Diagnostic management of patients with palpitations of unknown origin

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The first-line investigations in the diagnostic management of patients with palpitations include history taking, physical examination and ECG. These investigations yield a definitive or probable diagnosis in a good proportion of patients. If the patient is suffering from heart disease, or if the palpitations are frequent or poorly tolerated, ambulatory ECG monitoring and electrophysiological study should be undertaken.

Holter monitoring (useful when symptoms occur daily) has a rather low sensitivity, while event recorders (useful in compliant patients with infrequent palpitations that are fairly long-lasting) and external loop recorders (recommended in cases of infrequent short-lasting palpitations associated with hemodynamic impairment) have proved to have a higher sensitivity. The diagnostic yield of the electrophysiological study (generally recommended when the recording attempts using ambulatory ECG monitoring fail to provide a diagnosis) depends on the stimulation protocol used, the clinical characteristics of the patients studied, and the type of arrhythmias induced. Implantable loop recorders may be recommended in patients with rare, highly symptomatic palpitations associated or not with hemodynamic impairment, when the other diagnostic modalities prove to be inconclusive.

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Definition and clinical significance of palpitations

Defined as an unpleasant sensation of the awareness of the heartbeat, palpitations are a very frequent symptom in the general population and in patients with heart disease in particular[1,2]. They may be caused by several disorders of the heart rhythm, whether benign, such as supraventricular and ventricular ectopic beats, or prognostically unfavorable, such as severe bradycardia, atrioventricular conduction blocks, and ventricular tachycardia. Moreover, palpitations may often be caused not by genuine rhythm disorders, but by episodes of rapid sinus rhythm or sinus tachycardia due to various causes (psychiatric disorders, emotion, physical effort, drugs, anemia, hyperthyroidism, etc.)[3].

It is particularly important to differentiate anxiety-based palpitations from extrasystolic and paroxysmal tachycardiac palpitations. In general, anxiety-based palpitations are perceived by the patient as a form of anguish; the heart rate is slightly above normal, and the onset and cessation are gradual. In contrast, extrasystolic palpitations give rise to sensations of "missing a beat", "sinking of the heart" or "fluttering wings in the chest", interspersed with periods in which the heart beats normally. Paroxysmal tachycardiac palpitations, which are linked to supraventricular or ventricular tachycardia, begin and end suddenly; the heart rate is generally high and the patient's subjective perception is different from that of the other types of palpitations. Finally, sometimes the patients fail to describe the characteristics of their symptoms and the palpitations remain indeterminate.

Although palpitations as a whole are generally associated with a low mortality and cardiac morbidity[3], they may be indicative of major arrhythmic events, thereby directly influencing the prognosis[1], in patients with structural heart disease, or when a family history of sudden death and/or arrhythmogenic heart disease are present, or when other symptoms (dyspnea, syncope, pre-syncope, dizziness, asthenia, profuse sweating and chest pain) are also present. On the other hand, in patients without heart disease or with mild heart disease, palpitations (especially anxiety-based and extrasystolic palpitations) generally have a benign prognosis. Nevertheless, such patients may suffer from clinically important arrhythmias that are amenable to treatment, such as atrial fibrillation, atrial flutter, or frequent ventricular ectopic beats. Moreover, as revealed by Krahn et al.[4], in pa-

tients with syncope of unknown origin who underwent loop recorder implantation, the clinical variables (age, presence of heart disease) do not always point out those patients who will develop prognostically unfavorable arrhythmic disorders during follow-up.

Finally, regardless of the severity of the arrhythmia responsible, frequent and long-lasting palpitations may prove very troublesome, result in a significant impairment of the patient's quality of life, give rise to anxiety and lead to frequent visits to the emergency department[3].

Diagnostic management of patients with palpitations

In patients with palpitations it is essential to ascertain the presence of structural heart disease and/or heart disease at risk of arrhythmias, and to obtain an ECG recording during the episodes of palpitation. In all subjects with palpitations, the first-line investigations will therefore include a thorough clinical history, careful objective examination and 12-lead ECG at baseline and, if possible, during an episode of palpitations[5]. In some particular situations, it may be useful to perform blood analyses, such as a full blood count, electrolytes, blood glucose and thyroid function tests, and a psychiatric evaluation[6]. Finally, effort stress testing is indicated in the case of palpitations constantly associated with physical exercise. The need for further investigations (echocardiogram, coronary angiography, etc.) will depend on the nature of the suspected or ascertained heart disease.

