The Role of the Heart in Congenital Diaphragmatic Hernia

Neil Patel
Royal Hospital for Children
Glasgow, UK
Pulmonary hypoplasia

Schmidt et al, 2012

Pulmonary hypertension

Yamataka and Puri, 1997
PULMONARY VASODILATORS?

INOTROPES & PRESSORS?

ECMO?

TIMING OF SURGERY?

PREDICTING OUTCOME?

NEW THERAPEUTIC APPROACHES?
Cardiac function in CDH

What?
Why?
When?
How often?
(Who cares?)
Tissue Doppler Imaging of RV in CDH

- Reduced systolic velocities (S’)
- Loss of diastolic (e’) velocity

Patel et al, Neonatology 2009
Abnormal pulmonary vascular structure & function

↑ Pulmonary Vascular Resistance

Right-to-left shunting
(atria and PDA)

RIGHT VENTRICULAR (DIASTOLIC) DYSFUNCTION
Speckle tracking echocardiography in CDH

- Longitudinal strain (LS)
- Circumferential strain (CS)
- Radial strain (RS)
Ventricular strain in CDH (first 48h of life)

- CDH
- Controls

* p < 0.05
Abnormal pulmonary vascular structure & function

↑ Pulmonary Vascular Resistance

Right-to-left shunting (atria and PDA)

RIGHT VENTRICULAR DYSFUNCTION

Ventricular interdependence

LEFT VENTRICULAR DYSFUNCTION
Ventricular inter-dependence in CDH

RV and LV global longitudinal strain in CDH

$r^2 = 0.37; p = 0.0016$

CDH 2020 Houston  Massolo et al, Neonatology 2019
Severe left diaphragmatic hernia limits size of fetal left heart more than does right diaphragmatic hernia


Ultrasound Obstet Gynecol 2015; 46: 688–694
Possible mechanisms of fetal LV hypoplasia

- Reduced pulmonary blood flow
- Altered ductus venosus streaming
- Mechanical compression

Fig. 2. Diagram summarizing five mechanisms for cardiovascular compensation during fetal life with severe CDH. (Adapted with permission from WB Saunders, Katz AL, Wissell TE, Baurigart S, Chin Perinatal 1993.)
Abnormal pulmonary vascular structure & function

↑ Pulmonary Vascular Resistance

Right-to-left shunting (atria and PDA)

RIGHT VENTRICULAR DYSFUNCTION

Ventricular interdependence

LEFT VENTRICULAR DYSFUNCTION

Fetal LV hypoplasia

↑ afterload at birth

CDH 2020 Houston
LV function improves in first days of life

Systolic TDI velocities (LV S’)

Diastolic TDI velocities (LV E’)

