Best evidence topic - Arrhythmia

Does biventricular pacing provide a superior cardiac output compared to univentricular pacing wires after cardiac surgery?

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Summary

A best evidence topic in cardiac surgery was written according to a structured protocol. The question addressed was whether biventricular pacing provides a superior cardiac output compared to univentricular pacing wires after cardiac surgery. Using the reported search, 439 papers were found from which 13 papers represented the best evidence on the subject. The author, journal, date and country of publication, patient group studied, study type, relevant outcomes and results are tabulated. We conclude that in 9 of the 13 papers presented, significant increases in the cardiac index and mean arterial pressure were found with biventricular pacing. In the four negative studies, which included an experimental study, the patients tended to have normal or better ejection fractions and narrow QRS complexes. Up to a 22% increase in Cardiac Index was reported in the positive studies. Exact pacing wire placement varies and some studies caution that if in the wrong place, the index can actually drop. Transoesophageal flow volume loops have been used to guide placement. Benefits seem greatest in patients with a poor ejection fraction and a wide QRS complex.

Keywords: Thoracic surgery; Biventricular pacing; Cardiac surgery

1. Introduction

A best evidence topic was constructed according to a structured protocol. This protocol is fully described in the ICVTS.

2. Clinical scenario

You are in theatre assisting with a patient who has just undergone an aortic and mitral valve replacement. The left ventricular function was impaired and the consultant asks for biventricular epicardial pacing leads. You have not seen these before and ask your consultant if this helps the cardiac index. He suggests that you look it up and answer the question for yourself.

3. Three-part question

For (patients after cardiac surgery) do (biventricular pacing wires compared to right ventricular wires alone) provide a (superior cardiac output)?

4. Search strategy

Medline 1950 to Dec 2008 using the Ovid SP interface (left ventri$.mp or biventricular.mp) AND (exp Pacemaker, Artificial/OR Cardiac Pacing/or pacing.mp) AND (exp Thoracic Surgery/OR Cardiovascular Surgical Procedures/OR exp Cardiac Surgical Procedures/OR CABG.mp OR cardiac surgery.mp).

5. Search outcome

Four hundred and thirty-nine papers were found from which 13 represented the best evidence papers. These are documented in Table 1.

6. Results

Epicardial pacing is commonly indicated in cardiac surgical patients and this is conventionally performed using right ventricular (RV) and right atrial (RA) pacing wires. RV pacing wires are usually used due to ease of application to the anterior wall of the RV.

In the non-cardiac surgical literature, cardiac resynchronization therapy (CRT) is known to benefit patients in heart failure. The Pacing Therapies for Congestive Heart Failure (PATH-CHF) study [2, 3] has demonstrated the advantageous haemodynamics of CRT in patient with severe LV dysfunction. Similarly, the Multisite Stimulation Cardiomyopathy (MUSTIC) study [4] demonstrated a significant improvement in LV ejection fraction (EF) and patient symptoms after 12 months of biventricular pacing in 131 heart failure patients.

In patients after cardiac surgery, Flynn et al. [5] studied the effect of atrio-monoventricular pacing with active lead placement on the right ventricle (control), the anterior left ventricle and the posterior left ventricle. In the 25
Table 1
Best evidence papers

