Late asymptomatic atrial lead perforation, a fortuitous finding during lead extraction using thoracoscopic surveillance: a case report and review of the literature

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A 61-year-old male patient was referred for lead extraction due to pacemaker-related systemic infection. He had a dual-chamber pacemaker implanted 18 years ago from the right subclavian vein. Due to non-capture of the tined atrial lead 9 years later, a new atrial lead was implanted from the left site because of occlusion of the right subclavian vein (Figures 1 and 2). Because of the long implantation time and the tined fixation of all three leads, it was decided to perform a thoracoscopic-controlled procedure, which we recently introduced to observe for venous complications in high-risk endovascular lead extraction procedures.1 These procedures are performed under general anaesthesia with selective double-lumen tube ventilation. The patients are positioned in supine position with the right arm slightly deviated posteriorly. Prior to the extraction, a 10-mm, 30° endoscope is introduced via a 12 mm Visiport Plus (Covidien, Mansfield, MA) in the 5th intercostal space on the anterior axillary line. A second Visiport is introduced as a working port in the 6th intercostal space on the midclavicle line. Two X-ray detectable swabs are inserted in the pleural space and positioned in the superior thoracic aperture that can be used to apply pressure with a fenestrated endoscopic grasper in order to control a potential bleeding site.

After positioning the thoracoscope, we noted an extensive adhesion between the lower lobe of the right lung and the right atrial free wall. To enable the right lung to collapse for thoracoscopic surveillance, the adhesion was clipped in order to separate the lung from the right atrial wall, leaving a stump of fibrous tissue connected to the right atrium wall (Figure 3). Dissection of the stump revealed the presence of a lead tip that had perforated the right atrial wall into lung tissue. After putting a purse string suture on the atrium wall around the lead tip, the latter we cut thorascopically, and the lead subsequently removed endovascularly from the subclavian site. A literature review of 25 reported cases of late atrial lead perforation was added to the findings in our case report.

Keywords: Atrial lead perforation • Lead extraction • Video-assisted thoracoscopic surgery (VATS) • Bleeding control

Review of the literature

We searched PUBMED for late perforation of atrial leads in the period from 1987 to 2015. We defined late perforation when occurring after discharge from the hospital following a successful implantation. We added secondary references to the cases in this overview. Twenty-six patients, including our patient, fulfilled these criteria of late atrial lead perforation.

There were 14 males and 12 females, in age varying from 26 to 81 years (average 55.9 ± 16.1). Fifteen screw-in leads perforated, four passive fixation leads, one atrial perforation occurred with...
the broken proximal end of a ventricular lead, and the fixation mechanism was unknown in six cases. Table 1 summarizes the data of all cases.

Electrical performance perforated leads
Electrical performance, e.g. capture, sensing and lead impedance of the atrial lead, was not reported in eight patients and not specified in one patient. The main malfunction was loss of capture in 14 patients, associated with undersensing and impedance changes in three patients each. One patient showed only undersensing with adequate capture and one showed no change in electrical parameters. There was no information on the perforated broken ventricular lead.

Clinical symptoms
Seventeen patients presented with clinical symptoms, predominantly chest pain in 10 patients, combined in four patients with, respectively, dyspnoea, hypotension, collapse, and pericardial effusion.