Early ventricular function: CDH Study Group Registry Analysis 2015-2018

1646 CDH cases

1173 cases early cardiac function

- 711 (61%) normal cardiac function
- 182 (15%) RV dysfunction only
- 61 (5%) LV dysfunction only
- 219 (19%) RV and LV dysfunction
<table>
<thead>
<tr>
<th>Variable</th>
<th>Cardiac Function Category</th>
<th></th>
<th></th>
<th></th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>N (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Birth weight, median (SD), kg</td>
<td>711 (61)</td>
<td>182 (15)</td>
<td>61 (5)</td>
<td>219 (19)</td>
<td>-</td>
</tr>
<tr>
<td>Gestational age, median (SD), weeks</td>
<td>2.93 (0.63)</td>
<td>3.02 (0.61)</td>
<td>3.00 (0.48)</td>
<td>2.96 (0.56)</td>
<td>0.489</td>
</tr>
<tr>
<td>Male n (%)</td>
<td>37.4 (2.33)</td>
<td>37.5 (2.11)</td>
<td>37.8 (1.80)</td>
<td>37.6 (1.85)</td>
<td>0.928</td>
</tr>
<tr>
<td>Inborn n (%)</td>
<td>410/709 (58)</td>
<td>91/182 (50)</td>
<td>36/61 (59)</td>
<td>121/219 (55)</td>
<td>0.275</td>
</tr>
<tr>
<td>Prenatal diagnosis n (%)</td>
<td>437/710 (62)</td>
<td>122/181 (67)</td>
<td>34/61 (59)</td>
<td>159/219 (73)</td>
<td>0.009</td>
</tr>
<tr>
<td>Left sided CDH n (%)</td>
<td>534/708 (25)</td>
<td>150/182 (82)</td>
<td>44/61 (72)</td>
<td>186/219 (85)</td>
<td>0.007</td>
</tr>
<tr>
<td>Major Cardiac anomaly n (%)</td>
<td>599/710 (84)</td>
<td>155/182 (85)</td>
<td>50/59 (85)</td>
<td>167/214 (78)</td>
<td>0.145</td>
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<tr>
<td>Chromosomal anomaly n (%)</td>
<td>49/711 (7)</td>
<td>13/180 (7)</td>
<td>10/61 (16)</td>
<td>20/219 (9)</td>
<td>0.054</td>
</tr>
<tr>
<td>Other anomaly n (%)</td>
<td>57/710 (8)</td>
<td>13/181 (7)</td>
<td>4/61 (6)</td>
<td>22/219 (10)</td>
<td>0.685</td>
</tr>
<tr>
<td>CDHSG Stage group A/B n (%)</td>
<td>79/711 (11)</td>
<td>20/180 (11)</td>
<td>9/61 (15)</td>
<td>28/219 (13)</td>
<td>0.778</td>
</tr>
<tr>
<td>CDHSG Stage group C/D n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Liver in chest n (%)</td>
<td>335 (52)</td>
<td>60 (37)</td>
<td>19 (36)</td>
<td>40 (25)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Patch Repair n (%)</td>
<td>307 (48)</td>
<td>103 (63)</td>
<td>33 (64)</td>
<td>122 (75)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
Mmmm, Tastes like a combination of Who Cares? & So What?
Abnormal pulmonary vascular structure & function
↑ Pulmonary Vascular Resistance
Right-to-left shunting (atria and PDA)
RIGHT VENTRICULAR DYSFUNCTION

Fetal LV hypoplasia
↑ afterload at birth
LEFT VENTRICULAR DYSFUNCTION

Reduced cardiac output

Hypoxemia, acidosis, systemic hypotension

CDH 2020 Houston Patel et al, Sem Perinatol 2019
Right Ventricular Diastolic Function Measured by Tissue Doppler Imaging Predicts Early Outcome in Congenital Diaphragmatic Hernia

Florian Moenkemeyer, MD; Neil Patel, MD

$r=-0.84$. P=0.0001
Ventricular Performance is Associated with Need for Extracorporeal Membrane Oxygenation in Newborns with Congenital Diaphragmatic Hernia

Gabriel Altit, MDCM, FRCPC, FAAP\textsuperscript{1,2,3}, Shazia Bhombal, MD, FAAP\textsuperscript{2,3}, Krisa Van Meurs, MD, FAAP\textsuperscript{2,3}, and Theresa A. Tacy, MD, FAAP\textsuperscript{1,3}

<table>
<thead>
<tr>
<th></th>
<th>ECMO  (n = 15)</th>
<th>Non-ECMO (n = 29)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>RV pGLS (%)</td>
<td>−5.2 (3.9)</td>
<td>−10.7 (5.0)</td>
<td>.001</td>
</tr>
<tr>
<td>LV pGLS (%)</td>
<td>−9.1 (4.9)</td>
<td>−14.9 (5.3)</td>
<td>.002</td>
</tr>
</tbody>
</table>
Early Postnatal Ventricular Dysfunction Is Associated with Disease Severity in Patients with Congenital Diaphragmatic Hernia