<table>
<thead>
<tr>
<th>Author, date, country and study type (level of evidence)</th>
<th>Patient group</th>
<th>Outcomes</th>
<th>Key results</th>
<th>Study weaknesses</th>
</tr>
</thead>
</table>
| Flynn et al., (2005), Eur J Cardiothorac Surg, UK, [5]  | 25 patients after cardiac surgery with left ventricular dysfunction (mean LVEF 33%) underwent pacing with active lead placement on the right ventricle (control), the anterior left ventricle and the posterior left ventricle in random order, with each pacing mode of 10 min duration, following cardiopulmonary bypass. Fixed AV delay of 120 ms | Cardiac index (L/min per m²) | RV pacing 2.74 ± 0.72 L/min/m² LVA pacing 3.02 ± 0.73 L/min/m² LVP pacing 3.08 ± 0.80 L/min/m² (P < 0.019) | Did not compare atrio-cardiothorac Surg, UK, with left ventricular dysfunction (lymin per m²) 2 2.74
  "0.72 l
  y
  min
  m
  2
  – RV or LV pacing with atrial pacing alone |
| Prospective cohort study (level 2b) | | Mean arterial pressure (mmHg) | RV pacing 67.88 ± 10 mmHg LVA pacing 71 ± 10.1 mmHg LVP pacing 71.1 ± 10.9 mmHg (P < 0.020) | Fernandez et al. in a letter point out that this paper actually used biventricular pacing not LV pacing as the RV leads were used as the inactive leads for the LV pacing [12] |
| Foster et al., (1995), Ann Thorac Surg, USA, [6] | 18 patients post CABG, Temporary epicardial pacing electrodes were placed on the right atrium and into anterior paraseptal sites on the right and left ventricle AV delay 150 ms fixed | Cardiac index | Atrial 3.03 ± 0.14 L/min/m² Atrio-right ventricular 2.98 ± 0.16 L/min/m² Atrio-left ventricular 3.07 ± 0.18 L/min/m² Atrio-biventricular 3.26 ± 0.18 L/min/m² (P < 0.05) | Small pilot study. Not blinded |
| Prospective cohort study (level 2b) | | Mean arterial pressure | Atrial 81 ± 2 mmHg Atrio-right ventricular 78 ± 2 mmHg Atrio-left ventricular 76 ± 2 mmHg Atrio-biventricular 78 ± 2 mmHg (P = NS) |
| | | SVR | Atrial 1.078 ± 81 dyne/s/cm² Atrio-right ventricular 1.057 ± 86 dyne/s/cm² Atrio-left ventricular 1.038 ± 96 dyne/s/cm² Atrio-biventricular 0.981 ± 80 dyne/s/cm² (P < 0.05) |
| Weisse et al., (2002), Thorac Cardiovasc Surg, Germany, [7] | 22 patients with poor left ventricular function EF 29.8 ± 4.8 underwent CABG. They had atrio-biventricular, atrio-monventricular and atrial pacing | Haemodynamic parameters 3–24 h after elective coronary artery revascularisation | – Atrio-biventricular pacing increased cardiac index and decreased wedge pressure compared with AAI pacing – In patients with left bundle branch block, atrio-left ventricular and atrio-biventricular pacing increased cardiac index and decreased wedge pressure – In patients with wall-motion abnormalities and impaired cardiac conduction, a site specific pacing therapy can help to optimise postoperative haemodynamics and reduce the use of inotropic substances | Small pilot study. Not blinded |
| Prospective cohort study (level 2b) | Temporary epicardial pacing electrodes were placed on the right atrium and the paraseptal region of the left and right ventricle | | | |

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Table 1 (Continued)

