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Original Article

Efficacy of Esophageal Electrocardiogram for Diagnosis of Wide QRS Complex Tachycardias: Results from Emergency Room Cases

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Abstract:
Objective To evaluate the diagnostic value of esophageal electrocardiogram in Wide QRS complex tachycardias (WCTs), especially in the emergency room (ER).
Methods Esophageal electrode intubation was performed on emergency patients with WCTs, the esophageal electrocardiograms were recorded to compare with conventional electrocardiogram for diagnosis of atrioventricular conduction.
Results Esophageal cardiac electrocardiogram and transesophageal pacing results revealed that the characteristic of WCTs, with neither misdiagnosis nor misjudgment.
Conclusion Esophageal electrocardiograms are simple and easy to perform, can accurately reflect atrioventricular conduction, and improve detection rate of "atrioventricular separation". Therefore, they have high diagnostic value for WCTs.
Key words : Wide QRS complex tachycardia ; Atrioventricular separation; Esophageal electrocardiogram;

1. Introduction

Wide QRS complex tachycardias (WCTs) refer to a tachycardia with a QRS complex time limit exceeding 0.12 s and a frequency > 100 beats/min. Among them, ventricular tachycardia accounts for about 80%, while a supraventricular rhythm with aberrant conduction accounts for about 20% [1].

These conditions have different electrophysiological mechanisms, as well as treatment and prognosis. Therefore, rapid and accurate differential diagnosis have important clinical value for emergency treatment. At present, many procedures have been developed for identification of ECG for WCTs, including early Wellens identification, the Brugada four-step, Vereckei four-step, aVR Lead four-step, and the recent ventricular tachycardia integration methods, among others. [2-5]. Notably, all these techniques have significantly contributed to diagnosis of WCTs, thus are widely used in clinical practice. Moreover, these procedures emphasize that the phenomenon of "atrioventricular separation" has the highest specificity during WCTs diagnosis. Although the phenomenon of "atrioventricular separation" is regarded as the "gold standard" for diagnosing ventricular tachycardia, the reality is that it is less sensitive in WCTs , since the atrial P wave with relatively small amplitude is superimposed onto the wide QRS complex or T wave in WCTs, which makes it difficult for P waves to be identified. Occasionally P waves appear on ST-segment or equipotential lines, thus medical staff cannot be sure that they are real P waves or local interference waves.

Many scholars have proposed the use of specific ECG lead methods, such as S5 lead, Lewis's lead, and Fontaine lead, among others [6-7]. Most ECG workers are familiar with these methods, which increase the amplitude of the P wave, thereby enhancing detection rate of the phenomenon of "compartment separation". Although the above-mentioned specific lead methods are simple to operate, these operation still perform ECG on the body surface of the chest, sometimes P wave amplitude is still not large enough to distinguish among WCTs. The esophageal electrode is inserted into esophagus (just behind the left atrium of the heart). The recorded esophageal electrocardiogram has a high P wave. In most cases, the P wave amplitude is higher than the QRS complex (Figure 1). The esophageal electrocardiogram's tall P wave has numerous characteristic advantages compared to the body surface electrocardiogram's small P wave, hence it has been widely applied for diagnosis and differential diagnosis of WCTs in emergency rooms, and achieved excellent clinical outcomes. In this article, we present five cases of use of electrocardiogram for diagnosis of WCTs in the emergency room.

