Cerebral autoregulation in pediatric ECMO: 2 centers experience

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Experience of 2 pediatric ECMO centers

- From January 2018
- 40 children
- VA and VV ECMO
- 0 to 18 years

Nantes (France)

Genoa (Italy)
Dr Stefano Pezzato
ECMO

- Hemodynamic failure
  - Cardiac surgery
  - Medical conditions
- Respiratory failure (ARDS)
- Cardio pulmonary resucitation (ECPR)
ECMO

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ECMO and neurological outcome

- 102 ECMO centers in the US
- From 1990 to 2009
- 31,335 ECMO patients < 18 years
- All indications

<table>
<thead>
<tr>
<th>Complication</th>
<th>Incidence (%)</th>
<th>Patient Survival (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNS hemorrhage</td>
<td>7.4</td>
<td>36</td>
</tr>
<tr>
<td>CNS infarction</td>
<td>5.7</td>
<td>48</td>
</tr>
<tr>
<td>clinically determined seizures</td>
<td>8.4</td>
<td>47</td>
</tr>
<tr>
<td>EEG-determined seizures</td>
<td>2.1</td>
<td>35</td>
</tr>
</tbody>
</table>

Cerebral autoregulation and ECMO

- Pre ECMO period
- Brain primary injury
- Cannulation
- ECMO run
- Secondary injury
- Decannulation
- Post ECMO period
Cerebral autoregulation and ECMO

Pre ECMO period
- Cannulation
- Brain primary injury

ECMO run
- Secondary injury

Decannulation
- Post ECMO period
- ??

Autoregulation
Cerebral autoregulation and ECMO

- 14 healthy newborn lambs
- VA ECMO vs controls
- Progressive decrease of CPP

Supposed mechanism: loss of pulsatility

Short. Ped Res 1993
Questions

1. Can we monitor AR at bedside during ECMO?
2. Clinical impact of cerebral autoregulation disorders?
3. Can we control them?
   - Type of cannulation
   - ECMO flow
   - Optimal ABP
   - Optimal PCO2
   - ...
Which signals and index?

- RSO2
- ICM+
- ABP
- COx
RSO2 artefacts
RSO2 artefacts

Values > 95%
RSO2 artefacts

Values > 95%

- For the moment manually removed
- Need automatic function to be used at bedside
ABP artefacts
ABP artefacts
ABP artefacts
ABP artefacts removal: peak to peak filter?
ABP artefacts removal: peak to peak filter?
Variables derived from COx
Variables derived from COx

« Critical » zone

Cox 0.3
Variables derived from COx

« Critical » zone

% time with Cox > 0.3

Cox 0.3
Variables derived from COx

« Critical » zone

% time with Cox > 0.3

Cox 0.3

AUC Cox > 0.3

AUC global COX
Variables derived from COX

- « Critical » zone
- % time with Cox > 0.3
- AUC Cox > 0.3
- AUC global COX

Cut off?
ABPopt, ULA, and LLA: single window approach
ABPopt, ULA, and LLA: single window approach

Periods of 4-6-8-12 hours?
Bins of MAP of 2-3-5mmHg width?
ABPopt, ULA, and LLA: single window approach

1. How is ABP distributed?
2. How are the error bars distributed?
3. Do we have the U shape curve?
4. How is the fitting of the curve?
5. Which values of ABPopt do we get?

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Periods of 4-6-8-12 hours?
Bins of MAP of 2-3-5 mmHg width?

Periods of 8h
Bins of 2 mmHg
Multi-window ABPopt calculation with weighting

- Increase yield of the monitoring
- Multi-window approach
Multi-window ABPopt calculation with weighting

• Increase yield of the monitoring

• Multi-window approach

• Weighting algorithm
  - Length of the calculation window increasing from 2 to 8 hours
  - Application of a weight factor considering:
    - Period length
    - Size of the fit error
    - Obtention of a vertex

Liu. J of Neurotrauma 2017
Multi-window ABPopt calculation with weighting

- Increase yield of the monitoring
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Weighting algorithm
- Length of the calculation window increasing from 2 to 8 hours
- Application of a weight factor considering:
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1 point/min

Liu. J of Neurotrauma 2017
Is this method applicable in our population?

Yield: 89.8% time ABPopt available
Is this method applicable in our population?

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VA ECMO
1 month
Post operative
Is this method applicable in our population?

Yield: 89.8% time ABPopt available

VA ECMO
1 month Post operative

VA ECMO
2 months Post operative
VA ECMO
1 year
Post operative
VA ECMO
1 year
Post operative

VA ECMO
1 month
Post operative
Stable period

VA ECMO
2 months
Post operative
Hypotension

VA ECMO
2 months
Post operative
Hypotension

VA ECMO
2 months
Post operative

VA ECMO
3 months
Post operative
But also hypertension !!!

VA ECMO
5 years
Fulminant myocarditis
Variables

From ULA
• AUC MAP > ULA
• % time with ABP > ULA
Variables

From ULA
- AUC MAP > ULA
- % time with ABP > ULA

From ABPopt
- Delta ABP-ABPopt
- % time +/- 5 mmHg
Variables

From ULA
- AUC MAP > ULA
- % time with ABP > ULA

From ABPopt
- Delta ABP-ABPopt
- % time +/- 5 mmHg

From LLA
- AUC ABP < LLA
- % time with ABP < LLA
Influence of PCO2

- Arterial PCO2: only discontinuous values: 2 to 4/day
- Continuous veinous PCO2?
Conclusion

• AR monitoring in ECMO is feasible using routine devices
• Artefacts removal: manual for the moment
• Multi-window ABPopt calculation with weighting is feasible
• Inclusion of the influencing variables in the model in process
• Results of the association between AR impairment and neurological outcome in the CARNet meeting