Introduction...

- Therapeutic cardiac stimulation has been in practice for many decades.

- Lately devices have shrunk in size, increased longevity and complexity.

- Increased interest in physiological or atrial based pacing.
Choice of appropriate pacing mode...

- Understanding the underlying pathology.
- Influence of pacing on this morbidity.
- Evidence base that reports the efficacy and safety of the pacing mode.

**NBG code**

<table>
<thead>
<tr>
<th>I Chamber Paced</th>
<th>II Chamber Seased</th>
<th>III Response to Sensing</th>
<th>IV Programmable Functions/Rate Modulation</th>
<th>V Antitachy Function(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>V: Ventricle</td>
<td>V: Ventricle</td>
<td>T: Triggered</td>
<td>P: Simple programmable</td>
<td>P: Pace</td>
</tr>
<tr>
<td>D: Dual (A+V)</td>
<td>D: Dual (A+V)</td>
<td>D: Dual (T+I)</td>
<td>C: Communicating</td>
<td>D: Dual (P+S)</td>
</tr>
<tr>
<td>O: None</td>
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<td>O: None</td>
<td>R: Rate modulating</td>
<td>O: None</td>
</tr>
<tr>
<td>S: Single (A or V)</td>
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<td>O: None</td>
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</tbody>
</table>
The ideal pacing mode...

- Heart rate increase
- Stroke volume maximization
- Atrial based pacing
- Normal ventricular activation

Ventricular activation...

Common indications of pacing

- Sinus Node disease
- AV nodal disease.

<table>
<thead>
<tr>
<th>Sinus Node Dysfunction</th>
<th>AV Block</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sinus bradycardia</td>
<td>First-degree AV block</td>
</tr>
<tr>
<td>Sinus arrest</td>
<td>Second-degree AV block</td>
</tr>
<tr>
<td>SA block</td>
<td>– Mobitz types I and II</td>
</tr>
<tr>
<td>Brady-tachy syndrome</td>
<td>Third-degree AV block</td>
</tr>
<tr>
<td>Chronotropic incompetence</td>
<td>Bifascicular and trifascicular block</td>
</tr>
</tbody>
</table>
Sinus Node Disease

- Sinus Bradycardia
- Sinus Arrest
- Sinus exit block
- Brady-Tachy

Chronotropic Incompetence
- In the absence of reversible cause PM implantation is the TTT.

- Available modes are: Dual chamber (DDD-DDI), Single chamber (AAI-VVI) +/- R
Evidence...

- AF
- Stroke
- HF
- Quality of life
- Mortality
- PM syndrome
- Effect of RV pacing.
- Role of single chamber PM in SND (AAI-VVI)
- Rate adaptive pacing
AF...

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<table>
<thead>
<tr>
<th>Study</th>
<th>Physiologic</th>
<th>Ventricular</th>
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<tr>
<td>Danish</td>
<td>26/119</td>
<td>40/115</td>
</tr>
<tr>
<td>CTOPP</td>
<td>234/1094</td>
<td>387/1474</td>
</tr>
<tr>
<td>PASE</td>
<td>35/203</td>
<td>38/204</td>
</tr>
<tr>
<td>MOST</td>
<td>217/1014</td>
<td>270/996</td>
</tr>
<tr>
<td>UKPACE</td>
<td>98/1912</td>
<td>111/1009</td>
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</tbody>
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Overall: 690/3433 826/3799
```

Association: chi-square = 17.71 p = 0.00005

Hazard Ratio

![Graph showing hazard ratios for different studies and overall comparison between atrial and ventricular pacing.]

Favors atrial-based pacing Favors ventricular-based pacing

stroke...

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Overall: 177/3433 238/3799
```

Association: chi-square = 4.44 p = 0.035

Hazard Ratio

![Graph showing hazard ratios for different studies and overall comparison between atrial and ventricular pacing.]

Favors atrial-based pacing Favors ventricular-based pacing
- HF and quality of life
- PM syndrome.
- RV pacing.
- Single chamber: AAI (≤ 70 years - DANPACE increase AF ? With AAI)
  - VVI (back up non frequent pacing, AF, sedentary life, comorbidities)

- Rate adaptive: evidence of increased HF hospitalization and AF, no increase in exercise time at long term, reassessed at FUP

All cause mortality.

<table>
<thead>
<tr>
<th>Study</th>
<th>Physiologic</th>
<th>Ventricle</th>
<th>VVI %</th>
<th>HR [95% CI]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Danish</td>
<td>39/110</td>
<td>57/115</td>
<td>4.1</td>
<td>0.66 [0.44, 0.98]</td>
</tr>
<tr>
<td>CTOFP</td>
<td>390/1094</td>
<td>545/1474</td>
<td>42.8</td>
<td>0.02 [0.81, 1.65]</td>
</tr>
<tr>
<td>PASS</td>
<td>32/203</td>
<td>34/204</td>
<td>2.9</td>
<td>0.94 [0.58, 1.52]</td>
</tr>
<tr>
<td>MOST</td>
<td>200/1514</td>
<td>206/936</td>
<td>17.8</td>
<td>0.87 [0.81, 1.18]</td>
</tr>
<tr>
<td>UKPACE</td>
<td>32/1012</td>
<td>367/1009</td>
<td>34.4</td>
<td>1.01 [0.99, 1.03]</td>
</tr>
</tbody>
</table>

Overall 1054/3403 1247/9708 100 0.99 [0.97, 1.01]