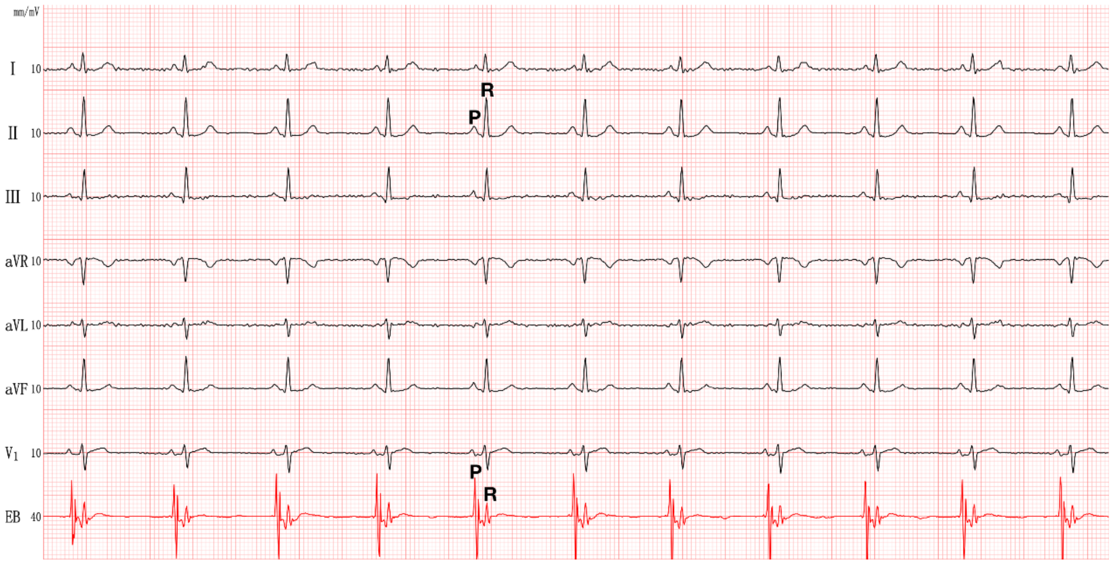

Figure 1. Profile of a conventional electrocardiogram showing that the P wave amplitude in lead II is the highest, but is still smaller than the QRS complex amplitude. The synchronized esophageal lead shows that the P wave amplitude is higher than the QRS complex, reflecting the esophageal lead the huge advantage of P wave recognition.

Case 1

A 60-year-old male patient admitted in the ER with sudden palpitations and discomfort for 2 hours. Emergency ECG revealed WCTs, as shown in Figure 2. There was no obvious P wave in each lead, and the wide malformation of QRS complex showed a left bundle branch block pattern. The interval was 0.14 s and the QRS complex of leads II, III, and aVF exhibited a coarse start and middle frustration, fragmentation. His heart rate was 156 beats/min. ECG diagnosis: WCTs (suggesting supraventricular tachycardia with complete left bundle branch block). The patient was generally in good physical condition, with clear consciousness, stable blood pressure, and only manifested symptoms of palpitations. To verify the ECG diagnosis and facilitate subsequent clinical treatment, an esophageal ECG was performed, and showed that the high-point three-phase "P" wave (Down arrow) with a frequency of 312 times/min, coincided with the QRS complex (Up arrow) indicating a 2:1 relationship. In addition, the PR interval was stable, indicating that there was a conduction relationship between the atrio-ventricles. Therefore, the clear diagnosis was: atrial flutter with 2:1 atrioventricular conduction and complete left bundle branch block.

