

Right heart perforation by pacemaker leads

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Cardiac pacing is a proven therapy of cardiac conduction disturbances and an effective treatment modality in many cardiac arrhythmias. Implantable cardiac defibrillators (ICDs) are particularly beneficial for selected groups of patients with a history of severe ventricular arrhythmias or at a high risk of sudden cardiac death. Despite their potential lifesaving properties, both pacemakers and ICDs are associated with a number of complications. The most frequent include pneumothorax; myocardial perforation; lead malposition, displacement or fracture due to excessive manipulation of the device by the patient (Twiddler's syndrome) [1]. Another group of complications comprises infections: from the pacemaker pocket to bacterial endocarditis with its origin on leads or the tricuspid valve, failure of leads to pace and/or sense appropriately, erosion of the pacemaker site or its leads, and thrombotic events with the most frequently observed subclavian vein thrombosis [2]. In the era of massive anticoagulation and antiplatelet therapy bleeding complications are not uncommon, either.

The rate of acute complications from device implantation is acceptable and ranges from 3% to 7% [1-3], depending on the patient group. Nevertheless the problem seems important when account is taken of the fact that permanent devices are implanted in over 250,000 patients a year in the United States alone.

The paper entitled "Heart perforation in patients with permanent cardiac pacing - personal observations" presents cases of lead perforation treated in a single medical centre, with well-described diagnostic and treatment procedures. Results of this paper are largely consistent with literature findings, but there nevertheless are some interesting differences, as outlined below [4]. Studies have reported overall lead perforation rates after pacemaker implantation to be 0.1-0.8%, and after ICD placement - 0.6-5.2% [3]. The highest reported rate of perforation, based on autopsy, was 27% for patients with atrial leads [5]. Authors of the present paper report a very low incidence rate (0.09%), which is probably related to the engagement of a highly experienced medical team [4]. There are no uniform classifications accounting for the complication. It may be acute (developing during the first 24 h after implantation), subacute (up to 1 month) or chronic. Another classification system divides perforations into early (occurring during the first month after placement) and late. In the present paper, the authors report on cases of subacute and delayed lead perforations. Most of them (5/6 patients) were symptomatic, but in all of them pacing or sensing failure was present [4].

Excessive loop or tension on the lead will predispose to a forward movement through the thinner right atrial or ventricular wall, particularly the apex.

Other contributing factors may be the growing prevalence of thinner, dilated cardiac chambers with impaired systolic function as well as recent episode of myocardial infarction. Five out of 6 presented patients suffered from coronary heart disease [4]. It would be very interesting to establish whether they had an episode of myocardial infarction in the past and, if so, to know its precise location. As commonly known, a higher risk of lead perforation is observed in patients with inferior wall or right ventricular myocardial infarction. The fact that atrial perforations were more common type than ventricular is not surprising. The right atrial wall is very thin, averaging only 2 mm in thickness, while the right ventricular wall is twice as thick [6]. Therefore logically one would anticipate a higher risk of atrial wall perforation. In contrast to that pattern, however, five out of six diagnosed perforations reported in this paper involved the right ventricular wall [4].

Symptoms, signs and changes of pacing parameters depend on the location of the lead tip. It can be located in the pericardium, mediastinum, pleural space, lung, chest muscles and even in the abdomen. Consequently, the most commonly observed symptoms include chest pain, dyspnoea, syncope, abdominal pain, muscle or diaphragm stimulation and hiccups. The haemodynamic status depends predominantly on the development of pericardial effusion. Cardiac tamponade leads to hypotension, shock or even cardiac arrest, and requires lifesaving intervention, usually open-chest surgery. Perforated electrodes also frequently lead to pacing and sensing failures. In general, the capture threshold will be increased, whereas the sensing threshold will be reduced. Inappropriate ICD shocks are also observed.

