II and III) and three unipolar leads (leads aVR, aVL and aVF).[(1)] The types of interference described above have different effects on all electrodes. Table I shows the disturbed electrodes in connection with the disturbed leads. This table is based on Einthoven's triangle to help us localise the source of the disturbance detected in the ECG. After performing the appropriate diagnostics in the evaluation of the patient's symptom, the diagnosis of a vasovagal event was made. She was counselled accordingly and discharged with regular follow-up. However, this incidental finding in the patient's ECG warranted further explanation, which led to further exploration.

The spikes in the ECG were uniform, clearly indicating that the recorded electrical activity was from an external device emitting electrical discharges at a constant frequency. Alternating current (AC) interference from an external source was ruled out since the ECG showed low frequency spikes (14 Hz) and AC usually has a wavelength of 60 Hz. Hence, judging from the stability of the spikes and prominence in the leads closer to the source of disturbance, the interference detected in the patient's ECG was assumed to be due to a device that was not from an external source.[(2)] It was eventually found that these spikes were due to the electrical interference by a sacral nerve stimulator

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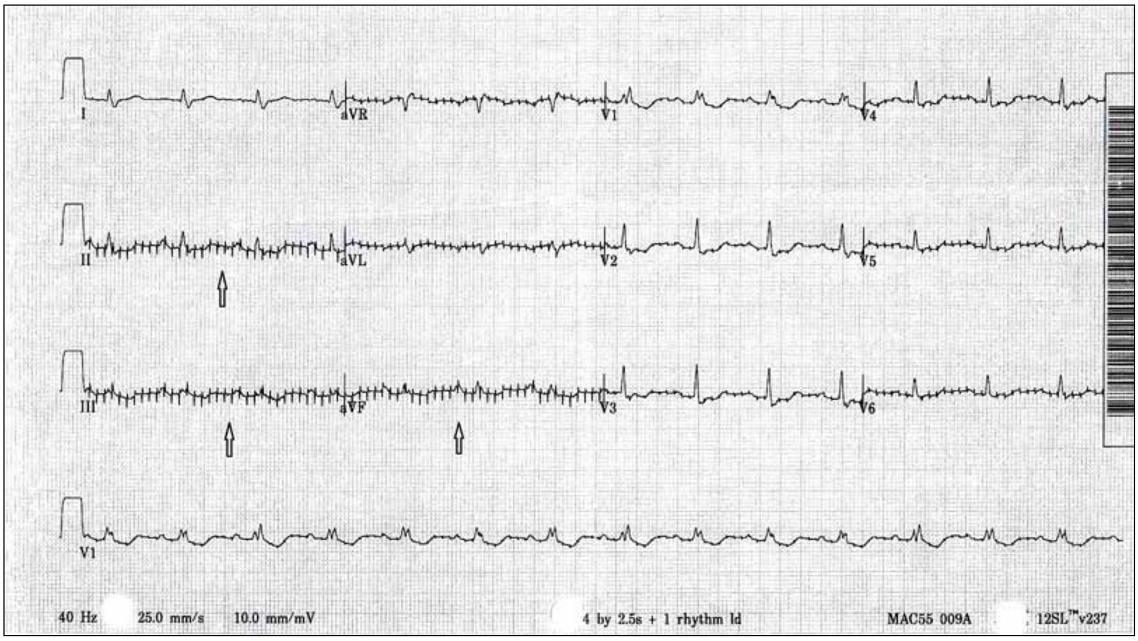

Fig. 1 ECG of the patient shows electrical disturbance in the form of regular spikes. Electrical interference is more prominent in the inferior leads (arrows).