Neil Patel, MD, Anna Claudia Massolo, MD, Anshuman Paria, MBBS, Emily J. Stenhouse, MBChB, Lindsey Hunter, MRCPCH, Emma Finlay, BSE, and Carl F. Davis, FRCS

LV dysfunction significantly associated with ECMO and non-survival
Ventricular Dysfunction is a Critical Determinant of Mortality in Congenital Diaphragmatic Hernia

Neil Patel, Pamela A Lally, Florian Kipfmüller, Anna Claudia Massolo, Matias Luco, Krisa P Van Meurs, Kevin P Lally, Matthew T Harting, and, for the Congenital Diaphragmatic Hernia Study Group
# Ventricular Dysfunction is a Critical Determinant of Mortality in Congenital Diaphragmatic Hernia

Neil Patel, Pamela A Lally, Florian Kipfmüller, Anna Claudia Massolo, Matias Luco, Krisa P Van Meurs, Kevin P Lally, Matthew T Harting, and, for the Congenital Diaphragmatic Hernia Study Group

<table>
<thead>
<tr>
<th>Variable</th>
<th>Multivariate analysis</th>
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<tbody>
<tr>
<td></td>
<td>HR</td>
<td>SE</td>
<td>P</td>
<td>95% CI</td>
<td></td>
</tr>
<tr>
<td>Birth weight &lt;3kg</td>
<td>1.44</td>
<td>0.22</td>
<td>0.020</td>
<td>1.06 – 1.95</td>
<td></td>
</tr>
<tr>
<td>Defect Stage C/D</td>
<td>3.37</td>
<td>0.92</td>
<td>&lt;0.001</td>
<td>1.97 – 5.77</td>
<td></td>
</tr>
<tr>
<td>Liver in chest</td>
<td>1.63</td>
<td>0.34</td>
<td>0.018</td>
<td>1.09 – 2.46</td>
<td></td>
</tr>
<tr>
<td>Cardiac Dysfunction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RV only</td>
<td>1.02</td>
<td>0.23</td>
<td>0.92</td>
<td>0.66 – 1.58</td>
<td></td>
</tr>
<tr>
<td>LV only</td>
<td>1.90</td>
<td>0.52</td>
<td>0.020</td>
<td>1.11 – 3.26</td>
<td></td>
</tr>
<tr>
<td>RV &amp; LV</td>
<td>1.59</td>
<td>0.29</td>
<td>0.011</td>
<td>1.11 – 2.27</td>
<td></td>
</tr>
</tbody>
</table>
The Left Ventricle in Congenital Diaphragmatic Hernia: Implications for the Management of Pulmonary Hypertension

John P. Kinsella, MD1, Robin H. Steinhorn, MD2, Mary P. Mullen, MD3, Rachel K. Hopper, MD4, Roberta L. Keller, MD5, D. Dunbar Ivy, MD2, Eric D. Austin, MD6, Usha S. Krishnan, MD4, Erika B. Rosenzweig, MD6, Jeffrey R. Fineman, MD6, Allen D. Everett, MD9, Brian D. Hanna, MD11, Tilman Humpl, MD12, J. Usha Raj, MD13, and Steven H. Abman, MD14, on behalf of the Pediatric Pulmonary Hypertension Network (PPHNet)

- Pulmonary Venous Hypertension
- Decreased cardiac output
- Pulmonary edema, worsened with PH drug therapy

LV hypoplasia or dysfunction

- Decreased phasic lung stretch and/or compression of lung,
- Decrease surface area for gas exchange,
- Poor lung recruitment and lung injury from mechanical ventilation

High tone and abnormal reactivity;
structural remodeling
decreased vessel growth

Pulmonary Vascular Disease
Lung Hypoplasia

CDH 2020 Houston

J Peds, 2018
Fig. 3. Example protocol for timing of cardiac function assessment in CDH.
The Blind Men of Indostan and the Elephant in the Echo Lab

Lawrence G. Rudsik, MDCM, FACC, FASE, and Jonathan Afilalo, MD, MSc, FRCPC, *Montreal, Québec, Canada*
PULMONARY VASODILATORS?