The most frequently reported predictors of lead perforation are temporary leads, steroid use, active fixation leads, low body mass index ($< 20 \text{ kg/m}^2$), older age, female gender and concomitant anticoagulation therapy [7, 8]. Temporary leads are typically stiffer than permanent leads, thus elevating the risk of myocardial perforation especially in the case of recent or acute myocardial infarction. Lead type may also increase the risk of perforation: it occurs more frequently with atrial leads, active fixation systems, ICD leads, leads with a small diameter or a small tip surface – as well as excessive length of the electrode [9]. Perforations occur more frequently in the right ventricular apex which is thinner than the intraventricular septum or the outflow tract [10-12]. In contrary to these general data, however, the authors noted only one case of perforated right ventricular apex and as many as 6 cases of perforated right ventricular outflow tract [5]. The only known protective factor for cardiac perforation is right ventricular systolic pressure $> 35 \text{ mm}$

Hg. Decreased incidence rate may be due to coexisting right ventricular hypertrophy [13]. The incidence of cardiac muscle perforation by ICD leads is associated with the number of delivered shocks [14].

Patients with the above symptoms should be investigated to evaluate the risk of lead perforation. Pacemaker system interrogation, echocardiography, chest radiography and computed tomography (CT) scanning can be very helpful to either prove or rule out the complication. Capture and sensing threshold values should be compared against previous results. Although inappropriate pacemaker function may indicate a possibility of perforation or intracardiac leads migration, normal pacemaker function does not exclude the complication. Crucial for the diagnosis of perforation is visualization of the lead and its tip. Chest X-ray is a technique used to compare the lead tip position and lead curvature with previous results. The diagnosis of perforation is certain if the lead is outside the cardiac silhouette. It can also be helpful to evaluate extracardiac complications such as pleural or pericardial effusion and pneumothorax. Transthoracic echocardiography is a very simple, bedside tool which makes it possible to assess electrode location. It is sufficient for proving diagnosis in most cases and very helpful for monitoring pericardial effusion dynamics. Computed tomography scan proves very valuable when echocardiography and X-ray test are not diagnostic. Consequently, CT scan is currently a gold standard in the diagnosis of lead perforations [15], even though the technique also has its limitations. The star artifact is a well-known artifact related to the imaging of metal implants. Surrounding the electrode tip, it sometimes makes it difficult to precisely identify the lead tip.

Late perforations are often asymptomatic and characterized by a very low rate of cardiac tamponade or death [16]. The finding of a late perforation may represent an asymptomatic acute perforation or a true late perforation.

Because the right heart is a low-pressure system, a perforation may be sealed by a combination of muscle contraction and fibrosis over the lead, resulting in no sequelae. The rate of unrecognized asymptomatic perforations is much higher than symptomatic and reaches 15% [6]. In these cases the lead impedance and pacing thresholds did not differ between patients with and without lead perforation. In a small perforation, dislocation of the lead may be very small, so the cathode may be close to the epicardium and the anode within the endocardium, resulting in proper pacemaker function. It thus follows that normal impedance and pacing parameters do not exclude the presence of a perforation. On the other hand, elevated pacing thresholds may indicate a perforation. Similarly to symptomatic perforations, in asymptomatic cases atrial

leads perforate more frequently than ventricular ones, and ICD leads perforate more frequently than ventricular pacemaker leads.

Patient management strategy should depend on the dynamics of symptoms, pericardial effusion and haemodynamic status. In the case of haemodynamic instability, rapid progression of pericardial effusion, surgical management (open chest surgery) seems to be the best treatment option. In other cases, in stable conditions, simple direct traction with or without percutaneous dilators can be considered, though under close echocardiographic monitoring and with a surgical backup. Lead extraction should be followed by new lead placement in a different location, preferably in the right ventricular outflow tract or the intraventricular septum. In the case of open-chest surgery the implantation of epicardial leads should be considered. During the postprocedural period, closed haemodynamic and echocardiographic monitoring is mandatory because delayed re-tamponade could develop (especially when the surgeon could not identify the location of cardiac muscle perforation) [12]. In cases of acute or subacute lead perforation the implantation of a new pacemaker might be unnecessary.

Appropriate management of asymptomatic lead perforation is a debated issue. Some studies suggest that the diagnosis of lead perforation necessitates lead removal [3]. Results of other studies [6], however, suggest that the extraction of a chronically perforated lead without malfunctioning of the device is not mandatory. In addition, the risk of cardiac tamponade should be considered after the removal of chronically implanted leads. Another fact worth considering is that a significant number of those leads are partially perforated.

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