Other symptoms were haemodynamic instability in three patients,
<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Patients</th>
<th>Lead</th>
<th>Pace/sense</th>
<th>Delay</th>
<th>Symptoms</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Irwin JM</td>
<td>1987</td>
<td>F, 80</td>
<td>Tined</td>
<td>No capture</td>
<td>7 months</td>
<td>Syncope, hiccups</td>
<td>Thoracotomy with lead removal, uncomplicated</td>
</tr>
<tr>
<td>2. Deutsch LS</td>
<td>1990</td>
<td>M, 36</td>
<td>Broken</td>
<td>Non-functional</td>
<td>4 days</td>
<td>Chest pain</td>
<td>Lead extraction, post-operative pneumothorax</td>
</tr>
<tr>
<td>3. Van Nooten G</td>
<td>1990</td>
<td>F, 64</td>
<td>Screw-in</td>
<td>Undersensing</td>
<td>7 days</td>
<td>Chest pain, dyspnea</td>
<td>Percardiocentesis, followed by normalization of lead function</td>
</tr>
<tr>
<td>4. Trigano NJ</td>
<td>1996</td>
<td>F, 45</td>
<td>Screw-in</td>
<td>No capture, undersensing</td>
<td>2 years</td>
<td>Asymptomatic</td>
<td>Thoracotomy with lead removal, uncomplicated</td>
</tr>
<tr>
<td>5. Tran NT</td>
<td>2001</td>
<td>M, 33</td>
<td>Screw-in</td>
<td>Not reported</td>
<td>7 days</td>
<td>Pleuritic chest pain</td>
<td>Thoracoscopic lead removal, repair atrial wall (fibrin glue)</td>
</tr>
<tr>
<td>6. Ellenbogen KA</td>
<td>2002</td>
<td>F, 81</td>
<td>Screw-in</td>
<td>No capture</td>
<td>18 days</td>
<td>Chest pain, hypotension</td>
<td>Percardiocentesis, followed by normalization lead function</td>
</tr>
<tr>
<td>7. Velavan P</td>
<td>2003</td>
<td>F, 64</td>
<td>Screw-in</td>
<td>Not reported</td>
<td>2 months</td>
<td>Chest pain, collapse</td>
<td>Thoracotomy followed by repair after pericardiocentesis</td>
</tr>
<tr>
<td>8. Dilling-Boer D</td>
<td>2003</td>
<td>M, 51</td>
<td>Screw-in</td>
<td>No capture, decrease lead impedance</td>
<td>4 days</td>
<td>Pericarditis chest pain</td>
<td>Thoracotomy followed by repositioning atrial lead</td>
</tr>
<tr>
<td>9. Kahn MN</td>
<td>2005</td>
<td>F, 26</td>
<td>Screw-in</td>
<td>Not reported</td>
<td>10 months</td>
<td>Pleuritic chest pain</td>
<td>Lead extraction followed by implantation new atrial lead</td>
</tr>
<tr>
<td>10. Kahn MN</td>
<td>2005</td>
<td>M, 71</td>
<td>Screw-in</td>
<td>Not reported</td>
<td>8 months</td>
<td>Pleuritic chest pain</td>
<td>Lead extraction followed by implantation new atrial lead</td>
</tr>
<tr>
<td>11. Howell C</td>
<td>2005</td>
<td>F, 49</td>
<td>Screw-in</td>
<td>Not reported</td>
<td>4 months</td>
<td>Dyspnea</td>
<td>Atrial lead withdrawn and successfully repositioned</td>
</tr>
<tr>
<td>13. Henrikson CA</td>
<td>2006</td>
<td>F, 66</td>
<td>Screw-in</td>
<td>No capture, undersensing</td>
<td>14 days</td>
<td>Asymptomatic</td>
<td>Expectant attitude, free of complications after 1 year</td>
</tr>
<tr>
<td>14. Sticco CC</td>
<td>2006</td>
<td>M, 56</td>
<td>Screw-in</td>
<td>Not reported</td>
<td>2 weeks</td>
<td>Haemodynamic unstable, Tamponade</td>
<td>Thoracotomy, lead removal and repair aorta perforation</td>
</tr>
<tr>
<td>15. Kaljusto M-L</td>
<td>2007</td>
<td>M, 70</td>
<td>Screw-in</td>
<td>Not reported</td>
<td>2 weeks</td>
<td>Chest pain, tamponade</td>
<td>Thoracotomy, repair aorta, new Atrial lead implanted</td>
</tr>
<tr>
<td>16. Spender S</td>
<td>2007</td>
<td>F, 56</td>
<td>Screw-in</td>
<td>Not reported</td>
<td>4 weeks</td>
<td>Asymptomatic</td>
<td>Atrial lead withdrawn and successfully repositioned</td>
</tr>
<tr>
<td>17. Namazi MH</td>
<td>2008</td>
<td>M, 48</td>
<td>Screw-in</td>
<td>No capture</td>
<td>2 weeks</td>
<td>Diaphragmatic stimulation</td>
<td>Atrial lead withdrawn and successfully repositioned</td>
</tr>
<tr>
<td>18. Sadamatsu K</td>
<td>2009</td>
<td>M, 63</td>
<td>Screw-in</td>
<td>No capture</td>
<td>5 years</td>
<td>Asymptomatic</td>
<td>Thoracotomy for repair withdrawal of the atrial lead</td>
</tr>
<tr>
<td>19. Kaul P</td>
<td>2009</td>
<td>M, 59</td>
<td>Tined</td>
<td>Not reported</td>
<td>13 years</td>
<td>Asymptomatic</td>
<td>Thoracotomy, lead removal by complicated by TV thrombosis</td>
</tr>
<tr>
<td>20. O’ Neill R</td>
<td>2010</td>
<td>F, 65</td>
<td>Not reported</td>
<td>Pleura</td>
<td>1 year</td>
<td>Pleuritic chest pain</td>
<td>Thoracotomy, lead removal and repair perforation atrial wall</td>
</tr>
</tbody>
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Continued

in one patient combined with pericardial effusion;\textsuperscript{14} dyspnoea in two patients;\textsuperscript{12,26} and syncope\textsuperscript{3} and diaphragmatic stimulation\textsuperscript{18} both in one patient.