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<tr>
<td>Tanaka et al., (2002), Jpn J Thorac Cardiovasc Surg, Japan, [8]</td>
<td>4 CHF patients had leads in the right atrium, right ventricle and left ventricle after cardiac surgery</td>
<td>Haemodynamic parameters post operative</td>
<td>Biventricular pacing increased mean systemic blood pressure by 11% and mean LV stroke work index by 19% in the acute post surgery period and reduced mitral regurgitation</td>
<td>Just 4 cases</td>
</tr>
<tr>
<td>Case series (level 4)</td>
<td>All patients had severe LV dysfunction and dilatation with intraventricular conduction delay</td>
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<tr>
<td>Tomioka et al., (2006), Eur J Cardiothorac Surg, USA, [9]</td>
<td>Lab experiment on pigs. 10 pigs had unipolar pacing electrodes in the apex and LV posterior wall (atrio-biventricular) BVP or the proximal high septum (atrio-high septal) HSP</td>
<td>Cardiac index</td>
<td>Sinus rhythm 4.0 ± 0.8 l/min/m² Atrial pacing 4.4 ± 0.6 l/min/m² Atrio-biventricular 3.4 ± 0.3 l/min/m² Atrio-high septal 4.0 ± 0.2 l/min/m² Bivent significantly worse than NSR (P &lt; 0.05)</td>
<td>Small study on pigs with normal hearts and narrow QRS complexes, also sinus rhythm was slower than paced rhythm of 100 bpm</td>
</tr>
<tr>
<td>Prospective cohort study (level 2b)</td>
<td></td>
<td>Mean arterial pressure</td>
<td>Sinus rhythm 58 ± 12 mmHg Atrial pacing 61 ± 9 mmHg Atrio-biventricular 50 ± 4 mmHg Atrio-high septal 55 ± 4 mmHg Bivent significantly worse than NSR (P &lt; 0.05)</td>
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<td>Dekker et al., (2004), J Thorac Cardiovasc Surg, Netherlands, [10]</td>
<td>11 patient in heart failure with LBBB were eligible for cardiac resynchronization therapy who were referred for surgical left ventricular lead placement because of failed coronary sinus lead implantation. Other cardiac surgery was not performed</td>
<td>Ejection fraction</td>
<td>Baseline 27 ± 9% Best LV lead site 35 ± 10% Worst LV lead site 29 ± 9% (P = 0.007)</td>
<td>– Small study – Not in patients undergoing cardiac surgery</td>
</tr>
<tr>
<td>Propective cohort study (level 2b)</td>
<td></td>
<td>Stroke work</td>
<td>Baseline 29 ± 10 g/m Best LV lead site 48 ± 10 g/m Worst LV lead site 35 ± 12 g/m (P = 0.006)</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Stroke volume</td>
<td>Baseline 51 ± 6 ml Best LV lead site 71 ± 24 ml Worst LV lead site 55 ± 10 ml (P &lt; 0.01)</td>
<td></td>
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<tr>
<td>Schmidt et al., (2007), European Pacing Arrhythmias and Cardiac Electro-physiology, Switzerland, [8]</td>
<td>26 patients with EF &lt; 35%, Symptomatic heart failure, and QRS &gt; 120 ms. – CABG and valve operation were included</td>
<td>Haemodynamic variables during various pacing configurations (intrinsic rhythm, RA-Biv pacing, RA-LV, RA-RV, AAI pacing)</td>
<td>Neither cardiac index Cl nor PAP (pulmonary artery pressure) or (PCW) pulmonary capillary wedge pressure (PCW) showed significant difference during the various pacing configurations</td>
<td>– Biventricular pacing after heart surgery does not improve parameters of regional and global LV systolic function</td>
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<tr>
<td>Prospective cohort study (level 2b)</td>
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<tr>
<td><strong>Healy et al., (2008), Interact CardioVasc Thorac Surg, Ireland, [13]</strong></td>
<td>16 patients undergoing first time CABG with bradycardia or heart block. None had EF &lt; 30%</td>
<td>Cardiac output</td>
<td>No pacing</td>
</tr>
<tr>
