Continuous and noninvasive arterial blood pressure monitoring

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Déclaration de Relations Professionnelles  
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**Affiliation/Financial Relationship**

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**Company**

- Edwards Lifesciences S.A.S.
- Pulsion Medical Systems
- Masimo
1. Blood pressure monitoring

### Invasive
- Reference method
- Direct and continuous measurement
- Positive benefit/risk analysis
- Independent of local changes in vasomotor tone and arterial rigidity
- Repeated blood sampling

### Non invasive
- Continuous or discontinuous indirect measurement
- Occlusive methods: sphygmomanometry, oscillometry
- Non occlusive methods: tonometry, photoplethysmography
- Dependent of local changes in vasomotor tone

**AAMI recommendations**: bias < 5 mmHg; precision < 8 mmHg; LOA ± 15 mmHg
2. Continuous blood pressure monitoring

Real-time measurement of blood pressure

- Hemodynamic instability
- Effects of vasoactive drugs
Qualitative analysis of blood pressure waveform

Useful information at the bedside
Specific abnormalities
SBP and PP variation during mechanical ventilation

PPV = \( \frac{(PP_{\text{max}} - PP_{\text{min}})}{\left[(PP_{\text{max}} + PP_{\text{min}})/2\right]} \)

PPV threshold value = 9 to 13% (Cannesson, Anesthesiology 2011)
Assessment of preload dependence

Dynamic indices

Preload dependence

Preload independence

SV

Preload

SVV Flotrac/Vigileo
Edwards

PPV Intellivue
Philips

PPV S/5
GE

SVV PPV PICCO plus
Pulsion
Stable relationship between the systolic area of arterial pressure waveform (As) and stroke volume

\[ SV = \frac{As}{Z} \]

\( Z \) = vascular arterial impedance
Mini-invasive assessment of CO with pulse contour analysis
3. Continuous and noninvasive blood pressure monitoring

**NEXFIN**  
*Edwards Lifesciences, Irvine, USA*

**CNAP**  
*CNSystems, Graz, Austria*

*Digital photoplethysmography*

*CO assessment with pulse contour analysis*
### Continuous and noninvasive BP monitoring

#### NEXFIN
- **Pubmed:** 40 references
- Anesthesiology, critical care and emergency = 21
- Phase III studies = ± 1
- BP comparators: radial/femoral invasive BP, oscillometric BP, invasive PPV, SVV
- CO comparators: TD, TP-TD, TTE, Esophageal Doppler, cardiac NMR

#### CNAP
- **Pubmed:** 24 references
- Anesthesiology, critical care and emergency = 15
- Phase III studies = 0
- BP comparators: radial/femoral invasive BP, oscillometric BP, invasive PPV, SVV
NEXFIN: blood pressure monitoring

\[ \text{SBP} \]
\[ r = 0.75 \]
\[ p < 0.001 \]

\[ \text{DBP} \]
\[ r = 0.78 \]
\[ p < 0.001 \]

\[ \text{MBP} \]
\[ r = 0.88 \]
\[ p < 0.001 \]

\[ \text{N} = 220 \text{ couples of measures in 44 cardiac surgical patients:} \]

\[ \text{SBP} = 108 \pm 20 \text{ (55-166) mmHg} \]
\[ \text{DBP} = 67 \pm 10 \text{ (44-94) mmHg} \]
\[ \text{MBP} = 81 \pm 12 \text{ (48-117) mmHg} \]

\[ \text{Fischer, BJA 2012} \]
Average of SBP\_AI and SBP\_NF

Mean: 5.7
SD: 2.2

Average of DBP\_AI and DBP\_NF

Mean: -8.9
SD: 2.7

Average of MBP\_AI and MBP\_NF

Mean: -4.6
SD: 1.7

AAMI recommendations on MBP: bias < 5 mmHg; precision < 8 mmHg; LOA ± 12.7 mmHg

Bias = -4.6 mmHg
Precision = 6.5 mmHg
LOA = ± 12.7 mmHg

Fischer, BJA 2012
## CNAP: blood pressure monitoring

**AAMI recommendations on MBP:** bias < 5 mmHg; precision < 8 mmHg; LOA ± 15 mmHg

<table>
<thead>
<tr>
<th>Author</th>
<th>Bias (mmHg)</th>
<th>Precision (mmHg)</th>
<th>LOA (mmHg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jeleazcov (BJA 2010)</td>
<td>-1.6</td>
<td>-</td>
<td>± 12.0</td>
</tr>
<tr>
<td>Ilies (BJA 2012)</td>
<td>-4.3</td>
<td>-</td>
<td>± 19.5</td>
</tr>
<tr>
<td>Hahn (BJA 2012)</td>
<td>-3.1</td>
<td>9.4</td>
<td>± 18.5</td>
</tr>
<tr>
<td>Gayat (AAS 2013)</td>
<td>-8.0</td>
<td>-</td>
<td>± 26.0</td>
</tr>
<tr>
<td>Schramm (Anesth Analg 2013)</td>
<td>3.9</td>
<td>-</td>
<td>± 22.6</td>
</tr>
</tbody>
</table>
NEXFIN: prediction of fluid responsiveness
CNAP: prediction of fluid responsiveness

**Biais, Anesth Analg 2011**  
*N = 35 vascular surgery patients*

**Monnet, BJA 2012**  
*N = 47 critically-ill patients*

\[
\text{ROC}_{\text{AUC}} \Delta \text{PP}_{\text{ART}} = 0.96 \pm 0.03
\]

\[
\text{ROC}_{\text{AUC}} \Delta \text{PP}_{\text{CNAP}} = 0.94 \pm 0.04
\]

\[
\text{ROC}_{\text{AUC}} \text{PPVi} = 0.89 \ (0.77-1.01)
\]

\[
\text{ROC}_{\text{AUC}} \text{PPVni} = 0.89 \ (0.78-1.01)
\]
Non-invasive continuous arterial pressure and cardiac index monitoring with Nexfin after cardiac surgery

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\[
\text{CI}_{\text{TD-TP}} \text{ versus } \text{CI}_{\text{Nexfin}}
\]

\[
2.5 \pm 0.6 \text{ (1.5-4.5)} \text{ vs. } 2.5 \pm 0.7 \text{ (1.1-4.7)} ; P=0.898
\]

\[
\text{r} = 0.57 ; P < 0.001
\]

Bias = 0.01 L/min/m²

LOA + 1.23 L/min/m²

Error percentage = 50%

99% of changes in CI are within 0.4 L/min/m² (20%) of LOA
Conclusions

- **NEXFIN** and **CNAP** devices are reliable tools to continuously and noninvasively assess blood pressure (*AAMI recommendations*)
- **NEXFIN** and **CNAP** could be clinically useful to predict fluid responsiveness
- **NEXFIN** could be useful as a CO trend monitor
- Phase III validation studies are mandatory in different subgroups of moderate to high-risk patients before recommending a wider use at the bedside