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Mater Mothers’ Hospit

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8:30 - 9:25  WS #109: Neonatal Emergencies
9:35 - 10:30  WS #121: Neonatal Emergencies (Repeated)
I represent the Perinatal Society of Australia and New Zealand on the Australian Resuscitation Council

Thanks to the conference organisers for inviting me!
Objectives

• Awareness of some important contemporary principles of neonatal resuscitation
• Awareness of common presentations of neonatal emergencies after birth
• Awareness of range of causes
• Understand some important causes
Be prepared

Equipment

• Checklists, protocols, algorithms (www.resus.org.au, Q Health Guidelines)

• Consider standardized kits (e.g. for vascular access)

Training

• Good training resources, including simulation

• Reinforcement activities and drills (high frequency, short duration)

Teamwork

• Learn & practice together

• Role allocation

• Task and moral support
Effective ventilation is the key to successful neonatal resuscitation

AAP/AHA, ERC & ARC/NZRC 2010 Guidelines
Effective ventilation is the key to successful neonatal resuscitation

- No gas exchange from gasless lung
- Neonatal heart is resilient during hypoxia, acidosis
- Serious arrhythmias other than sinus bradycardia uncommon
- Good gas exchange usually leads to ROSC
Timing of cord clamping

Uncomplicated term birth
• delay clamping for minimum of 1 min or until cessation of cord pulsation
  – improved iron status through infancy, increased likelihood of jaundice requiring phototherapy (McDonald, Cochrane Database 2008)

Uncomplicated preterm > 30 weeks
• delay clamping 30 sec - 3 min
  – increases BP during stabilisation, reduces risk of IVH & need for blood transfusion (Rabe et al, Neonatology 2008)

Preterm < 30 weeks
• delay clamping 1 min
  – reduces all-cause mortality and reduces need for red cell transfusion (Fogarty et al 2018)
Timing of cord clamping in compromised infants?

Severely compromised infant

- optimal timing unknown & resuscitation measures may need to take priority
Initial assessment and steps

Term gestation? Breathing or crying? Good tone?

Yes
Stay with mother

No
Prevent heat loss
Ensure open airway
Stimulate

Routine care:
Prevent heat loss
Ongoing evaluation
Temperature management

• For <28 week babies
  - Ambient temp of at least 26°C
  - Polyethylene bag or wrap, without drying or unwrapping
  - Avoid drafts

• For well babies
  - Dry
  - Skin to skin with mother
  - Avoid drafts

• For all babies
  - Prevention of hyperthermia

• For 35+ weeks, at risk for HIE
  - Early consideration of induced hypothermia (see Queensland Guidelines)
Assessment of oxygenation – eyeball vs oximetry

“The mean $\text{Spo}_2$ when infants were perceived to be pink by all 27 observers was 69%, ranging from 10% to 100% between observers. The median $\text{Spo}_2$ for individual babies varied from 42% to 93%”
Airway Management

- Normal newborn infants do not require suctioning of the nose, mouth or pharynx after birth.

- Suctioning can delay the normal rise in oxygenation.

- Suction recommended only
  - when babies show obvious signs of obstruction
  - to visualise the vocal cords during intubation

- Positioning is critical
Airway Management – Thick Meconium

ILCOR 2010

• No evidence for oropharyngeal suction after delivery of head
• Airway suctioning of vigorous babies discouraged – more likely to cause harm

ILCOR 2019

• Non-vigorous babies – no evidence of benefit
Initiating ventilation;

- Can be accomplished with a variety of devices and interfaces, but they are not all created equal!
- Aim is initially to establish functional residual capacity (FRC)
- Optimal strategy - not established
- Studies suggest sustained initial breaths and PEEP helpful
Ventilation

The diagram illustrates the relationship between TLC (Total Lung Capacity), volume, pressure, and FRC (Functional Residual Capacity). It shows three conditions:

- **Normal FRC**:
  - Path A represents normal FRC.

- **High FRC (overexpansion)**:
  - Path C represents high FRC, indicating overexpansion.

