Bioimpedance spectroscopy measurements of phase angle and height for age are predictive of outcome following surgery for congenital heart disease

Magee A G1, Meyer R2, Johnson M1,4, Newell C4, Johnstone C1, Sykes K5, Wootten SA4, Pappachan JV6, Marino LV1

Department of Dietetics/ SLT, University Hospital Southampton NHS Foundation Trust 1, Department of Paediatrics, Imperial College London2, Department of Neonatal Medicine, University Hospital Southampton NHS Foundation Trust3, NIHR Biomedical Research Centre Southampton and University of Southampton4, Paediatric Cardiology, University Hospital Southampton NHS Foundation Trust5, Paediatric Intensive Care Unit, University Hospital Southampton NHS Foundation Trust6.

Background

We know that around 28% of infants undergoing cardiac surgery will have a Height for age 2 score (HAZ) of < -2. Low HAZ is a measure of dynamic malnutrition. Infants with a poor nutritional status undergoing cardiac surgery tend to have a longer PICU stay and may have an increased risk of dying by 12 months. Bioimpedance phase-angle (BIS-PA) is a prognostic marker associated with increased risk of poorer outcomes-chronic renal disease, oncology, HIV, liver disease, adult critical care. It may therefore be a measure of resilience and cellular integrity.

Objectives

1. To describe the relationship between nutritional status, bioelectrical impedance spectroscopy (BIS) phase-angle and post-operative outcomes.
2. To determine whether serial peri-operative BIS-PA will identify children with poor post-operative resilience who are at risk of prolonged PICU-LOS.

BIS – phase angle

BIS – applies a small electrical current passes through the body in a circuit

Resistance – quantity & composition of the tissues & total body water

Reactance – cellular integrity (capacitance)

PA – degree to which there is overall resistance to an electrical current

A lower PA is associated with < cellular integrity – greater risk – poorer outcomes

BIS data files processed Bioimp (ImpediMed)

• Standard tetrapolar electrodes distribution
• Baseline, post-op day 0 & 2, discharge

BIS spectroscopy (BIS) phase-angle cut-offs at each of the time points as the mean HAZ score in these children was -1.8 ± 1.5

Statistical significance was a p value <0.05

Models p-value 0.05 included in a multivariate regression model, adjusted for age, PIMS-2 score, RACHS-1 and operative procedure, CPB and ACC

Acknowledgements

• NIHR Southampton Biomedical Research Centre and Nutricia (UK) for their support
• Medical students; Kate Allen-McGraw and Richa Dhar for their assistance with data collection
• Luise Marino was supported by a post-doctoral fellowship award from NIHR Health Education England (Wessex) in collaboration with an educational grant from Nutricia, UK

Results

PA cut off values for PICU-LOS

<table>
<thead>
<tr>
<th>PICU-LOS</th>
<th>Cut off value</th>
<th>Area under curve, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline phase angle</td>
<td>1.5</td>
<td>0.95</td>
</tr>
<tr>
<td>Post-op day 0 phase angle</td>
<td>2.9</td>
<td>0.59</td>
</tr>
<tr>
<td>Post-op day 2 phase angle</td>
<td>2.7</td>
<td>0.0001</td>
</tr>
<tr>
<td>Discharge from hospital</td>
<td>2.7</td>
<td>0.0002</td>
</tr>
</tbody>
</table>

Risk in prolonged PICU-LOS

28% Stunting <-2 z score

Underweight at time of surgery

9 days longer in hospital

Increased risk of dying at 12 months of age

28% of infants had HAZ < -2

Clinical outcomes – definitions

PICU-LOS ≥ 4 days

Anthropometry- moderate malnutrition

• HAZ ≤-2.2 scores below the mean of the WHO child growth standards

Conclusions

1. Moderate malnutrition is common in children undergoing surgery for CHD
2. A phase-angle of < 2.7 at day 2 was associated with a with 4 fold increased risk in prolonged PICU-LOS
3. Changes in bioelectrical impedance spectroscopy (BIS) phase-angle appear to precede anthropometric score in predicting poor PICU outcomes as the mean HAZ score in these children was -1.8 ± 1.5
4. Use of phase angle may promote greater awareness of post-operative risk allowing for better targeting of supplemental nutrition /fluid management in the post-operative period

Methods

Prospectively enrolled children n=122

• March 2015 – April 2016

BIS spectroscopy

• ImpediMedSFB7 - calibrated before each use
• Baseline, post-op day 0 & 2, discharge
• Measurements in triplicate - mean used in the analysis
• Standard tetrapolar electrodes distribution
• BIS data files processed Bioimp (ImpediMed)

Data points rejected if:

• i) positive X centre (Xc) values
• ii) negative resistance values
• Phase angle at a current frequency of 50Hz was used for analysis

Data analysis n=117 children

• 2 children died – post-operative period with only baseline measures collected
• BIS-PA measured failed to record in n=3
• BIS – PA measures n=3,636

• 4 time points:
  • baseline before surgery (n=129)
  • post-operative day 0 (n=110)
  • post-operative day 2 (n=95)
  • Discharge (n=60)

Statistics

• ROCs were drawn at baseline, post-operative day 0, day 2 & discharge with area under the curves (AUC) were calculated for all of the phase angle

• Optimal cut-off values for phase angle were chosen based on the highest AUC and a p value <0.05

• Univariate logistic regression were executed with PICU-LOS as dependent variables & HAZ/ phase angle cut-offs at each of the time points as independent variables

• Models p-value 0.05 included in a multivariate regression model, adjusted for age, PIMS-2 score, RACHS-1 and operative procedure, CPB and ACC

• Statistical significance was a p value <0.05