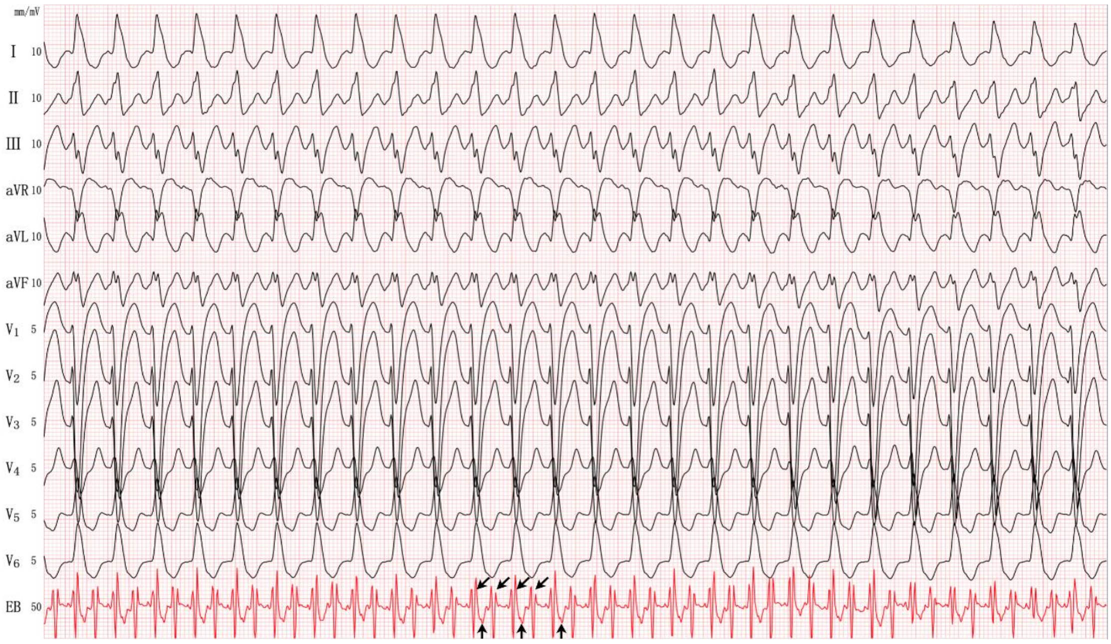

Figure 2

Case 2

A 31-year-old male patient with paroxysmal tachycardia for 16 hours, without amaurosis and syncope, was admitted in ER. The ECG is shown in Figure 3. No clear P wave was observed in the 12-lead conventional electrocardiogram, while the QRS complex showed a "left bundle branch block" pattern. The QRS interval and heart rate were 0.13s and 197 beats/min, respectively. The beginning of the complex was coarse, the main wave of the QRS complex in lead I was downward, and the electric axis shifted to the right. Leads II, III, and aVF exhibited a single R wave, while the peak time of the R wave in lead II was 70ms. ECG diagnosis was WCTs, indicating ventricular tachycardia. The patient was generally in good condition. In order to confirm the diagnosis, esophageal electrocardiogram was performed, revealing a clear three-phase sinus P wave (down arrow), frequency 105 times/min. In addition, the P wave frequency was less than that of QRS , the period between PR varied. This indicated a typical "atrioventricular separation" phenomenon, making it clear that the tachycardia was indeed ventricular tachycardia.