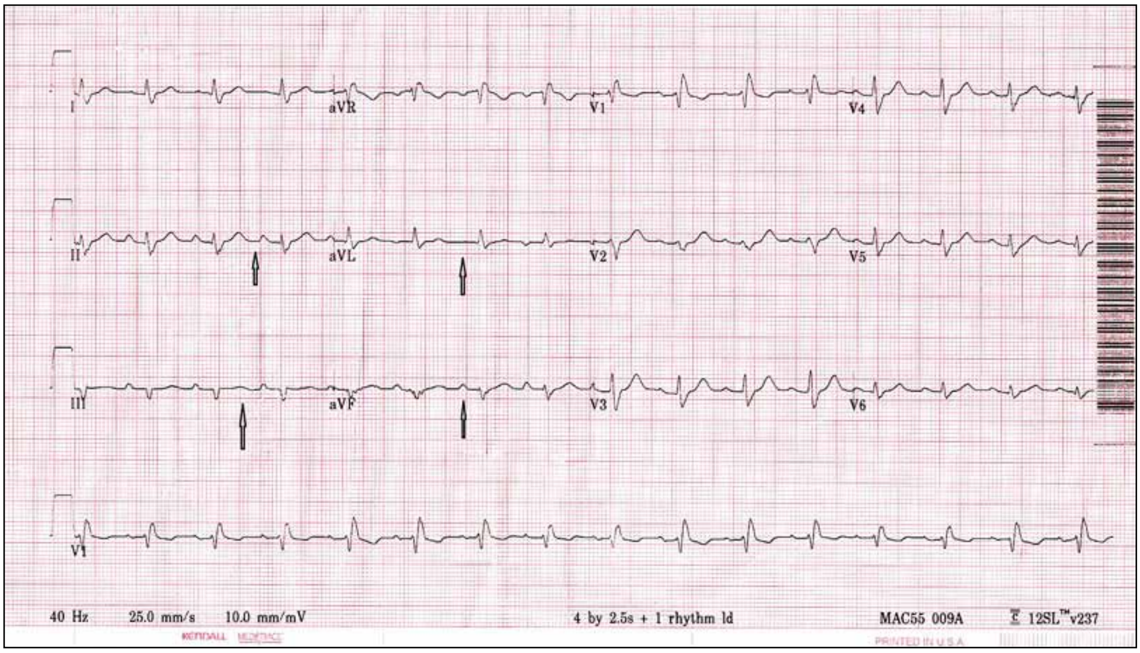

Fig. 2 ECG of the patient after removal of the bladder stimulator shows areas with no disturbance (arrows).

situated in the lower back. This resulted in the ECG artefact. During an ECG recording, skin electrodes detect changes in voltage, which are then displayed graphically. These voltage changes reflect the electrical current during cardiac depolarisation and repolarisation. Thus, an ECG machine is designed to record the frequencies that lie within the bandwidth sampled for the detection of intracardiac signals. In this case, as our patient had a bladder stimulator with a frequency of 14 Hz, the ECG machine determined that as an intracardiac signal that had produced the artefact.

Bladder stimulators usually produce their own electrical current with varying frequencies, amplitude and duration. Our patient had an InterStim® II neurostimulator[3] (Medtronic, Minneapolis, MN, USA) inserted for her neurogenic bladder, as her symptoms

Table I Localisation of the interference based on the analysis of limb electrodes.

Lead I	Lead II	Lead III	Disturbed electrodes
Disturbed	Disturbed	OK	Right arm
Disturbed	OK	Disturbed	Left arm
OK	Disturbed	Disturbed	Left leg
Greatly disturbed	Disturbed	Disturbed	Right arm and left arm
Disturbed	Greatly disturbed	Disturbed	Right arm and left leg
Disturbed	Disturbed	Greatly disturbed	Left arm and left leg
Identical interference in all three leads			Right leg

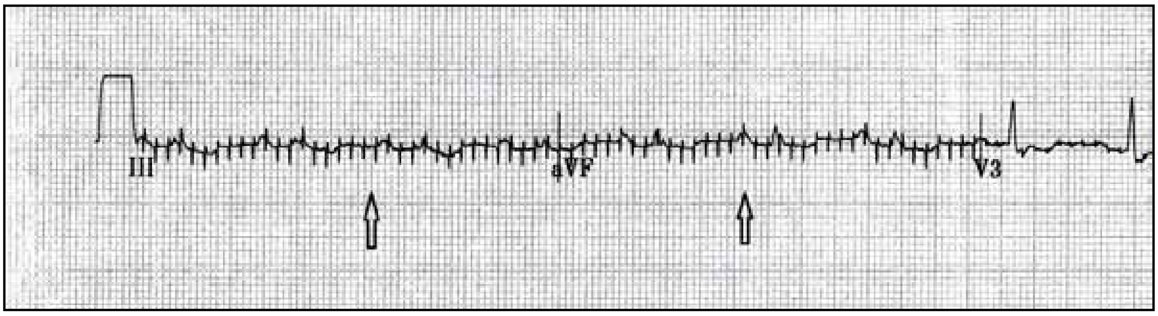

Fig. 3 Magnified view of the regularly spaced spikes in lead III and aVF.

were not resolved with conventional management. InterStim® II neurostimulator uses mild electrical stimulation of the sacral nerves to influence the behaviour of the bladder, sphincter and pelvic floor muscles. It was set at a rate of 14 Hz and found to be consistent with the artefacts in the patient's ECG. The concomitant use of a bladder stimulator during ECG recording had made it possible to have the bladder stimulator's current recorded via the skin electrodes.

