Short communication

Chest compressions may be safe in arresting patients with left ventricular assist devices (LVADs)

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A R T I C L E   I N F O

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A B S T R A C T

Introduction: The number of patients with left ventricular assist devices (LVADs) is increasing each year. Despite a lack of evidence, many emergency medical systems and hospitals have recommended against performing chest compressions in these patients. This deviation from conventional resuscitation algorithms is secondary to concern that chest compressions could dislodge the LVAD.

Objective: To assess whether cannula dislodgment occurred in LVAD patients receiving chest compressions.

Methods: We retrospectively analyzed the outcomes of all LVAD patients who received chest compressions for cardiac arrest over a four year period in a large urban hospital. Eight cases were reviewed for both cannula integrity and outcomes.

Results: Using autopsy and adequate flow through device as proxy for intact inflow/outflow cannulas, none of the eight patients receiving chest compressions had cannula dislodgment. Four of the 8 patients had return of neurologic function.

Conclusions: In this small retrospective case series, standard chest compressions in patients with LVADs did not cause cannula dislodgment. More research is necessary to determine the utility of chest compressions in the LVAD population.

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1. Introduction

The population of LVAD-supported patients is increasing. By 2015, the predicted annual implants will be in excess of 7000 patients. As this high risk population increases in size, developing optimal resuscitative strategies becomes increasingly important.

LVAD patients have a unique physiology and anatomy that challenges existing ways to manage them. One unique difference of current generation LVADs is they often lack a peripheral pulse. This makes following the traditional outline of advanced cardiac life support (ACLS) problematic. The major manufacturer of current LVAD devices warns “there may be risk associated with performing external chest compressions”. Consequently, many pre-hospital, as well in-hospital, guidelines recommend against using chest compressions in these patients. Fear of cannula dislodgment or damage to the outflow conduit are the primary concerns for these recommendations.

This case series describes eight LVAD patients who received chest compressions.

2. Methods

2.1. Design

This retrospective observational case series from a single North American hospital was approved by our Institutional Review Board (IRB). We used autopsy data, blood flow (as documented by the control monitor), return of effective circulation (ROEC), and return of neurologic function (RONF) to confirm the integrity of the cannula with the left ventricle. We use the term ROEC, similar to the more common return of spontaneous circulation (ROSC), to remove the confusion of terms in a patient with poor native left ventricular function.

2.2. Subjects

This analysis includes data from all eligible subjects encountered over a four year period from April 2009 through April 2013.

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Table 1
Demographics of LVAD patients receiving chest compressions.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Type of LVAD</th>
<th>Gender</th>
<th>Age</th>
<th>Time from insertion to arrest</th>
<th>Duration of chest compressions</th>
<th>OHCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Heartmate II</td>
<td>M</td>
<td>57</td>
<td>254 days</td>
<td>&gt;20 min</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>Heartmate II</td>
<td>M</td>
<td>64</td>
<td>556 days</td>
<td>15–20 min</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>Heartmate II</td>
<td>M</td>
<td>69</td>
<td>234 days</td>
<td>10–15 min</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
<td>Heartmate II</td>
<td>M</td>
<td>80</td>
<td>50 days</td>
<td>&lt;1 min</td>
<td>No</td>
</tr>
<tr>
<td>5</td>
<td>Heartmate II</td>
<td>M</td>
<td>50</td>
<td>1324 days</td>
<td>Unclear</td>
<td>Yes</td>
</tr>
<tr>
<td>6</td>
<td>Heartmate II</td>
<td>M</td>
<td>79</td>
<td>431 days</td>
<td>2.5 h</td>
<td>Yes</td>
</tr>
<tr>
<td>7</td>
<td>Heartmate II</td>
<td>F</td>
<td>56</td>
<td>753 days</td>
<td>Unclear</td>
<td>Yes</td>
</tr>
<tr>
<td>8</td>
<td>Heartmate II</td>
<td>M</td>
<td>76</td>
<td>85 days</td>
<td>5 min/3 min</td>
<td>No</td>
</tr>
</tbody>
</table>

Table 2
Results of LVAD patients post-chest compressions.

<table>
<thead>
<tr>
<th>Patient</th>
<th>ROEC</th>
<th>RONF</th>
<th>Reason for arrest</th>
<th>Defibrillation</th>
<th>VAD flow</th>
<th>Autopsy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No</td>
<td>No</td>
<td>Accidental disconnect</td>
<td>No</td>
<td>51 min⁻¹</td>
<td>No</td>
</tr>
<tr>
<td>2</td>
<td>Yes</td>
<td>No</td>
<td>Accidental disconnect</td>
<td>No</td>
<td>5.71 min⁻¹</td>
<td>Yes, confirmed intact cannulas</td>
</tr>
<tr>
<td>3</td>
<td>Yes</td>
<td>No</td>
<td>Accidental disconnect</td>
<td>Yes, AICD</td>
<td>5.41 min⁻¹</td>
<td>No</td>
</tr>
<tr>
<td>4</td>
<td>Yes</td>
<td>Yes</td>
<td>LV thrombus</td>
<td>No</td>
<td>6.61 min⁻¹</td>
<td>Yes, confirmed intact cannulas</td>
</tr>
<tr>
<td>5</td>
<td>Yes</td>
<td>Yes</td>
<td>Accidental disconnect</td>
<td>No</td>
<td>5.21 min⁻¹</td>
<td>No</td>
</tr>
<tr>
<td>6</td>
<td>No</td>
<td>No</td>
<td>Vfib</td>
<td>Yes, AICD</td>
<td>No flow documented</td>
<td>Yes, confirmed intact cannulas</td>
</tr>
<tr>
<td>7</td>
<td>Yes</td>
<td>Yes</td>
<td>Driveline malfunction</td>
<td>No</td>
<td>3.71 min⁻¹</td>
<td>No</td>
</tr>
<tr>
<td>8</td>
<td>Yes</td>
<td>Yes</td>
<td>Unclear</td>
<td>No</td>
<td>5.2/4.91 min⁻¹</td>
<td>No</td>
</tr>
</tbody>
</table>

2.3. Setting

Our hospital is an urban Level II trauma center receiving over 60,000 annual visits to the emergency department.