In a good proportion of patients, first-line investigations yield a definitive diagnosis of the cause of the palpitations, or at least exclude the presence of major arrhythmic disorders with reasonable certainty[3]. Indeed, in subjects without significant heart disease or with anxiety-based or extrasystolic palpitations, in whom palpitations are sporadic, not sustained and well tolerated from the hemodynamic point of view, further investigations are not usually necessary. However, the lack of an ECG recording during the episode of palpitations allows us to make only a presumptive diagnosis of the etiology of the palpitations. Indeed, it is not very unusual for patients with unrecognized tachycardia at initial medical evaluation to be diagnosed as suffering from anxiety disorders[7]. In contrast, if the palpitations are paroxysmal, frequent, sustained, poorly tolerated or accompanied by other symptoms (such as syncope, pre-syncope, etc.), or if the patient is suffering from heart disease, second-line investigations should be undertaken[1] (Fig. 1). Second-line investigations include ambulatory ECG monitoring (AECG) and electrophysiological study (EPS). In patients with structural heart disease (for example patients with myocardial infarction) who suffer from paroxysmal tachycardiac palpitations, or in those with palpitations preceding syncope, EPS should generally precede AECG. In the other patients EPS normally follows AECG.

First-line investigations

Clinical history and physical examination. When assessing the type of palpitations and the presence of heart disease, the patient's clinical history and physical examination are of fundamental importance[2]. Palpitations may have various causes, and a thorough anamnesis together with a careful physical examination may be sufficient for an initial diagnosis, albeit presumptive.

Electrocardiogram. Twelve-lead ECG recording during the course of spontaneous symptoms constitutes the gold standard for the diagnostic evaluation of palpita-

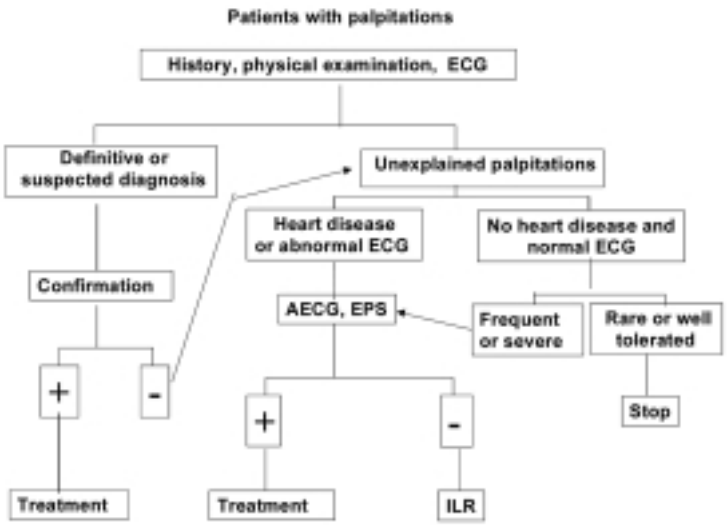

Figure 1. *Diagnostic flow-chart for patients with palpitations. AECG = ambulatory ECG monitoring; ECG = 12-lead electrocardiogram; EPS = electrophysiological study; ILR = implantable loop recorder.*

tions. Indeed, ECG recording is able to establish whether or not the palpitations are associated with a cardiac rhythm disorder and, in the majority of cases, leads to the correct diagnosis of the responsible arrhythmia[2,3]. However, in normal clinical practice, it is not always possible to perform 12-lead ECG during a spontaneous episode of palpitations. Indeed, the patient must be able to get to the nearest emergency department while the symptoms are still ongoing. This generally means that: the episode will have to be long-lasting (at least 1 hour) and that the patient must have the logistical means of reaching the emergency facility and not be prevented from doing so by the presence of other associated symptoms (syncope, pre-syncope, asthenia, etc.).