<td><strong>Prospective cohort study (level 2b)</strong></td>
<td>Leads connected to 1) negative lead to the anterior surface of the right ventricle, 2) negative lead to the anterolateral aspect of the left ventricle, 3) positive ventricular lead to the diaphragm, 4) negative lead to the right atrium, and 5) positive atrial lead to the diaphragm</td>
<td>Conduit flow using transit time flow measurement device</td>
<td>No pacing</td>
</tr>
<tr>
<td><strong>Berberian et al., (2005), Ann Thorac Surg, USA, [14]</strong></td>
<td>Seven patients in first or third degree heart block after valve replacement surgery had temporary wires sewn to the right atrium, right ventricle, and left ventricle (obtuse margin)</td>
<td>Cardiac index at optimal AV delay</td>
<td>Bivent pacing</td>
</tr>
<tr>
<td><strong>Dzemali et al., (2006), PACE, Germany, [15]</strong></td>
<td>54 patients undergoing cardiac surgery with an ejection fraction of &lt; 35%. (mean EF 25%). 45 had CABG</td>
<td>Cardiac index</td>
<td>Responders index rose from 5.1 ± 1.3 to 6.7 ± 1.4 l/min/m². The CI was better than with AAI or no pacing</td>
</tr>
<tr>
<td><strong>Prospective cohort study (level 3b)</strong></td>
<td>The LV lead was placed next to the left atrial appendage high on the LV</td>
<td>Systolic blood pressure</td>
<td>Responders 121 ± 17.1 mmHg non-responders 104 ± 14 mmHg</td>
</tr>
<tr>
<td><strong>Case series (level 4)</strong></td>
<td>32 of the 54 patients responded to biventric pacing and thus were labelled responders</td>
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<tr>
<td><strong>Kleine et al., (2002), Ann Thorac Surg, Germany, [16]</strong></td>
<td>72-year-old patient with QRS 170 ms, EF 40%, requiring AVR and MVR who went into pulmonary oedema during the angiogram requiring intubation, and IABP. DDD RV pacing</td>
<td>Successful weaning</td>
<td>Left posterolateral wall left ventricular pacing lead was placed close to the left atrial appendage. QRS reduced from 170 ms to 110 ms with biventricular pacing and the patient was successfully weaned off bypass with a better TOE picture</td>
</tr>
<tr>
<td><strong>Raichlen et al., (1984), Circulation, USA, [17]</strong></td>
<td>18 patients following CABG. Pacing wires were sutured in the right atrium, left ventricular apex, right ventricular apex, and right ventricular outflow tract</td>
<td>Cardiac index</td>
<td>RV apex 2.62 ± 0.57 l/min/m² RV outflow tract 2.49 ± 0.54 l/min/m² LV apex 2.51 ± 0.76 l/min/m² (P = 0.03)</td>
</tr>
<tr>
<td><strong>Prospective cohort study (level 3b)</strong></td>
<td>100 bpm DDD pacing with AV delay of 120 ms</td>
<td></td>
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<tr>
<td><strong>Muehlischlegel et al., (2008), J Cardiac Surg, Germany, [18]</strong></td>
<td>10 patients undergoing cardiac surgery with mean EF 35%. (must be &lt; 50% or with wide QRS). Temporary pacing electrodes were placed on the right atrium, apex of the right ventricle, and lateral wall of the LV by the obtuse marginals</td>
<td>Cardiac output</td>
<td>RA-RV pacing</td>
</tr>
<tr>
<td><strong>Prospective cohort study (level 2b)</strong></td>
<td>AV delay 150 ms</td>
<td>Mean arterial pressure</td>
<td>RA-RV pacing</td>
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patients studied, pacing with the active lead placed posteriorly on the left ventricle increased cardiac index from 2.74 to 3.08 L/min/m² ($P=0.019$). Significant increases in mean arterial pressure were also observed (67.88 mmHg to 71.12 mmHg, $P=0.02$) with the use of this pacing mode. There were no complications relating to application or removal of the left ventricle pacing leads.