ECMO?

TIMING OF SURGERY?

WEANING OF SUPPORT?

PREDICTING OUTCOME?

INOTROPES & PRESSORS?

NEW THERAPEUTIC APPROACHES?

WEANING OF SUPPORT?

PREDICTING OUTCOME?

NEW THERAPEUTIC APPROACHES?

TIMING OF SURGERY?
Abnormal pulmonary vascular structure & function

↑ Pulmonary Vascular Resistance

Right-to-left shunting (atria and PDA)

RIGHT VENTRICULAR DYSFUNCTION

Reduced cardiac output

Hypoxemia, acidosis, systemic hypotension

Fetal LV hypoplasia

↑ afterload at birth

↑ pulmonary venous pressure

Ventricular interdependence

CDH 2020 Houston
Implications of Atrial-Level Shunting by Echocardiography in Newborns with Congenital Diaphragmatic Hernia

Melissa Wehrmann, MD¹, Sonali S. Patel, MD, PhD¹, Caitlin Haxel, MD¹,², Courtney Cassidy, RDCS¹, Lisa Howley, MD¹,³, Bettina Cuneo, MD¹, Jason Gien, MD⁴, and John P. Kinsella, MD⁴

<table>
<thead>
<tr>
<th>Characteristics and outcomes</th>
<th>Right-to-left</th>
<th>Left-to-right</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent predicted lung volume, %, mean ± SD</td>
<td>7 14.71 ± 8.30</td>
<td>24 24.63 ± 8.23</td>
<td>.0091</td>
</tr>
<tr>
<td>Liver up, n (%)</td>
<td>9 9 (100)</td>
<td>42 23 (54.8)</td>
<td>.0109</td>
</tr>
<tr>
<td>ECMO during hospitalization, n (%)</td>
<td>9 4 (44.4)</td>
<td>42 9 (21.4)</td>
<td>.1505</td>
</tr>
<tr>
<td>Survival to discharge, n (%)</td>
<td>9 6 (66.7)</td>
<td>42 38 (90.5)</td>
<td>.0596</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Echocardiographic measurements</th>
<th>Right-to-left</th>
<th>Left-to-right</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LV 2D area (diastole) z-score, mean ± SD</td>
<td>9 −1.89 ± 0.71</td>
<td>37 −1.38 ± 0.90</td>
<td>.1179</td>
</tr>
<tr>
<td>LV 2D area (systole) z-score, mean ± SD</td>
<td>9 −1.42 ± 0.95</td>
<td>37 −0.49 ± 1.24</td>
<td>.0415</td>
</tr>
<tr>
<td>LV myocardial performance index, mean ± SD</td>
<td>5 0.18 ± 0.08</td>
<td>36 0.50 ± 0.66</td>
<td>.0088</td>
</tr>
<tr>
<td>RV myocardial performance index, mean ± SD</td>
<td>4 0.49 ± 0.03</td>
<td>28 0.54 ± 0.24</td>
<td>.3719</td>
</tr>
<tr>
<td>Ductus arteriosus direction, n (%)*</td>
<td>6 (66.7)</td>
<td>3 (7.7)</td>
<td>.0002</td>
</tr>
<tr>
<td>Right-to-left</td>
<td>0</td>
<td>5 (12.8)</td>
<td></td>
</tr>
<tr>
<td>Left-to-right</td>
<td>3 (33.3)</td>
<td>31 (79.5)</td>
<td></td>
</tr>
</tbody>
</table>
Inhaled Nitric Oxide Is Associated with Improved Oxygenation in a Subpopulation of Infants with Congenital Diaphragmatic Hernia and Pulmonary Hypertension

- Nonresponders (n=57)
- Responders (n=38)