All patients who undergo LVAD implantation at our facility have follow-up visits with our Mechanical Circulatory Support Program staff. We also provide follow-up care for patients (2 during this study period) who undergo LVAD implantation at other facilities. Additionally, we provide follow-up visits and phone follow up with patients who undergo LVAD implantation at our facility yet live remotely (3 during this study period).

2.4. Process

Our facility is of the belief that chest compressions are beneficial for LVAD patients who are arresting. We resuscitate these patients using similar algorithms to non-LVAD patients by utilizing chest compressions and defibrillation. Many of our emergency medical service (EMS) agencies recommend against using chest compressions on their patients. However, all of our patients had providers who performed chest compressions.

Determining an “arrest state” is difficult in the LVAD population. Paramount to this is determining perfusion of tissue. In our study, perfusion was assessed via mean arterial pressure, skin warmth, capillary refill, auscultation of the machine, and/or the presence of a low flow alarm on the machine. Automated blood pressure determination often fails in the non-pulsatile LVAD population and requires manual blood pressure cuffs to determine its value. Ultimately, the perfusion status of these patients was left to the determination of the treating provider (Table 1).

3. Results

Over a select four-year period, 152 patients underwent LVAD implantation at our facility. During this time, eight LVAD patients arrested. All of them received chest compressions. The mean

Fig. 1. CT image of LVAD displaying right ventricle proximity to sternum and in flow cannula within the left ventricle.
age (sd) was 66 years (11) old. Eighty-eight percent were male. Duration of chest compressions ranged from <1 min to 2.5 h. Seventy-five percent were out-of-hospital arrests. The mean (sd) duration of LVAD implantation was 461 (442) days.

Post-arrest stable pump parameters (flow 3.7–6.6 L min\(^{-1}\)) were documented in 7 of 8 patients. Four of these 8 patients had RONF. Autopsy was performed on 3 patients, including the patient in whom pump parameters were not documented. Direct observation during autopsy showed no disruption of the inflow or outflow grafts. Using autopsy and adequate flow through device as proxy for intact inflow/outflow cannulas, none of the eight patients receiving chest compressions had cannula dislodgment.

One of our cases involved a patient who was transported 2.5 h in an ambulance to our facility while receiving chest compressions. Despite what would be considered a substantial amount of trauma to the chest over this time frame, autopsy confirmed that the cannulas were intact. Additionally, one of our patients received chest compressions on two separate occasions (Table 2).

4. Discussion/limitations

This small case series allows a preliminary assessment of whether chest compressions should be performed on arresting LVAD patients. Two questions arise from this series. First, are chest compressions safe in LVAD patients? Second, are chest compressions effective in this population? Our series suggests that chest compressions may be safe in this population. Certainly more data from multiple institutions is needed to uphold this assertion. Limitations to our data are extensive. We used cannula flow and autopsy as a surrogate for dislodgment. A small disruption in the cannula is possible with retention of flow. The clinical significance of such a disruption is not known.

Time from implantation is also an important consideration. A newly implanted LVAD would likely have an increased risk of dislodgment. More caution is necessary in this subgroup. In our study, the shortest time from implantation to arrest was 50 days.

One fear in recommending chest compressions is that a potentially harmful therapy would be applied to a subset of patients not in need of treatment. Assessment of perfusion via pulse is usually not feasible in the LVAD population. Therefore, the potential for performing chest compressions in a non-arresting patient is possible. The combination of the machine’s internal flow alarm, auscultation of the machine, capillary refill, and skin signs makes even pre-hospital assessment of circulation possible but not without potential error.

Addressing the question of whether compressions are effective is equally important. Given the relatively small number of arresting LVAD patients, a large trial with sufficient power to prove the efficacy of chest compressions is unlikely in the near future. In the arresting patient with a nonfunctioning LVAD (no auscultation of machine and presence of low flow alarm), the patient will not have perfusion unless chest compressions are performed. In this patient population, chest compressions may be reasonable.\(^6\) The efficacy of chest compressions is potentially lower in this subgroup. Current generation LVADs have no valves, and flow can occur around the rotor. Therefore, retrograde flow through the outflow cannula is possible if the LVAD is nonfunctional.

The arresting patient with a functioning LVAD is significantly less clear. They may have no cardiac activity but still have adequate perfusion. Conversely, chest compressions may be more effective in this population, as the compression may only need to deliver blood to the left ventricle to restore effective circulation. More research is needed to decide whether chest compressions should be performed in arresting LVAD patients (Fig. 1).

5. Conclusions

This small retrospective case series suggests chest compressions may be safe in patients with left ventricular assist devices (LVADs).

Conflict of interest statement

Shinar, Cheskes, and Bellezzo have no conflict of interest with the paper “Chest compressions should be performed on patients with left ventricular assist devices (LVADs) in cardiac arrest”.

Stahovich – Speaker’s Bureau for Thoratec; Chillcott – Speaker’s Bureau for Thoratec; Dembitsky – Speaker’s Bureau for Thoratec, Consultant.

References


Further reading