Foster et al. [6] studied the effects of atrio-biventricular pacing in comparison to atrio-monoventricular pacing in 18 elective coronary artery bypass patients of whom 14 had LV ejection fractions (LVEF) of over 40%. They found that biventricular pacing was associated with a significant increase in cardiac index (CI) relative to all other pacing modes studied and decreased systemic vascular resistance.

Weisse et al. [7] studied the effect of atrio-biventricular pacing in 22 patients with poor left ventricular function (EF 29.8 ± 4.8) who underwent CABG. Temporary epicardial pacing electrodes were placed on the right atrium and the paraseptal region of the left and right ventricle. The study showed that in patients with left bundle branch block, atrio-biventricular (and also atrio-left ventricular) pacing increased cardiac index and decreased wedge pressure compared to atrial (atrio-right ventricular) pacing.

Tanaka et al. [8] studied the effect of biventricular pacing in four patients with severe left ventricular dysfunction and dilatation with intraventricular conduction delay. They found that in the acute post-surgical period, biventricular pacing increased mean systemic blood pressure by 11% and mean LV stroke work index by 19% and also reduced mitral regurgitation.

Dekker et al. [10] studied 11 patients, who had been referred for surgical LV lead placement after failed coronary sinus lead implantation using pressure-volume loops created by a conductance catheter to select the optimal site. They found that biventricular pacing with an optimal LV lead position significantly increased stroke volume (51–71 ml, $P=0.01$), and ejection fraction (27–35%, $P=0.007$). Biventricular pacing at a suboptimal site did not significantly change left ventricular function and even worsened it in some cases.

Schmidt et al. [11] reported that neither cardiac index nor pulmonary artery pressure or pulmonary capillary wedge pressure showed any significant difference during the various pacing configurations in a study of 26 patients including both CABG and valve procedures. They conclude that biventricular pacing after heart surgery does not improve parameters of regional and global LV systolic function.

Healy et al. [13] looked at coronary conduit flow as well as cardiac index in patients after first-time CABG with either DDD RV pacing or DDD biventricular pacing. They found no differences between these modes but all of their patients had LVEF above 30% and narrow QRS complexes.

Berberian et al. [14] observed a 22% increase in the cardiac index in eight patients having DDD RV pacing compared to DDD biventricular pacing. These patients were all undergoing valve replacement or already had a conduction block and five had a QRS interval of more than 150 ms. Dzemali et al. [15] showed in 54 patients with ejection fractions <30% undergoing cardiac surgery that many of these patients could have their cardiac index significantly improved with biventricular pacing. Kleine et al. [16] reported a single patient with a 170 ms QRS who only successfully weaned from bypass after biventricular pacing was instituted.

Raichlen in 1984 investigated the effect of LV or RV pacing in elective CABG patients but found no difference in these patients with good LV function [17].

Muehlchleger et al. [18] in ten patients with poor LV function found a 44% increase in cardiac index compared to pre-operatively, and 13% better than a univentricular lead. They place their lead on the obtuse margin of the LV next to the first obtuse marginal artery.

One animal-based study by Tomioka et al. [9] showed that biventricular pacing in pigs actually disrupts the natural sequence of shortening of the myocardial band and results in impaired LV function but they found that high septal pacing preserves the sequential shortening pattern of the myocardial band and LV function.

7. Clinical bottom line

In nine of the 13 papers presented, significant increases in the cardiac index and mean arterial pressure were found with biventricular pacing. In the four negative studies, which included an experimental study, the patients tended to have normal or better ejection fractions and narrow QRS complexes. Up to a 22% increase in Cardiac Index was reported in the positive studies. Exact placement varies and some studies caution that if in the wrong place, the index can actually drop. Transoesophageal flow volume loops have been used to guide placement. Benefits seem greatest in patients with a poor ejection fraction and a wide QRS complex.
References


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eComment: Improving reporting quality in meta-analyses – endorsement of the QUOROM statement

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doi:10.1510/icvts.2008.201350A

We read with great interest the recent best evidence topic regarding the role of biventricular pacing in contrast to univentricular pacing after cardiac surgery [1]. The authors composèd their manuscript according to a structured protocol published in iCVTS earlier [2].

Given the evolution of evidence-based medicine, certain reporting standards have been implemented in the meantime. Observational studies such as cohort or case-control studies should be composed according to the STROBE statement in order to improve the reporting quality. Randomized-controlled trials should adhere to the CONSORT statements in full papers as in conference abstracts [3]. As far as meta-analyses are concerned, the QUOROM (quality of reporting of meta-analyses) statement has been stated in 1999 [4]. The QUOROM group recommended a statement, a checklist, and a flow diagram. The checklist describes their preferred way to present the abstract, introduction, methods, results, and discussion sections of a report of a meta-analysis. It is organised into 21 headings and subheadings regarding searches, selection, validity assessment, data abstraction, study characteristics, and quantitative data synthesis, and in the results with ‘trial flow’, study characteristics, and quantitative data synthesis; research documentation was identified for eight of the 18 items. The flow diagram provides information about both the numbers of RCTs identified, included, and excluded and the reasons for exclusion of trials.