PO$_2$ (mm Hg) vs Time from iNO (hours)
Continuous intravenous sildenafil as an early treatment in neonates with congenital diaphragmatic hernia

Florian Kipfmuller MD¹ | Lukas Schroeder MD¹ | Christoph Berg MD² | Katrin Heindel MD¹ | Peter Bartmann MD, PhD¹ | Andreas Mueller MD¹

15 non-responders
11 responders
Inhaled Nitric Oxide Is Associated with Improved Oxygenation in a Subpopulation of Infants with Congenital Diaphragmatic Hernia and Pulmonary Hypertension

Table I. Characteristics of initial responders and nonresponders to iNO therapy

<table>
<thead>
<tr>
<th>Patient characteristics</th>
<th>Nonresponder to iNO therapy (n = 57)</th>
<th>Responder to iNO therapy (n = 38)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male sex (n, %)</td>
<td>28 (49%)</td>
<td>23 (61%)</td>
<td>.30</td>
</tr>
<tr>
<td>Gestational age (wk)</td>
<td>38.0 ± 0.2</td>
<td>38.4 ± 0.2</td>
<td>.43</td>
</tr>
<tr>
<td>Birthweight (kg)</td>
<td>3.2 ± 0.1</td>
<td>3.2 ± 0.1</td>
<td>.57</td>
</tr>
<tr>
<td>LHR</td>
<td>0.97 ± 0.05</td>
<td>1.01 ± 0.04</td>
<td>.07</td>
</tr>
<tr>
<td>LHR (observed to expected lung to head ratio)</td>
<td>0.37 ± 0.02</td>
<td>0.34 ± 0.02</td>
<td>.59</td>
</tr>
<tr>
<td>Liver up position CDH (n, %)</td>
<td>37 (65%)</td>
<td>25 (66%)</td>
<td>&gt;.99</td>
</tr>
<tr>
<td>Right sided CDH (n, %)</td>
<td>10 (18%)</td>
<td>2 (7%)</td>
<td>.32</td>
</tr>
<tr>
<td>PaO₂ at initiation (mm Hg)</td>
<td>65 ± 6</td>
<td>51 ± 3</td>
<td>.27</td>
</tr>
<tr>
<td>FiO₂ at initiation (%)</td>
<td>76 ± 4</td>
<td>78 ± 4</td>
<td>.71</td>
</tr>
<tr>
<td>P/F at initiation (mm Hg)</td>
<td>121 ± 16</td>
<td>82 ± 10</td>
<td>.45</td>
</tr>
<tr>
<td>A-a gradient at initiation (mm Hg)</td>
<td>397 ± 28</td>
<td>422 ± 30</td>
<td>.77</td>
</tr>
<tr>
<td>pH at initiation</td>
<td>7.18 ± 0.02</td>
<td>7.20 ± 0.02</td>
<td>.63</td>
</tr>
<tr>
<td>All right to left shunting on echo (n, %)</td>
<td>19 (37%) (n = 52)</td>
<td>8 (22%) (n = 37)</td>
<td>.16</td>
</tr>
<tr>
<td>Bowing ventricular septum (n, %)</td>
<td>50 (56%)</td>
<td>15 (43%)</td>
<td>.14</td>
</tr>
<tr>
<td>LV dysfunction (n, %)</td>
<td>14 (27%) (n = 52)</td>
<td>3 (8%)</td>
<td>.03</td>
</tr>
</tbody>
</table>
Use of Milrinone to Treat Cardiac Dysfunction in Infants with Pulmonary Hypertension Secondary to Congenital Diaphragmatic Hernia:

<table>
<thead>
<tr>
<th>Duration of milrinone therapy</th>
<th>prec.</th>
<th>12–24 h post</th>
<th>48–72 h post</th>
</tr>
</thead>
<tbody>
<tr>
<td>PDA flow velocity, m/s</td>
<td>left to right</td>
<td>0.8 (1.1)</td>
<td>0.8 (0.4)</td>
</tr>
<tr>
<td></td>
<td>right to left</td>
<td>1.9 (0.6)</td>
<td>1.3 (0.1)</td>
</tr>
<tr>
<td>FiO₂</td>
<td></td>
<td>0.55 (0.19)</td>
<td>0.47 (0.25)</td>
</tr>
<tr>
<td>Mean airway pressure, cm H₂O</td>
<td></td>
<td>11.8 (4.1)</td>
<td>10.3 (5.8)</td>
</tr>
<tr>
<td>O₂</td>
<td></td>
<td>10.6 (5.6)</td>
<td>7.9 (6.2)*</td>
</tr>
<tr>
<td>Mean BP, mm Hg</td>
<td></td>
<td>52.7 (4.3)</td>
<td>53.7 (11.5)</td>
</tr>
<tr>
<td>Systolic BP, mm Hg</td>
<td></td>
<td>72.6 (6.3)</td>
<td>75 (20.7)</td>
</tr>
<tr>
<td>Diastolic BP, mm Hg</td>
<td></td>
<td>42.8 (4.2)</td>
<td>43 (6.9)</td>
</tr>
</tbody>
</table>

Fig. 1. Early diastolic velocities (E') in the RV before and during milrinone therapy. Circles represent means, bars represent 95% CI. *p<0.05.

Fig. 2. Isovolumic contraction velocities (IVV) in the RV before and during milrinone therapy. Circles represent means, bars represent 95% CI.

Fig. 3. Systolic ejection velocities (S) in the RV before and during milrinone therapy. Circles represent means, bars represent 95% CI.
Informing ECMO strategy:

1. **Severe LV dysfunction** / hypotension
   - ECMO (VA?)
   - + time (< 1 week)
   - +/- cardiotropes
   - ?Wean off, then repair

2. **Pulmonary hypoplasia**, hypercarbia, ventilation failure
   - ? Is ECMO appropriate
   - ? Early repair on ECMO

3. **Pulmonary hypertension** / oxygenation failure / RV failure
   - ECMO (VV or VA?)
   - Optimize PVR
   - + time
   - ? Wean and repair off, consider repair on ECMO if no early improvement
Targeted therapy of PH and cardiac function in CDH

Regular assessment of cardiac function and pulmonary artery pressure

Targeted treatment of PAP/cardiac dysfunction

RV dysfunction / hypoxia
- 1st line pulmonary vasodilator (iNO)
- 2nd line pulmonary vasodilator (Hypoxia: IV sildenafil, RV dysfx: milrinone)
- 3rd line: consider prostacyclin / ECMO

LV dysfunction
- 1st line cardiotrope (milrinone)
- 2nd line cardiotrope (epinephrine + hydrocort)
- 3rd line: consider VA ECMO

Determine optimal timing of interventions:
- CDH repair
- ECMO
- Extubation

PGE₁ to maintain PDA: e.g. if RV dilatation / PAP ≥ systemic BP / constricting ductus arteriosus

CDH 2020 Houston
Improved pre-natal prognostication

Lung volume (LHR / MR TFLV)

LV hypoplasia

Postnatal Dysfunction

Pulmonary vasculature / PVR

IMPROVED PREDICTION OF SEVERITY AND OUTCOMES
Initiating resuscitation before umbilical cord clamping in infants with congenital diaphragmatic hernia: a pilot feasibility trial