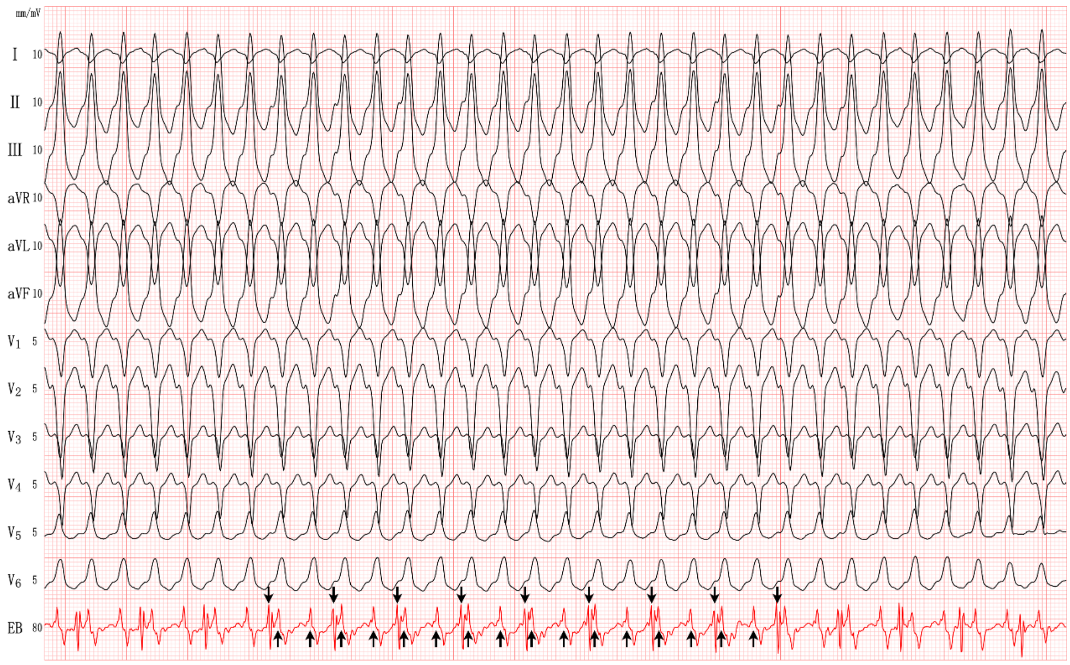

Figure 3

Case 3

A 23-year-old male patient, clinically diagnosed with Ebstein malformation, a rare congenital cardiac defect. The patient suffered from intermittent tachycardia for more than 3 years. Physical examination revealed a blood pressure of 105/55mmHg, and a heart rate of 150 beats/min. He had no history of syncope. Emergency ECG is shown in Figure 4. Summarily, we found no clear P wave in the 12-lead conventional ECG, the QRS complex was wide and deformed, with a coarse initial part and a visible pre-excitation delta wave. Moreover, the interval of QRS complex was 0.22s , with a heart rate of 153 beats/min, which indicated "left bundle branch block". ECG diagnosis was WCTs (pre-excitation tachycardia? Ventricular tachycardia waiting to be distinguished). An esophageal ECG was performed, revealing a high-point three-phase "P" wave (down arrow), a frequency of 306 times/min, which was exactly 2:1 with the QRS complex (up arrow) relationship, and a stable PR interval. This indicated that there was a conduction relationship between the atrio-ventricle. Therefore, the diagnosis was atrial flutter with ventricular pre-excitation with 2:1 atrioventricular conduction.