Nine patients were asymptomatic at the time of detection of the perforation. Including our patient there were two patients in whom perforation was detected during lead extraction for systemic infection.\textsuperscript{20} Perforation was discovered in one patient at a routine chest X-ray\textsuperscript{19} and during coronary angiography for unstable angina in a second patient.\textsuperscript{23} The remaining five patients had pacing and/or sensing failure during regular follow-up.\textsuperscript{5,13,17,24,25}

In the total group, symptomatic patients can be considered as sub-acute needing short term or emergency intervention and the asymptomatic patients as chronic. There is a large difference in interval from implantation to the diagnosis of perforation between both groups, average 4.6 months (4 days–14 months) for the sub-acute group and 45.7 months (1 week–156 months) for the chronic group. One has to take into account that in the sub-acute group the time of perforation is at the moment of clinical symptoms, whereas in the chronic group the time of diagnosis can be much later than the moment of perforation. Application of a VATS procedure is advisable for the asymptomatic patients, but it can be difficult to apply in the symptomatic patient in an emergency situation.

Position of the lead tip

In the total cohort of 26 patients, the lead had perforated into the pleura in 16 patients. Collateral damage occurred in one patient with perforation of a coronary vein after perforation of the atrial wall.\textsuperscript{12} In another patient, mechanical irritation led to a fistulous connection with the right coronary artery.\textsuperscript{20} In two patients, the perforated lead ruptured the aorta.\textsuperscript{14,15} In our patient and a second patient, the atrial lead tip was fortuitous discovered in a fibrous granuloma arising from the right atrial wall.\textsuperscript{20}

Management of perforation

Thoracotomy was used in 13 patients. In 10 patients this was primarily done for repair and/or removal of the perforated lead. It was a fortuitous finding during surgery for a right coronary fistula in one patient and during emergency relief of pericardial effusion after perforation of the aorta in two patients,\textsuperscript{23} and in two patients during thoracotomy for emergency relief of pericardial effusion after perforation of the aorta. Only one patient who underwent thoracotomy had a complicated postoperative course with tricuspid valve thrombosis and pulmonary embolism.\textsuperscript{20} Endovascular lead extraction was performed in six patients, with a postoperative pneumothorax as a complication in one patient.\textsuperscript{8} Thoracoscopic surveillance was used in three patients, one with the Da Vinci robotic system.\textsuperscript{5} During these procedures the atrial injury was covered with fibrin glue in one patient, and surgical repair in two patients.\textsuperscript{9,10}

In three patients, the lead could be withdrawn and successful repositioned.\textsuperscript{17,18,21} In two patients, normal lead function was restored after pericardiocentesis only, without further complications.\textsuperscript{4,7}

In one patient with perforation of the lead into the pleural space, the patient elected to pursue expectant management. After programming the device to VVI-R mode, the patient was doing well without complications of the extracardiac lead in a 1-year

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<tr>
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<th>Delay</th>
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<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>21 Souretis G, 2012</td>
<td>M, 65</td>
<td>Screw-in lead</td>
<td>No capture</td>
<td>1 month</td>
<td>Dyspnea</td>
<td>Thoracotomy, lead removal and repair perforation</td>
</tr>
<tr>
<td>22 Khoury G, 2012</td>
<td>M, 67</td>
<td>Screw-in lead</td>
<td>Not reported</td>
<td>53 months</td>
<td>Asymptomatic</td>
<td>Lead extraction without further complications</td>
</tr>
<tr>
<td>23 Hussain S, 2012</td>
<td>F, 75</td>
<td>Tined lead</td>
<td>No capture, undersensing</td>
<td>1 week</td>
<td>Asymptomatic</td>
<td>Thoracotomy for repair fistula RCA, fortuitous finding during surgery for a right coronary fistula</td>
</tr>
<tr>
<td>24 De Schrijver N, 2014</td>
<td>M, 65</td>
<td>Screw-in lead</td>
<td>No capture</td>
<td>8 months</td>
<td>Asymptomatic</td>
<td>Thoracotomy for atrial lead removal</td>
</tr>
<tr>
<td>25 van Gelderen B, 2016</td>
<td>F, 65</td>
<td>Screw-in lead</td>
<td>Dyssynchrony, not specified</td>
<td>9 years</td>
<td>Asymptomatic</td>
<td>VATS for infection, fortuitous finding during extraction lead extraction</td>
</tr>
</tbody>
</table>

The table with the details of the individual patient data of the reported cases. N.A., not applicable. M, male; F, female and age in years. Lead indicates the type of lead divided in screw-in leads and tined leads. In the same column is indicated the position of the lead tip after the diagnosis of perforation, pleura, pericard, coronary vein, aorta and RCA, right coronary artery. Pace/sense indicates the type of pacemaker malfunction, which was not reported in all cases. Delay is the interval between implantation and the time of perforation. Symptoms are clinical symptoms due to perforation. Management indicates the type of treatment.
follow-up. Of note, in 2 out of the 26 patients, the atrial lead was introduced through a persistent left superior vena cava.4,15

Discussion

Late perforation of atrial leads is a rarely described phenomenon, and the majority of the reported patients are symptomatic. However, late perforations may go unnoticed, as in the absence of clinical symptoms malfunctioning leads are often replaced without specific investigation. Also in our patient, we noted perforation accidentally with thoracoscopic surveillance during lead extraction.