<table>
<thead>
<tr>
<th></th>
<th>Trial participants (n=19)</th>
<th>Historical controls (n=19)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apgar score at 1 min, median (IQR)</td>
<td>5 (3–7)</td>
<td>7 (3–8)</td>
<td>0.51</td>
</tr>
<tr>
<td>Apgar score at 5 min, median (IQR)</td>
<td>8 (5–8)</td>
<td>8 (5–9)</td>
<td>0.72</td>
</tr>
<tr>
<td>First Haemoglobin, g/dl; mean (SD)</td>
<td>17.6 (1.3)</td>
<td>16.3 (1.9)</td>
<td>0.02</td>
</tr>
<tr>
<td>Mean blood pressure 1 hour after birth; mean (SD)</td>
<td>51.1 (8.5)</td>
<td>44.3 (6.3)</td>
<td>0.008</td>
</tr>
<tr>
<td>First blood gas after birth*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH, mean (SD)</td>
<td>7.02 (0.15)</td>
<td>7.03 (0.13)</td>
<td>0.74</td>
</tr>
<tr>
<td>CO₂, mean (SD)</td>
<td>90 (26)</td>
<td>88 (25)</td>
<td>0.82</td>
</tr>
<tr>
<td>Base deficit, mean (SD)</td>
<td>8.9 (3.3)</td>
<td>9.8 (3.8)</td>
<td>0.51</td>
</tr>
<tr>
<td>Oxygenation index with first blood gas, median (IQR)</td>
<td>17.5 (12.8–25.5)</td>
<td>16.3 (12.2–22.8)</td>
<td>0.74</td>
</tr>
<tr>
<td>Vasopressors (first 48 hours), n (%)</td>
<td>13 (68)</td>
<td>16 (84)</td>
<td>0.45</td>
</tr>
<tr>
<td>iNO (first 48 hours), n (%)</td>
<td>9 (47)</td>
<td>11 (58)</td>
<td>0.52</td>
</tr>
<tr>
<td>ECMO (first 7 days), n (%)</td>
<td>7 (37)</td>
<td>4 (21)</td>
<td>0.48</td>
</tr>
<tr>
<td>Mortality (first 7 days), n (%)</td>
<td>0</td>
<td>1 (5)</td>
<td>&gt;0.99</td>
</tr>
</tbody>
</table>
Staff and patients of the:
Royal Hospital for Children, Glasgow
Royal Children’s Hospital Melbourne

Claudia Massolo
Florian Moenkemeyer
Florian Kipfmueller
Lindsey Hunter
Carl Davis, Morag Liddell
Kevin Lally, Pam Lally, Matt Harting
CDH Study Group and Registry
CDH Euroconsortium
CDH UK

Thanks to

CDH 2020 Houston
Associated with outcomes:
- Duration ventilation
- Length of stay
- Survival
- ECMO
Day 1

4 chamber view

PDA flow

STE Strain

RV GLS - 12%
LV GLS -
%

Day 3

RV GLS - 12%
LV GLS - 20%

Day 5

RV GLS - 16%
LV GLS - 20%

Milrinone and epinephrine

IV sildenafil

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Cardiac function and timing of repair?

- 38/40. 3kg. L CDH. Day 1 of life
- Conventional ventilation: 22/5, FiO$_2$ 0.35. Sats 96/97%. BP 45/32 (36)
- Cardiac function improved spontaneously by day 3 of life
- Primary repair, day 3. Stage “A” defect
New therapies in CDH: Physiological based cord clamping?

Physiologically based cord clamping improves cardiopulmonary haemodynamics in lambs with a diaphragmatic hernia

Aidan J Kashyap,¹,² Ryan J Hodges,¹,³ Marta Thio,⁴,⁵ Karyn A Rodgers,¹,² Ben J Amberg,¹,² Erin V McGillick,¹,² Stuart B Hooper,²,⁶ Kelly J Crossley,¹,² Philip L J DeKoning⁶,⁷

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Segmental longitudinal strain in the RV and LV, in CDH and controls

- Basal FW
- Mid FW
- Apex FW
- Apex Sep
- Mid Sep
- Basal Sep

Strain (%)

- Basal FW
- Mid FW
- Apex FW
- Apex Sep
- Mid Sep
- Basal Sep

* p<0.05 RV CDH vs controls
† p<0.05 LV CDH vs controls

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Massolo et al, Neonatology 2019