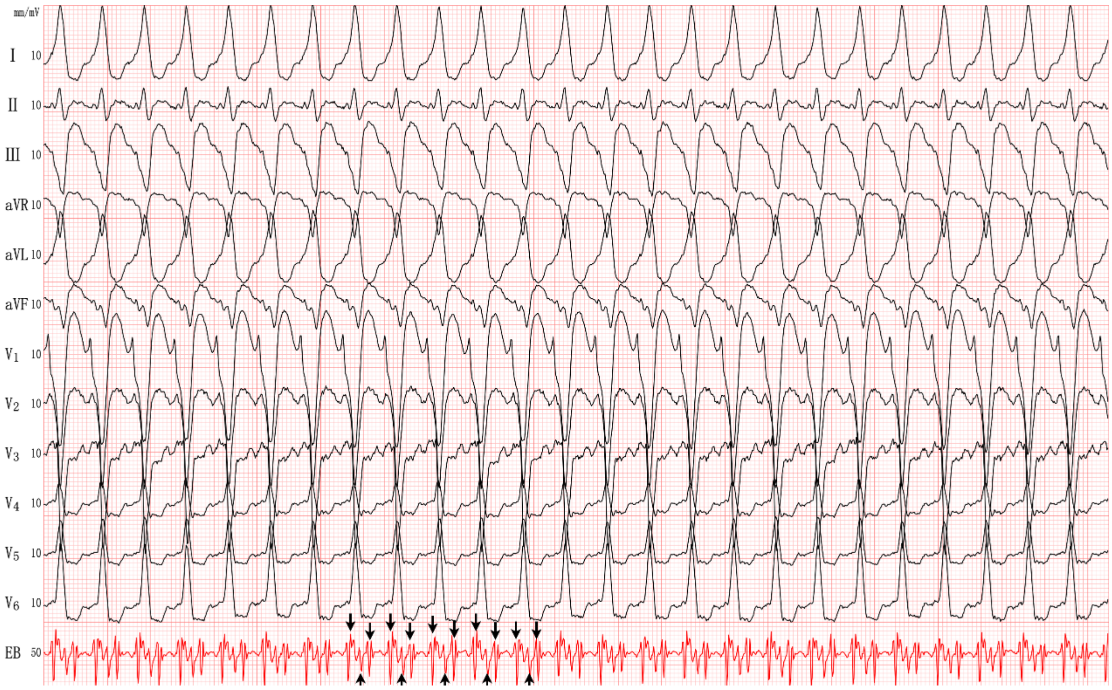

Figure 4

Case 4

A 45-year-old male patient came to the ER with sudden heart palpitations for 3 hours. Emergency ECG is shown in Figure 5. Summarily, a "P" wave was visible on the ST segment at the end of QRS in each lead of the 12-lead conventional ECG (the most typical point is the upward arrow in lead V2). In addition, he had a fixed RP interval of 125 ms, the initial part of the QRS complex was coarse, with an interval of 0.12s, and a heart rate of 176 beats/min. ECG diagnosis was reentrant supraventricular tachycardia (atrial tachycardia or antegrade atrioventricular reentrant tachycardia?) The patient was generally in good condition. To confirm the diagnosis, esophageal ECG was performed. Results showed a high-tip 4-phase P wave (downward arrow), which immediately followed at the end of QRS, with a constant RP interval of 150 ms, suggesting that the RP was in a 1:1 relationship. Since reentrant supraventricular tachycardia was first considered, he was given 5 times of S1S1 overspeed atrial stimulation at a rate of 270 times/min, to terminate the tachycardia. The P wave disappeared after the first QRS complex following stimulation, indicating that the stimulation effectively captured the atrium. However, the tachycardia was not terminated, and the RR interval did not change during stimulation, indicating that the atrium does not necessarily participate in maintenance of tachycardia Therefore, atrioventricular reentrant tachycardia and intraatrial reentrant tachycardia were directly excluded. In addition, the common slow-fast atrioventricular nodal reentrant tachycardia was also excluded, based on the esophageal lead RP interval greater than 90ms. Combined with the Conventional ECG (right I, II, III, V4-V6 conventional ECG) morphology of premature ventricular beats were consistent with the QRS morphology of this tachycardia, confirming that the tachycardia was indeed ventricular tachycardia with 1:1 ventricular retrograde.