Therefore, late occurrence of electrical pacemaker malfunction can be an indicator of lead perforation and may warrant further investigation. Computed tomography seems to be the most sensitive technique for diagnosis.13 A study by Hirschel et al. described the prevalence of asymptomatic pacemaker and ICD leads on CT. Atrial perforation was diagnosed in 15% (9 of 61) of the patients, 12% (6 of 49) had active, and 25% (3 of 12) a passive fixation mechanisms.27

Remarkably, there was no change in lead impedance or pacing threshold in all these patients, this in contrast with our experience in which we found abnormal pacing parameters in all asymptomatic patients. This finding may suggest a risk of overdiaignosing perforation using a CT scan.

One can only speculate about the mechanism of perforation. It is remarkable that 2 out of the 26 (7.6%) patients had a persistent left superior vena cava. This is much higher than the incidence of 0.3–0.5% in a population without congenital heart disease.28 Maybe the longitudinal force transmitted to the lead by myocardial contraction is higher due to the open straight trajectory from the coronary sinus to the atrial wall. One would expect that the classic j-shape curve of atrial leads protect against transmission of force to the myocardium. However, torque during typical movement of leads in the atrial appendage may weaken the myocardium and still transfer enough longitudinal force.

It is remarkable that continuous pressure on surrounding tissue from the lead tip must not only perforate the myocardium, but leads may also protrude through the pericardium, which is considered a firm barrier, all the way into the lung.17,22

The time from implant to actual perforation as detected by lead malfunction can be considerable and migration may continue in the ensuing years as shown in our patient. This progress occurs despite the formation of a fibrous cap, which also prevents acute bleeding into the pericardium and explains why patients remain asymptomatic.

Reported management of late perforations varies considerably. From lead removal by thoracotomy with concomitant repair of the atrial wall, to an expectant attitude without complications.17 Refrain from lead extraction in asymptomatic perforated leads and implantation of a new lead is suggested when there is no bleeding complication and there is an increased risk for lead extraction.29

In our patient, the asymptomatic perforation was 9 years after implant resulting in non-capture of the atrial lead. Because lead perforation was not obvious at that time, a new atrial lead was implanted. We discovered late perforation 9 years later during lead extraction for a systemic infection, which demonstrates an uncomplicated perforation in a 9-year follow-up. It remains unknown how many times endovascular lead extraction is performed with perforated leads, the incidence of complications in these cases, and even if a pre-existent perforation is recognized at this time. If lead extraction is indicated in case of known perforation endovascular extraction should be performed in the operation theatre with the patient completely prepared for thoracotomy, haemodynamic, and transoesophageal monitoring, and cardio surgical back-up.

In this respect, thoracoscopic surveillance may be beneficial during extraction of perforated leads. Not only for the detection of the condition or possible bleeding complications: it also enables to anticipate and control the perforation site in the atrial wall after removal of the lead as demonstrated in our patient. However, thoracoscopy will certainly add to the complexity and duration of the procedure, and has its own, albeit rare complications. Also, the use of thoracoscopy has to be decided in advance, as separate intubation of the lungs is necessary to allow deflation of the right lung. We therefore reserve this approach for high-risk extraction procedures.

Conclusion

Late perforation of the atrial lead is a rare phenomenon that can occur without clinical symptoms. However, in all asymptomatic patients, a late pacemaker malfunction was diagnosed in advance. This indicates that in case of late lead malfunction, it may be prudent to exclude perforation by CT.

Endovascular extraction of perforated leads may be challenging because of bleeding complications, but fibrous encapsulation around perforated leads may be difficult to overcome, especially when it concerns tined leads.

An expectant attitude and implantation of a new atrial lead might be considered in asymptomatic patients with an increased risk for lead extraction. Regular X-ray follow-up is indicated to confirm stability of the lead and exclude further migration.

Thoracoscopic surveillance during lead extraction not only provides an early warming for complications, but also creates the opportunity to repair atrial wall damage without thoracotomy.

Conflict of interest: B.M.V.G.: training and education pacing and CRT St Jude Medical, consultant RADI pressure wire systems, a St Jude Medical company and Consultant for Pacing and CRT Sorin Group CRM SAS.

References