OPTIMIZATION OF CARDIAC RESYNCHRONIZATION THERAPY DEVICE SELECTION GUIDED BY CARDIAC MAGNETIC RESONANCE IMAGING: COST-EFFECTIVENESS ANALYSIS

Carlos Crespo, Antonio Berruezo, Markus Linhart, Juan Acosta, Mikel Martínez, Aurea Mira, Gabriela Restovic, Joan Sagarra, Bernhard Fahn, Artem Boltyenkov, Luis Lasalvia, Laura Sampietro-Colom
To estimate the **cost-effectiveness** and the **budget impact** of using **two cardiac magnetic resonance imaging (cMRI) based algorithms** to ascertain CRT defibrillator indication (algorithm I- cMRI plus an innovative software- and algorithm II- cMRI alone) **compared with routine clinical practice** (without cMRI), in Heart Failure (HF) patients with an indication for cardiac resynchronisation therapy (CRT).
MODEL CHARACTERISTIC

COMPARATOR:

• Routine clinical practice
• Optimization algorithm (I & II)*

POPULATION: Primary prevention patients with heart failure, dilated cardiomyopathy, severe LV dysfunction (LVEF <35%) and wide QRS (>120 ms) who are referred for CRT

MODEL TYPE: RWE & extrapolation with incidence Markov Model with monthly cycles

PERSPECTIVE: Health National System (only direct cost)

EFFICIENCY: Cost per Quality-Adjusted Life years (€/QALYs)

TIME HORIZON: LIFE-TIME

DISCOUNT: 3% COSTS (€2018) & 3% EFFECTS

* All High risk patients treated with CRTD and all non-high risk patients treated with CRT
The health economic mode distinguishes between a **short-term** (represented by costs and consequences of the process of device implantation and classification) and a **long-term phase** (represented by the costs and consequences of the post implementation follow-up period).

**SHORT-TERM** *(real)*

<table>
<thead>
<tr>
<th>ROUTINE CLINICAL PRACTICE</th>
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<tbody>
<tr>
<td>HF PATIENTS CANDIDATE TO CRT</td>
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<tr>
<td>NON-HIGH RISK</td>
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<tr>
<td>HIGH RISK</td>
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<tr>
<th>OPTIMIZATION ALGORITHM</th>
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**LONG-TERM** *(extrapolation)*

In each state, hospitalization and death are possible.

* Risk based on algorithm
EVENTS INCLUDED

- Device Complications: inappropriate ICD shocks, lead dysfunction and infection. Battery change
- Hospitalization
- All cause death

NYHA class I: No limitation of physical activity. Ordinary physical activity does not cause undue fatigue, palpitation, dyspnea (shortness of breath);

NYHA class II: Slight limitation of physical activity. Comfortable at rest. Ordinary physical activity results in fatigue, palpitation, dyspnea (shortness of breath);

NYHA class III: Marked limitation of physical activity. Comfortable at rest. Less than ordinary activity causes fatigue, palpitation, or dyspnea.

NYHA class IV: Unable to carry on any physical activity without discomfort. Symptoms of heart failure at rest. If any physical activity is undertaken, discomfort increases.

In each state, hospitalization and death are possible.
• All cause mortality are based on regression risk equation of Medical treatment (Weibull) adjusted by CRT-P/CRT-D HR (Woods 2015).
• Hospitalization probability is based on risk equation, independently of the device.
• We did missing's imputation to obtain long-term survival, hospitalization and quality of life. Specific assumption (Dr. Berruezo team are checking clinical records).
  • QRS: based on QRs stimulated (15 cases).
  • LVEF final: equal to LVEF basal (3 cases)
  • NYHA final equal to the NHYA 12 months (33 cases)
  • EQ5D is based on NHYA.
• Drug costs are in ex-Factory price.
• Long term Inappropriate ICD shock probability is based on the short term probability of alive patients.
RESULTS
ALGORITHM 1 (SOFT): scar mass >10 g and the presence of BZ channel

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<tr>
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<th>NON-HIGH</th>
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<tr>
<td>CRT-D</td>
<td>51 (91%)</td>
<td>81 (65%)</td>
</tr>
<tr>
<td>CRT-P</td>
<td>5 (9%)</td>
<td>44 (35%)</td>
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<td>TOTAL</td>
<td>56 (100%)</td>
<td>125 (100%)</td>
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ALGORITHM 2: scar mass >10g and BZ mass >5.3 g

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<tr>
<td>CRT-D</td>
<td>57 (92%)</td>
<td>75 (63%)</td>
</tr>
<tr>
<td>CRT-P</td>
<td>5 (8%)</td>
<td>44 (37%)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>62 (100%)</td>
<td>119 (100%)</td>
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</table>