The ECG does, of course, yield valuable information even when not performed during an episode of palpitations, especially with regard to the presence of heart disease or conduction abnormalities. A 12-lead ECG therefore forms an integral part of the first-stage examinations to be performed in patients with palpitations.

Ambulatory electrocardiographic monitoring

AECG documents the heart rhythm during the clinical events and serves to establish, or exclude, an arrhythmic cause of palpitations. It makes use of both external and implantable devices. External devices may provide continuous "beat-to-beat" monitoring, as for Holter and telemetry apparatuses, or intermittent monitoring, as for event recorders and loop recorders. Monitoring by means of implantable devices involves using implantable loop recorders or the diagnostic functions of pacemakers and implantable cardioverter-defibrillators.

Event recorders. These are applied to the skin by the patients themselves when the symptoms occur and provide a prospective 1-lead ECG recording lasting for a few seconds. The optimum period of time during which the event recorder should be used generally ranges from 4 to 5 weeks[8-10].

External loop recorders. These devices are continuously connected to the patient by means of skin electrodes. Equipped with a memory loop, they provide a 1-3-lead ECG recording for a few minutes before and a few minutes after their activation; the patient himself activates the device by pressing a special button at the time of symptom onset. The latest devices are also able to record arrhythmic events automatically. The recordings made can subsequently be transmitted by telephone to the patient's medical center. The optimum duration of external loop recorder monitoring ranges from 2 to 4 weeks[11-14].

Implantable loop recorders. Of similar size to a pacemaker, loop recorders are implanted subcutaneously in the left precordial region[4]. The implantable loop recorder is equipped with a memory loop and, once activated by the patient by means of a magnet, records quite a good 1-lead ECG trace, both retrospectively and prospectively, for several minutes. These devices are also able to record arrhythmic events automatically. Implantable loop recorders have a long monitoring capability lasting up to 18 months and are explanted once the diagnosis has been made or the battery has run down.

Diagnostic yield. Prolonged AECG is regarded as diagnostic only when it is possible to establish a definitive correlation between the palpitations and the ECG recording[15-17]. Hence, in patients who do not develop clinical symptoms during prolonged AECG, these investigations are deemed non-diagnostic. AECG therefore has a low negative predictive power. Holter and loop recorders, which are also able to record arrhythmic events automatically, are regarded as non-diagnostic for the etiology of palpitations, even if the patient has evidence of asymptomatic sustained supraventricular tachycardia, or ventricular tachycardia. Moreover, if during monitoring more or less significant arrhythmias emerge which, however, are not associated with episodes of palpitations, one still cannot establish a diagnosis; it may however suggest and/or guide the execution of other examinations. The significance of such arrhythmias must, in any case, be assessed on the basis of their severity, their prevalence in the age group and in the population to which the individual belongs, and the presence of heart disease.

Holter monitoring, especially by means of the newest generation devices, is also able to provide parameters for use in the prognostic stratification of the patient (especially of patients with post-infarction ischemic heart disease). Indeed, these newest devices are able to evaluate various parameters such as heart rate variability, duration of the QT interval, ECG signal-averaging and ischemic modifications of the ST segment, in addition to the presence of rhythm disorders. However, the presence of frequent ectopic ventricular beats or non-sustained ventricular tachycardia, reduced heart rate variability, increased QT dispersion, and the presence of ventricular post-potentials have no value in the diagnosis of palpitations.

Whenever it is possible to establish a correlation between the patient's symptoms and an interpretable ECG trace, the specificity of AECG, at least in formulating a diagnosis of "*arrhythmic palpitation*" or "*non-arrhythmic palpitation*", is 100%. Indeed, the documentation of a normal sinus rhythm during an episode of clinically manifest palpitations is the quickest way to exclude an arrhythmic cause and to reassure the patient as to the prognosis. The sensitivity of AECG is, on the other hand, extremely variable and depends on the following factors: monitoring technique, duration of monitoring, patient compliance, and frequency of symptoms.