Association: chi-square = 1.72 p = 0.19
AV Nodal disease

- Class I

1. Dual-chamber pacing is recommended in patients with AV block (Level of Evidence: C)

2. Single-chamber ventricular pacing is recommended as an acceptable alternative to dual-chamber pacing in patients with AV block who have specific clinical situations that limit the benefits of dual-chamber pacing. These include, but are not limited to, sedentary patients, those with significant medical comorbidities likely to impact clinical outcomes, and those in whom technical issues, such as vascular access limitations, preclude or increase the risk of placing an atrial lead (Level of Evidence: B)

3. Dual-chamber pacing is recommended over single-chamber ventricular pacing in adult patients with AV block who have documented pacemaker syndrome (Level of Evidence: B)

- Class II

1. Single-lead, dual-chamber VDD pacing can be useful in patients with normal sinus node function and AV block (e.g., the younger patient with congenital AV block) (Level of Evidence: C)

2. VVI pacing can be useful in patients following AV junction ablation, or in whom AV junction ablation is planned, for rate control of AF due to the high rate of progression to permanent AF (Level of evidence B)

- Class III

1. Dual-chamber pacing should not be used in patients with AV block in permanent or longstanding persistent AF in whom efforts to restore or maintain sinus rhythm are not planned (Level of Evidence: C)
Evidence...

- The optimal pacing mode for patients with AV block has been the subject of debate.

- Randomized clinical trials (PASE, CTOPP, and UKPACE) have compared dual-chamber pacing to VVI pacing in patients with AV block.

Findings...

1- AF:
- CTOPP: 224/1034, 365/1474
- UKPACE: 98/1012, 111/1003

2- Stroke:
3- Mortality:
4- HF:
5- PM syndrome:
Although it is clear that the majority of patients who have already experienced pacing, prefer dual, neither PASE nor CTOPP reported significant differences in quality of life.

Studies of pacing mode confirmed that pacing clearly improved quality of life over no pacing, but it did not show a difference between dual- and single-chamber pacing.
Pacing mode may be more important in younger active patients. Unlike patients enrolled in the PASE study with multiple comorbidities.

Factors Influencing Choice of DDD over VVI

1- DDD preferred for more physically active patient preserve AV synchrony and Sinus chronotropic response rather than by activity sensor

2- Any degree of systolic +/- diastolic dysfunction where maintenance of AV synchrony is important for preserving hemodynamics.
Outcome of randomized controlled trials of dual-chamber versus ventricular pacing

<table>
<thead>
<tr>
<th>Outcome</th>
<th>References</th>
<th>Dual-chamber benefit over ventricular pacing</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>All-cause deaths</td>
<td>2, 11-15</td>
<td>No benefit</td>
<td></td>
</tr>
<tr>
<td>Stroke, embolism</td>
<td>2, 11-15</td>
<td>Benefit (in meta-analysis only, not in single trial)</td>
<td>HR 0.88.11 Benefit higher in SSS.</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>2, 11-15</td>
<td>Benefit</td>
<td>HR 0.817 and 0.76.13 Benefit higher in SSS.</td>
</tr>
<tr>
<td>HF, hospitalization for HF</td>
<td>2, 11, 12, 14, 15</td>
<td>No benefit</td>
<td></td>
</tr>
<tr>
<td>Exercise capacity</td>
<td>15</td>
<td>Benefit</td>
<td>Overall standardized mean improvement of 15%. Not significant compared to VVI.</td>
</tr>
<tr>
<td>Pacemaker syndrome</td>
<td>11-12, 15</td>
<td>Benefit</td>
<td>Documented in up to 25% of VVI pacemakers.</td>
</tr>
<tr>
<td>Functional status</td>
<td>11, 12, 15</td>
<td>No benefit</td>
<td></td>
</tr>
<tr>
<td>Quality of life</td>
<td>11-13, 15</td>
<td>Variable</td>
<td>Consistent duration of effect on quality of life, but the size cannot be estimated with confidence.</td>
</tr>
<tr>
<td>Complications</td>
<td>2, 11-13, 15</td>
<td>More complications with dual-chamber</td>
<td>Higher rate of lead dislodgment (4.25 vs. 1.48) and inadequate pacing (1.5 vs. 0.33).</td>
</tr>
</tbody>
</table>

Mode Selection Algorithm

[Diagram showing decision tree for mode selection based on sinus node disease and AV block, with options such as SND, VVIR, and DDD + AVM, followed by CRT if low EF/HF.]
Other indications...

Hypersensitive Carotid Sinus Syndrome

- AAI pacing alone has been shown to be ineffective in this syndrome.

- Class IIa

- Class III
Neurocardiogenic syncope

- Class IIa

- Class III

Rate drop response...
Long QT

- Class I

1. Dual-chamber or atrial pacing compared to ventricular pacing is recommended for symptomatic or high-risk patients with congenital long QT syndrome (Level of Evidence: C)

HOCM

- Class IIa

1. Dual-chamber pacing can be useful for patients with medically refractory, symptomatic hypertrophic cardiomyopathy with significant resting or provoked left ventricular outflow obstruction (Level of Evidence: C)

- Class III

1. Single-chamber (VVI or AAI) pacing is not recommended for patients with medically refractory, symptomatic hypertrophic cardiomyopathy (Level of Evidence: C)
Take home message

- **SND** derive benefit from atrial or dual-chamber pacing compared with ventricular pacing with regard to the risks of AF, stroke, pacemaker syndrome, and improved quality of life.

- **AV Block** DDD failed to show benefit over ventricular pacing regarding major outcomes including mortality, stroke, HF, and AF, it can reduce the incidence of PM syndrome and improve some indices of quality of life.

- For less common indications for pacing, the recommendations to consider dual-chamber pacing are based on small clinical studies. It is unlikely that large randomized trials will ever be conducted in these unique clinical subgroups.
Thank you!