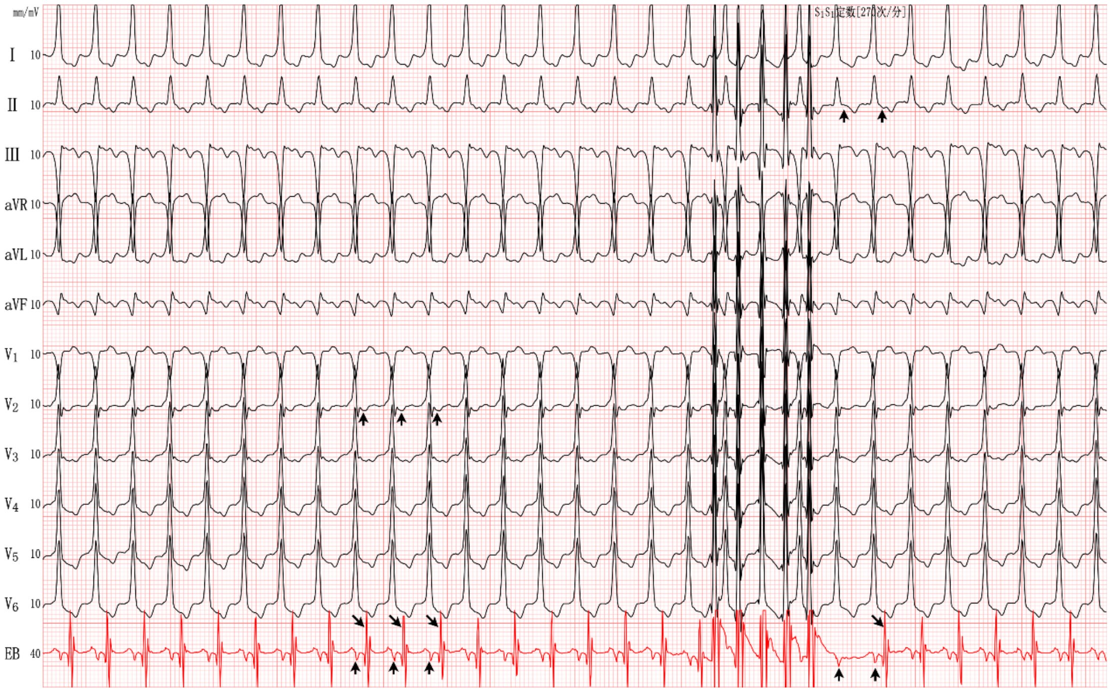

Figure 5

Case 5

A 43-year-old male patient, complaining of paroxysmal palpitations and discomfort for more than 1 year, came to see the doctor 3 hours after the attack. Results of the emergency ECG are shown in Figure 6. Regular 12-lead ECG revealed no clear P wave, and the QRS complex time limit was 0.13s, showing right bundle branch block combined with left anterior branch block, electrical axis +90°, r/s<1 in leads V5 and V6. The QRS complexes of the limb leads resembled retrograde P wave overlap, while the ventricular to atrium had a 1:1 retrograde. The ECG diagnosis was supraventricular tachycardia with complete right bundle branch and left anterior branch block (ventricular tachycardia), with 1:1 ventricle reverse transmission to be arranged. The recorded esophageal electrocardiogram confirmed that the ventricle was reversed 1:1, and the RP-interval was 116 ms, suggesting an antegrade atrioventricular reentrant tachycardia. Follow-up results are shown in Figure 7. The patient was given several S1S1 overspeed stimuli to capture the atrium and pass down the ventricle. Results showed that it was passed down as a narrow QRS complex (R1), WCTs continued to occur, although there was no related P wave before R2, while R2 was consistent with the previous tachycardia QRS complex. The case was confirmed as ventricular tachycardia with 1:1 retrograde ventricular atrial transmission.