Source: GAUDI-CRT
SHORT-TERM: ALGORITHM I

HF PATIENTS CANDIDATE TO CRT

ROUTINE CLINICAL PRACTICE

OPTIMIZATION ALGORITHM

HF: Hear Failure

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For each patient type:
- Device complications
- Inappropriate ICD shocks
- Transplant
- Survival
- Quality of life
HF PATIENTS CANDIDATE TO CRT

HF: Heart Failure

OPTIMIZATION ALGORITHM

SHORT-TERM: ALGORITHM II

ROUTINE CLINICAL PRACTICE

HF PATIENTS CANDIDATE TO CRT

HIGH RISK

34% HIGH RISK

HIGH RISK

92% CRT-D

37% CRT-P

63% CRT-D (overprotected)

8% CRT-P (underprotected)

TOTAL 62 (100%) 119 (100%)

Device complications

Inappropriate ICD shocks

Transplant

Survival

Quality of life

For each patient type:

66% NON-HIGH RISK

66% NON-HIGH RISK

92% CRT-D

34% CRT-P
LONG-TERM RESULTS
At the end of life, Algorithm I cost €20,960, Algorithm II €22,319 and routine clinical practice €28,447.

Positive values shows benefit of Algorithm I (1\textsuperscript{st} & 3\textsuperscript{rd}) and Algorithm II (2\textsuperscript{nd})
RESULTS: COST DISTRIBUTION

Implant cost is the highest cost for all alternatives (52% routine clinical practice 43%, Algorithm II and 42% Algorithm I.)
RESULTS: LIFE YEAR

At the end of life, Algorithm I shows 4.32 years, Algorithm II 4.23 years and routine clinical practice 4.16 years.

Positive values shows benefit of Algorithm I (1st & 3rd) and Algorithm II (2nd).
At the end of life, Algorithm I shows 3.26 QALYs, Algorithm II 3.20 QALYs and routine clinical practice 3.17 QALYs.

Positive values shows benefit of Algorithm I (1st & 3rd) and Algorithm II (2nd)
## ROUTINE CLINICAL PRACTICE: DATA SPLITED

<table>
<thead>
<tr>
<th>ROUTINE CLINICAL PRACTICE</th>
<th>PROBABILITY</th>
<th>COST</th>
<th>LIFE YEARS</th>
<th>QALY</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRTD HIGH PATIENTS</td>
<td>28.2%</td>
<td>€33,296.63</td>
<td>4.45</td>
<td>3.47</td>
</tr>
<tr>
<td>CRT-D NON-HIGH PATIENTS</td>
<td>44.8%</td>
<td>€34,031.97</td>
<td>3.88</td>
<td>2.97</td>
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<tr>
<td>(OVERPROTECTED)</td>
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<td></td>
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</tr>
<tr>
<td>CRT-D</td>
<td>72.9%</td>
<td>€33,747.86</td>
<td>4.10</td>
<td>3.16</td>
</tr>
<tr>
<td>CRT-P HIGH PATIENTS</td>
<td>2.8%</td>
<td>€6,873.98</td>
<td>4.95</td>
<td>3.33</td>
</tr>
<tr>
<td>(UNDERPROTECTED)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CRT-P NON-HIGH PATIENTS</td>
<td>24.3%</td>
<td>€14,996.14</td>
<td>4.25</td>
<td>3.16</td>
</tr>
<tr>
<td>CRT-P</td>
<td>27.1%</td>
<td>€14,167.35</td>
<td>4.32</td>
<td>3.18</td>
</tr>
<tr>
<td>GLOBAL</td>
<td>100%</td>
<td>€28,447.06</td>
<td>4.16</td>
<td>3.17</td>
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</table>
SENSITIVITY ANALYSIS
Algorithm I is cost-effective for the 77% combinations of % under/overprotection.

Positive values show the benefit of Algorithm I vs. alternatives (Cadet & Royal blue).
Algorithm I is less costly and more effective in 71% of cases vs Current Practice and 89% vs Algorithm II.

Cases under the threshold shows Algorithm I as cost-effective.
Algorithm I has the highest probability of being cost-effective (>90% for willingness to pay <€50,000)

† Spanish threshold: €30,000 QALY
BUDGET IMPACT
Algorithm I allows cost-saving of €720 million (318-894).
CONCLUSIONS
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• Algorithm I is less costly to the hospital vs routine clinical practice and algorithm II.

• Additionally, algorithm I improves life years and quality of life vs alternatives.

• Algorithm I is highly cost-effective due to its dominant strategy compared with routine clinical practice and algorithm II.
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REFERENCES (HRQOL)