Holter monitoring has been shown to have a rather low sensitivity (33-35%) in patients with palpitations of unknown origin, i.e. patients in whom first-line examinations fail to establish the origin of their symptoms[18]. In a meta-analysis of seven studies conducted in patients with syncope and/or palpitations of unknown origin, the sensitivity of Holter monitoring was reported to be only 22%[19]. Event and external loop recorders have displayed a quite good sensitivity of 66-73% in the study of palpitations of unknown origin[18]. However, these data refer to patients with frequent palpitations. To date, no data regarding the diagnostic yield of implantable loop recorders in the study of palpitations of unknown origin have been published in the literature.

Conditions diagnosed in patients with unexplained palpitations. According to Zimetbaum and Josephson[1], most patients with palpitations of unexplained origin who undergo prolonged AECG are found to have benign atrial premature beats (0-13%), ventricular premature beats (12-36%), normal sinus rhythm (18-39%) or sinus tachycardia (5-29%). Supraventricular tachycardia accounts for a fairly high percentage of the conditions diagnosed (4-18%), both in patients with heart disease and in those without. Atrial fibrillation is also a frequent finding in these patients (2-17%), while ventricular tachycardia is much less common (0-2%), and is typical of patients with severe structural or arrhythmogenic heart disease.

Limits. AECG has some notable limits. Indeed, it is not always possible to formulate a precise diagnosis of the type of arrhythmia recorded. This is particularly true when devices that provide a single ECG derivation, such as event recorders and loop recorders, are used. For instance, it is not always easy to make a correct differential diagnosis between supraventricular tachycardia with abnormal conduction and ventricular tachycardia. Moreover, AECG is unable to distinguish bradyarrhythmias due to a reflex mechanism from those caused by an intrinsic disease of the cardiac conduction system; the prognostic and therapeutic implications of this are considerable. Finally, the technical drawbacks of the various AECG devices are reported in table I.

Indications. According to the American College of Cardiology/American Heart Association[15,16] and the Italian guidelines for AECG[17], recurrent palpitations whose origin remains unknown after first-line investigations represent a class I indication for AECG, but "there are no specific guidelines that distinguish patients for whom it is appropriate to perform continuous monitoring from those for whom intermittent AECG is adequate". In table I we have summarized our recommendations for the use of AECG in patients with palpitations. Implantable loop recorders are currently indicated for the study of patients with transitory infrequent symptoms and of those who are not sufficiently compliant with other AECG recording devices[15]. These devices have been used successfully for the study of syncope[4], in which they have shown a better cost-effectiveness ratio than conventional tests[20,21], and could also prove useful for the study of palpitations of unknown origin[5,15,22].

Table I. Recommendations for the use of ambulatory ECG monitoring (AECG) techniques in patients with palpitations.

	Holter monitoring	Event recorders	External loop recorders	Implantable loop recorders
Advantages	Low cost; possibility of recording asymptomatic arrhythmias	Low cost; quite long monitoring duration	Retrospective and prospective ECG records; possibility of automatically recording asymptomatic arrhythmias	Retrospective and prospective ECG records; quite good ECG records; monitoring capability up to 18 months; possibility of automatically recording asymptomatic arrhythmias
Drawbacks	Monitoring limited to 24-48 hours; the size may prevent activities that may trigger the arrhythmias	Short-lasting arrhythmias are not recorded; arrhythmic triggers are not revealed; poor ECG records; difficult to use	Monitoring cannot be prolonged for more than 3-4 weeks; continual maintenance is required; the devices are uncomfortable; quite poor ECG records	Invasiveness; risk of local complications at the implantation site; high cost
Indications	Daily palpitations; patients who are unable to activate a device for AECG	Compliant patients with infrequent and fairly long-lasting palpitations unaccompanied by hemodynamic impairment that is likely to hinder use of the device	Weekly short-lasting palpitations associated with hemodynamic impairment, in very compliant patients	Monthly short-lasting palpitations associated with hemodynamic impairment; when all the other examinations prove inconclusive

Electrophysiological study

EPS may be performed, in accordance with standard protocols[23], using two different techniques: transesophageal EPS (at rest and during effort), and intracardiac EPS (under pharmacological stress, if deemed necessary). EPS does offer two very important advantages: it enables us to correctly identify the type of arrhythmia responsible for the palpitations; it allows for ablation therapy of the arrhythmia itself during the same session.