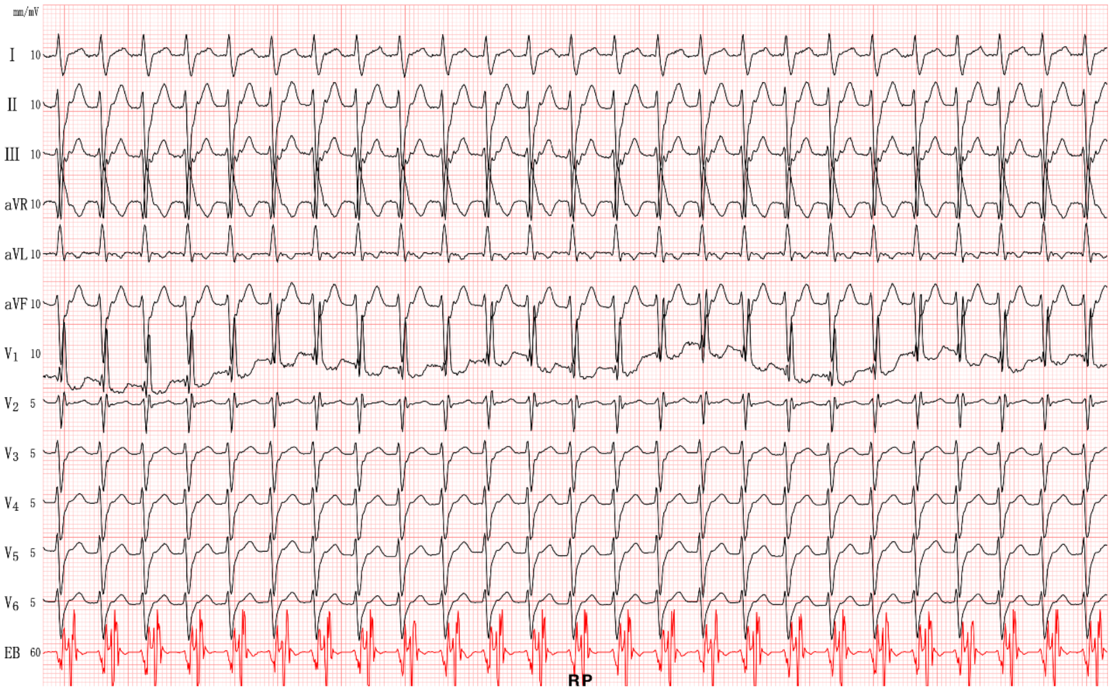

Figure 6

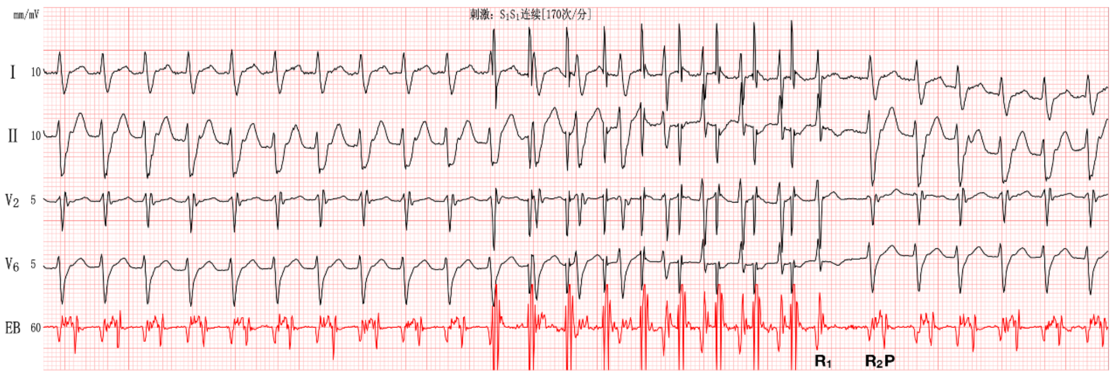

Figure 7

Discussion

Insert the esophageal electrode catheter from the nostril (or mouth) into the esophagus and place it behind the left atrium. The depth is approximately 36 ~ 40cm for males and 34 ~ 38cm for females, which also can be evaluated according to the calculation formula: (the height of the patient +200)/10= Intubation depth (cm); or record the appropriate left atrial potential according to the esophageal lead to determine the reasonable electrode depth. The external electrode leads are connected to the tail ring electrode of the esophageal lead and the recording device, and the ECG waveform of the corresponding lead is recorded, which is the esophageal ECG . Since it has the characteristics of P wave height, coupled with clarity and easy identification, it has a significant advantage for diagnosis of arrhythmia. Insertion of esophageal electrode catheter, such as in the case of gastric tube insertion, esophageal varices, or post-esophageal resection, is contraindicated. In our hospital, out of nearly 400 cases of esophageal cardiac electrophysiology catheterization, only a few instances of minor nasal mucosal frictional bleeding have been observed, with no severe complications reported. This can be attributed to the smaller size of the electrode catheter compared to a gastric tube, enabling proficient handling by clinical staff and nurses. Patients also demonstrate good tolerance to the procedure.