After one year, the patient had sepsis of the bladder stimulator pocket and it was subsequently removed. Repeat ECG at that time revealed normal waves without any electrical interference (Fig. 3).

DISCUSSION

In the case of our patient who was admitted for evaluation of syncope, ECG is one valuable tool that could lead us to the diagnosis. The regularly spaced spikes in the inferior leads called for differential diagnoses and led to the discovery of the electrical interference from the sacral nerve stimulator implanted in the patient. We were able to identify the cause, as the frequencies of both the artefacts in the ECG and the nerve stimulator were identical. Also, the presence of these disturbances, which were more pronounced in the inferior leads II, III, and aVF (closer to the device), pointed to the direction of the source of electrical interference. When the patient's bladder stimulator was removed a year later, the pattern of interference diminished from the ECG. A similar incident has also been described in the past,[2] where the source had been localised based on the location and type of interference. In our case report, we were able to substantiate our findings with a repeat ECG taken after the removal of the source of disturbance. Similarly, implanted cardiac pacemakers would also produce artificial spikes in ECG. Each pacemaker spike is followed by either a P wave, QRS complex or both, depending on the position of the pacemaker leads within the cardiac chambers. They are usually set at a heart rate of 60–80 beats per minute. In addition to this, various commonly used equipment could produce electrical artefacts in ECG. Some of these common sources of electrical interference include electrocautery, neurostimulator, transcutaneous electrical nerve stimulation units, diathermy, welders, electric motors and cellular phones.[4]

Had it not been for the precise identification of the source of these artefacts in the patient's ECG, it would have led to serious confusion and misinterpretation by the healthcare professional. Therefore, we would like to emphasise a variety of other common causes of electrical interference. AC interference is interference that arises from the superpositioning of the ECG wanted signal with sinusoidal voltages with the mains frequency. It can be recognised by its constant frequency of 50 Hz or 60 Hz, depending on the country. This constant frequency is often only recognised when the ECG recorder has a high paper speed (100 mm/s). Clinical guidelines for recording a standard 12-lead ECG specify a high frequency filter setting of no lower than 100 Hz.[5] Lowering the high frequency filter from 100 Hz to 40 Hz would eliminate the interferences caused by 60-cycle artefacts.[6] AC interference due to earth circuit or incorrect earthing occurs when the protective earth forms a closed ring. Often, little attention is paid to earthing. This can be remedied by interrupting the loop. Good earthing may be obtained by connecting the metal frame of the table to the earthing pins of the ECG recorder via a sufficiently thick cable (≥ 4 mm^2). For a permanent solution, the table should be contacted by tightening the earthing cable firmly.

Shaking/muscle tremors come from interference voltages from the patients themselves. Interference picked up by the ECG machine can originate from muscles other than the heart. For example, when the patient is cold, the musculature contracts and the currents are taken up by the ECG electrodes. At first glance, shaking often appears to be AC interference. However, they can easily be distinguished when observed at a high paper speed (100 mm/s).[6] The frequency in this case is not constant, as the amplitude and frequency of every wave are different. When the tremors are present due to myoclonus or Parkinson's disease, the limb leads can be moved closer to the heart.

Movement of the curve upwards or downwards is an easily recognisable feature of zero line fluctuations. It can be caused by anxiety, pain, cable movement, patient perspiration, orthopnoea or respiratory swing seen in patients with chronic obstructive pulmonary disease.[7] Thus, it has become highly essential that the artefacts in the interpretation of an ECG are appropriately recognised and eliminated. In this case report, we have highlighted the common causes of interference due to electrical devices that are used daily. Clinicians should be aware of these artefacts in ECG, and help promote appropriate ECG interpretation and intervention. This could help to prevent unnecessary misdiagnosis.

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