Diagnostic yield. In patients with unexplained palpitations, EPS is regarded as diagnostic if it induces any tachycardia accompanied by reproduction of the spontaneous symptoms, or if it induces sustained supraventricular tachycardia (> 1 min) or sustained ventricular tachycardia (> 30 s or requiring urgent interruption). It is considered negative if it does not induce the abovementioned tachycardias.

Only a few studies have used AECG to confirm the results of EPS in the diagnostic evaluation of patients with unexplained palpitations. The true diagnostic yield of EPS is therefore only partially known. Moreover, the diagnostic yield of EPS depends on the stimulation protocol used (aggressive protocols increase the sensitivity of the test at the expense of the specificity), and on the clinical characteristics of the patients studied.

The specificity of EPS strongly depends upon the type of induced arrhythmias. It is high, approaching 100%, when the induced arrhythmia is a sustained atrioventricular nodal reentrant tachycardia, an atrioventricular reentrant tachycardia, or a monomorphic sustained ventricular tachycardia[24-26]. On the other hand, it is rather variable, especially in patients with structural heart disease, when the induced arrhythmia is atrial fibrillation, atrial flutter, non-sustained ventricular tachycardia, polymorphic ventricular tachycardia, or ventricular fibrillation[26-32].

The sensitivity of EPS in patients with documented tachycardia (i.e. patients in whom a correlation between symptoms and an interpretable ECG trace is available) is quite good, ranging from 67 to 100% for atrioventricular nodal reentrant tachycardia and atrioventricular reentrant tachycardia[24,28,33,34], and from 60 to 85% for atrial fibrillation and atrial flutter[27,28,30]. Data about the sensitivity of EPS in the evaluation of palpitations of unknown origin are scant and incomplete[6,23,25,35]. The sensitivity seems to depend on the type of palpitations evaluated. In young patients with unexplained palpitations and without structural heart disease, EPS has proved to have quite a good sensitivity – as evaluated in terms of the reproduction of the patient's spontaneous symptoms – ranging from 58 to 87%[25,36,37].

Limits. Intracardiac EPS is costly, invasive, and also laden with some risk of complications, while transesophageal EPS is cheaper, semi-invasive and very rarely associated with significant complications. Moreover, in order to ascertain whether the arrhythmia induced during this provocative test is the arrhythmia responsible for the patient's clinical symptoms, it is generally necessary to establish the association between the induced arrhythmia and the reproduction of the patient's spontaneous symptoms. Indeed, EPS positivity only reveals the presence of a pathological substrate, which may (or may not) be responsible for the palpitations. However, in the vast majority of the cases, when the induced arrhythmia is a reentrant tachycardia, patients with palpitations of unknown origin identify the induced arrhythmia as the cause of their symptoms.

Indications. According to the American College of Cardiology/American Heart Association guidelines for clinical intracardiac electrophysiological and catheter ablation procedures[23], "long-term ambulatory recording is the most useful procedure for documenting a cardiac rhythm associated with palpitations", and "EPS is used if recording attempts fail to provide an answer". EPS constitutes a class I indication in patients with unexplained palpitations in whom a high pulse rate has been documented by a qualified person, and in patients with palpitations preceding syncope. EPS is a class II indication in patients with clinically significant palpitations, suspected of being of cardiac origin, in whom symptoms are sporadic and cannot be documented. In patients with heart disease EPS is generally performed using the invasive method. In patients without heart disease, or with mild heart disease, EPS may also be performed by means of the transesophageal technique.

Conclusions

In the majority of patients palpitations of unknown origin are a benign condition, and the clinical history, physical examinations and ECG are sufficient to yield a diagnosis or to exclude major arrhythmic disorders. On the contrary, in patients with heart disease, with paroxysmal tachycardiac palpitations, or with concomitant cardiovascular symptoms, AECG and/or EPS are deemed necessary. However, in this subgroup of patients the most safe and cost-effective diagnostic approach remains to be established.