WCTs, in which ventricular tachycardia accounts for about 80%, are a common medical emergency. Accurate diagnosis of this condition, which mainly causes malignant arrhythmia, hemodynamic disturbances and other serious complications, is clinically important for emergency treatment, selection of follow-up strategies and prognostic evaluation. WCTs do not easily show P wave in conventional ECG, which complicates diagnosis. Esophageal ECG has the advantage of P wave height and clarity, a phenomenon that enhances diagnosis of WCTs. Some suspicious ventricular tachycardias with 1:1 retrograde can also be obtained via electrical stimulation of the left atrium of the esophagus, to capture the downstream atrium ventricle, observe the QRS complex morphology and tachycardia QRS complex morphology, thereby aid in making judgments. Atrioventricular, ventricular-atrial conduction relationship to finally determine the type of tachycardia (case 5).

Atrial flutter is common in clinical practice. Generally, flutter waves have a frequency between 250 and 400 beats/min, with 2:1 or 4:1 atrioventricular conduction. Most of the atrial flutter presents 2:1 atrioventricular conduction, when one of the flutter waves overlaps the QRS complex. This makes it easy for the condition to be misdiagnosed as reentrant supraventricular tachycardia, such as Atrioventricular nodal reentry tachycardia, orthodromic atrioventricular reentrant tachycardia and Atrial tachycardia. When atrial flutter is combined with bundle branch block, the flutter wave is more difficult to determine clearly on the conventional ECG. However, the esophageal electrocardiogram can make it clear at a glance.

In the case of WCTs, esophageal electrocardiogram records that the ventricular rate is faster than the atrial rate, and the phenomenon of “atrioventricular separation”, except for the rare atrioventricular junction tachycardia with retrograde block, which can be determined as ventricular tachycardia (case 2). It is worth noting that although the clinically 1:1 retrograde tachycardia from the ventricle to the atrium is mostly considered supraventricular tachycardia, it is not uncommon for ventricular tachycardia with varying degrees of ventricular retrograde [8], as evidenced in Cases 4 and 5. Generally, idiopathic bundle branch reentrant ventricular tachycardia can easily be misdiagnosed as supraventricular tachycardia with bundle branch block. Therefore, esophageal electrocardiograms can only verify the diagnosis of atrioventricular conduction at this time, but cannot directly characterize the nature of tachycardia. Notably, electrical stimulation, through the esophagus, can cause electrical discharge stimulation. In most cases, the left atrium can be effectively captured and the retrograde relationship can be interrupted, as evidenced in Cases 4 and 5 of this study. By observing the comparison between the downloaded QRS and the tachycardia QRS complex, one can also effectively judge the nature of the tachycardia. If the WCTs is supraventricular tachycardia, appropriate electrical stimulation is required to effectively terminate the tachycardia and alleviate tachycardia attack. If the WCTs is ventricular tachycardia, then the esophageal electrode stimulation site is also only on the posterior wall of the left atrium, and is not related to the location of ventricular tachycardia. This indicates that electrical stimulation is also safe and reliable.

Ventricular tachycardia is caused by several factors, including coronary heart disease, cardiomyopathy, valvular heart disease, congenital heart disease, electrolyte disturbances, and drugs, among others . Generally, patients may experience symptoms such as palpitation, chest tightness, chest pain, blackout, and syncope, among others, although in very severe cases, disability, and death may occur. Notably, doctors need to actively take treatment measures once ventricular tachycardia occurs. To this end, the following treatment principles have been proposed: (1) preventing development of non-organic heart disease ventricular tachycardia, such as hypokalemia, using digitalis drugs; (2) actively managing the primary disease, by correcting heart failure, and treating ventricular aneurysm after myocardial infarction; (3) applying corresponding drugs or non-drug measures, after terminating ventricular tachycardia, to prevent recurrence; and (4) actively preventing occurrence of sudden cardiac death caused by ventricular tachycardia. However, a patient’s basic condition needs to be evaluated when applying the esophageal electrocardiogram. Patients are generally in good condition and can only tolerate esophageal intubation. Those who have not been evaluated should not undergo this operation to avoid unnecessary complications.

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