Furtado more, the search strategy has to be considered in meta-analyses [5]. Comparing search strategies involving EMBASE in addition to Medline, Embase-unique trials yielded significantly smaller estimates but influenced the pooled estimate by an average of only 6%. Searching Medline but not Embase risks biasing a meta-analysis by finding studies that show larger estimates, but their prevalence low enough that the risk may be slight, provided the rest of the search is comprehensive.

References


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eComment: Biventricular pacing improves cardiac function compared to univentricular pacing alone in postoperative patients

Author: Ioanna Kontari, Cardiothoracic Surgery Department of University Hospital of Patras, Rion Patras, Greece

Several studies have recently suggested that atrio-biventricular (RA-BIV) pacing or cardiac resynchronization therapy (CRT) may improve hemodynamics in post-cardiac surgery patients, as you mentioned in your very well-structured article [1]. Routinely, in cardiac surgical procedures, epicardial pacing leads are placed on the right atrium (RA) and right ventricle (RV) in case of significant bradycardia or development of atrioventricular block. However, it has been reported previously that atrio-RV (RA-RV) pacing may induce LV dyssynchrony and hemodynamic compromise compared with atrial pacing (RA) alone [2].

In a recent prospective observational study, Cannesson et al. studied the impact of atrio-biventricular pacing on hemodynamics and left ventricular dyssynchrony compared with atrio-right ventricular pacing alone in the postoperative period after coronary artery bypass grafting (CABG), confirm-
The beneficial effect of biventricular pacing even in postoperative patients [3]. Especially, 25 consecutive patients undergoing CABG surgery (9 off pump and 16 using cardiopulmonary bypass) were studied during atrial, RA-RV, and RA-BiV pacing. Patients with cardiac arrhythmias, preoperative left bundle-branch block, postoperative inotropic support, and intracardiac shunt were excluded. It is notable that preoperative left ventricular ejection fraction (LVEF) was between 30% and 70% (mean LVEF 54±11%), while QRS duration was <120 milliseconds in all patients. Cardiac output (CO) calculated by using the velocity-time integral obtained by transthoracic echocardiography and left ventricular dyssynchrony using tissue Doppler imaging (TDI) were assessed at each step [3].

Interestingly, the above study revealed that RA-RV pacing induces a decrease in CO compared with RA pacing, and that RA-BiV pacing significantly improves CO compared with RA-RV pacing in the postoperative period after CABG surgery [3]. This improvement is related to the restoration of LV synchronicity. Especially, the benefits of CRT are stemmed from a) the acute resynchronization of regional LV mechanics, b) the notable decrease in mitral regurgitation, and c) the reverse remodeling that is a long-term effect of CRT [3]. Moreover, CRT is able to improve contractility while decreasing myocardial oxygen consumption [4].

In chronic heart failure (HF) patients, RV pacing has even been shown to increase the risk of death or acute HF hospitalization. Several studies suggest that biventricular pacing has the ability to reverse the abnormal activation pattern induced by RV pacing and to restore hemodynamics [5]. Cannesson et al. support this hypothesis by describing the acute deleterious effect of RV pacing on CO. This effect seems to be related only to LV dyssynchrony induced by this pacing mode. By performing RA-BiV pacing, the authors were able to restore LV synchronicity and significantly increase CO. Thus they found that RA-BiV pacing was able to weakly but significantly increase CO compared with RA pacing alone [3].

In conclusion, the well-documented observation that BiV pacing significantly improves CO compared with RA-RV pacing after CABG surgery by restoring LV synchronicity, renders cardiac resynchronization therapy as the most optimal pacing mode even in postoperative patients.

References