References

1. Zimetbaum P, Josephson ME. Evaluation of patients with palpitations. N Engl J Med 1998; 338: 1369-73.
2. Brugada P, Gursoy S, Brugada J, Andriess E. Investigation of palpitations. Lancet 1993; 341: 1254-8.
3. Weber BE, Kapoor WH. Evaluations and outcomes of patients with palpitations. Am J Med 1996; 100: 138-48.
4. Krahn AD, Klein GJ Raymond Y, Norris C. Final results from a pilot study with an implantable loop recorder to determine the etiology of syncope in patients with negative

noninvasive and invasive testing. Am J Cardiol 1998; 82: 117-9.
5. Hlatky MA. Approach to the patient with palpitations. In: Goldman L, Braunwald E, eds. Primary cardiology. Philadelphia, PA: WB Saunders, 1998: 122-8.
6. Zipes DP, Miles WM, Klein LS. Assessment of patients with cardiac arrhythmia. In: Zipes DP, Jalife J, eds. Cardiac electrophysiology: from cell to bedside. Philadelphia, PA: WB Saunders, 1995: 1009-12.
7. Lessmeier TJ, Gamperling D, Johnson-Liddon V, et al. Unrecognized paroxysmal supraventricular tachycardia: potential for misdiagnosis as panic disorders. Arch Intern Med 1997; 157: 537-43.
8. Fogel RI, Evans JJ, Prystwsky EN. Utility and cost of event recorders in the diagnosis of palpitations, presyncope, and syncope. Am J Cardiol 1997; 79: 207-8.
9. Reiffel JA, Schulhof E, Joseph B, et al. Optimum duration of transtelephonic ECG monitoring when used for transient symptomatic event detection. J Electrocardiol 1991; 24: 165-8.
10. Kinlay S, Leitch JW, Neil A, et al. Cardiac event recorders yield more diagnoses and are more cost-effective than 48-hour Holter monitoring in patients with palpitations. Ann Intern Med 1996; 124: 16-20.
11. Zimetbaum PJ, Kim KY, Josephson ME, Goldberger AL, Cohen DJ. Diagnostic yield and optimal duration of continuous-loop event monitoring for the diagnosis of palpitations. Ann Intern Med 1998; 28: 890-5.
12. Brown AP, Dawkins KD, Davies JG. Detection of arrhythmias: use of a patient-activated ambulatory electrocardiogram device with a solid-state memory loop. Br Heart J 1987; 58: 251-3.
13. Zimetbaum P, Kim KY, Ho KK, Zebeda J, Josephson ME, Goldberger AL. Utility of patient-activated cardiac event recorders in general clinical practice. Am J Cardiol 1997; 79: 371-2.
14. Antman EM, Ludmer PL, McGowan N, Bosak Fredman PL. Transtelephonic electrocardiographic transmission for management of cardiac arrhythmias. Am J Cardiol 1988; 58: 1021-4.
15. Crawford MH, Bernstein SJ, Deedwania PC, et al. ACC/AHA guidelines for ambulatory electrocardiography: executive summary and recommendations. A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to revise the guidelines for ambulatory electrocardiography). Circulation 1999; 100: 886-9.
16. Kadish AH, Buxton AE, Kennedy HL, et al. ACC/AHA clinical competence statement on electrocardiography and ambulatory electrocardiography. A report of the ACC/AHA/ACP-ASIM Task Force on Clinical Competence (ACC/AHA Committee to develop clinical competence statement on electrocardiography and amblatory electrocardiography). J Am Coll Cardiol 2001; 38: 2091-100.
17. Linee guida per l'uso appropriato delle metodiche diagnostiche non invasive. Commissione ad hoc ANMCO-SIC-ANCE-GICR-SIEC. Ital Heart J Suppl 2000; 1: 811-29.
18. Zimtbaum PJ, Josephson ME. The evolving role of ambulatory arrhythmia monitoring in general practice. Ann Intern Med 1999; 150: 848-56.
19. Di Marco JP, Philbrick JT. Use of ambulatory electrocardiographic (Holter) monitoring. Ann Intern Med 1990; 113: 53-68.
20. Krahn AD, Klein GJ, Yee R, Manda V. The high cost of syncope: cost implications of a new insertable loop recorder in the investigation of recurrent syncope. Am Heart J 1999; 137: 870-7.
21. Krahn AD, Klein GJ, Yee R, Skanes AC. Randomized assessment of syncope trial: conventional diagnostic testing versus a prolonged monitoring strategy. Circulation 2001; 104: 46-56.
22. Waktare JEP, Camm AJ. Holter and event recordings for arrhythmia detection. In: Zareba W, Maison-Blanche P, Locati EH, eds. Noninvasive electrocardiology in clinical practice. Armonk, NY: Futura Publishing Company, 2001: 3-30.
23. Zipes DP, DiMarco JP, Gillette PC, et al. Guidelines for clinical intracardiac electrophysiological and catheter ablation procedures: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on clinical intracardiac electrophysiologic and catheter ablation procedures), developed in collaboration with the North American Society of Pacing and Electrophysiology. J Am Coll Cardiol 1995; 26: 555-73.
24. Hyucke EC, Lai WT, Nguyen NX, et al. Role of intravenous isoproterenol in electrophysiologic induction of atrioventricular node reentrant tachycardia in patients with dual atrioventricular node pathways. Am J Cardiol 1989; 64: 1131-7.
25. Bonso A, Delise P, Corò L, et al. Palpitazioni d'origine sconosciuta: qual è l'utilità della stimolazione atriale transesofagea? In: Piccolo E, Raviele A, eds. Aritmie cardiache. Milano: Centro Scientifico Editore, 1991: 229-36.
26. Morady F, Shapiro W, Shen E, et al. Programmed ventricular stimulation in patients without spontaneous ventricular tachycardia. Am Heart J 1984; 107: 875-82.
27. Delise P, Bonso A, Allibardi PL, et al. Clinical and prognostic value of atrial vulnerability. Evaluation using endocavitary and transesophageal electrophysiologic study. G Ital Cardiol 1990; 20: 533-42.
28. Brembilla-Perrot B, Spatz F, Khaldi E, et al. Value of esophageal pacing in evaluation of supraventricular tachycardia. Am J Cardiol 1990; 65: 322-30.
29. Brembilla-Perrot B. Value of oesophageal pacing in evaluation of atrial arrhythmias. Eur Heart J 1994; 15: 1085-8.
30. Delise P, Bonso A, Corò L, et al. Endocavitary and transesophageal electrophysiology findings in idiopathic atrial fibrillation. G Ital Cardiol 1991; 21: 1093-9.
31. Fujimura O, Yee R, Klein G, Sharma A, Boahene A. The diagnostic sensitivity of electrophysiologic testing in patients with syncope caused by transient bradycardia. N Engl J Med 1989; 321: 1701-7.
32. Brignole M, Menozzi C, Bottoni N, et al. Mechanisms of syncope caused by transient bradycardia and the diagnostic value of electrophysiologic testing and cardiovascular reflexivity maneuvers. Am J Cardiol 1995; 76: 273-8.
33. Wellens HJ, Brugada P, Bar FW. Indications for use of intracardiac electrophysiologic studies for the diagnosis of site of origin and mechanism of tachycardias. Circulation 1987; 75 (Suppl III): 110-5.
34. Denes P, Wu D, Dhingra R, et al. Demonstration of dual A-V nodal pathways: a common electrophysiologic response. Br Heart J 1975; 37: 1069-76.
35. Ross DL, Farre J, Bar FW, et al. Comprehensive clinical electrophysiologic studies in the investigation of documented or suspected tachycardias. Circulation 1980; 61: 1010-6.
36. Brembilla-Perrot B, Marcon F, Bosser G, et al. Paroxysmal tachycardia in children and teenagers with normal sinus rhythm and without heart disease. Pacing Clin Electrophysiol 2001; 24: 41-5.
37. Pongiglione G, Saul JP, Dunningam A, et al. Role of transesophageal pacing in evaluation of palpitations in children and adolescents. Am J Cardiol 1988; 62: 566-70.