- **Low FRC (atelectasis)**:
  - Path B represents low FRC, indicating atelectasis.
Ventilation

• Pressures adjusted according to response

For most infants, ventilation can be accomplished with progressively lower pressures and rates as resuscitation proceeds
The use of oxygen in newborn resuscitation will be remembered as one of the most dangerous therapies inflicted on newborns.
Recommendations for oxygen

**Term babies** commence resuscitation in room air

**Preterm** commence in room air or blended air & O2 (30-50%)

*In all cases, the first priority is to ensure adequate inflation of the lungs, followed by increasing the concentration of inspired oxygen only if needed*

Adjust oxygen using pulse oximetry to meet targeted saturations
Oxygen Saturation targets - term infant

**Figure 2**
Third, 10th, 25th, 50th, 75th, 90th, and 97th SpO₂ percentiles for term infants at ≥37 weeks of gestation with no medical intervention after birth.

*Source:* Dawson et al., Paediatrics 2010
Newborn Life Support

At all stages ask: do you need help?

1. Term gestation? Breathing or crying? Good tone?
   - Yes: Stay with mother
   - No: Prevent heat loss Ensure open airway Stimulate

2. HR below 100? Gasping or apnoea?
   - Yes: Positive pressure ventilation SpO2 monitoring
   - No: Laboured breathing or persistent cyanosis?

3. HR below 100?
   - Yes: Ensure open airway Reduce leaks Consider increasing pressure & oxygen
   - No: Post-resuscitation care

4. HR below 60?
   - Yes: Chest compressions 90/min 3 compressions to each breath 100% oxygen Consider intubation or LMA
   - No: Venous access, adrenaline Consider volume expansion

Guidelines revision 2016
Emergencies in newborns after birth

Numerous conditions

Limited range of presentations

Potential common outcome

Baby in extremis

Metabolic

Jaundice

Respiratory

Respiratory distress

GI

Vomiting/abdo distension

Seizures

Temp instability

Poor perfusion/collapse

Poor feeding
Baby Emma

• Uncomplicated pregnancy
• Normal morphology scan 18/40
• Spontaneous vaginal delivery at 38/40
• Apgars $8^1 9^5$
• BW 3540 gms
Presentation - Day 3

- Demand breastfeeding
- Breathing fast

On exam
- Soft systolic murmur
- Oxygen saturations 90-91%
Differential diagnosis?

- Respiratory
- Sepsis
- Inborn error of metabolism
- Cardiac lesions
- Trauma
Baby Emma - Admission

- Active and alert
- Pink, capillary refill <3 secs
- Respiratory Rate 66-75 bpm
- SaO₂ 90%
- Upper arm hypertension
- Reduced femoral pulses
Coarctation of the aorta

Assessment – immediate, appropriate referral
Prostaglandin infusion
Respiratory, inotropic support if needed
Correction of acid–base and electrolyte disturbances

Congenital Heart Disease

4-8/1000 live born babies have congenital heart disease (not including bicuspid aortic valve, MVP, PDA in prems)

Examples:

- VSD 1:280
- TOF 1:2375
- TGA 1:3175
- AS 1:5000
- Truncus 1:9346
- Ebsteins 1:20000
- ASD 1:1062
- Coarct 1:2700
- HLHS 1:3759
- TAPVR 1:10 638
- PA 1:10 000

Source: March of Dimes
Coarctation
Cardiac conditions

Cyanotic – “Terrible T’s”
- Tetralogy of Fallot
- Tricuspid Atresia
- Transposition Great Arteries
- TAPVR
- Truncus Arteriosus

Acyanotic – LV outflow tract obstruction
- HLHS
- Interrupted aortic arch
- Severe coarctation of the aorta
- Critical aortic stenosis

Acyanotic – CCF
- Left-to-right shunts
  - VSD/AVSD
  - PDA
- Tachycardia
  - SVT (HR>220)
  - thyrotoxicosis
Cardiac conditions

Many don't present with a “significant” murmur, (but loud murmur, thrill, hyperdynamic praecordium are suggestive)

Right arm/lower limb BP helpful (lower BP in legs if coarctation or interrupted aortic arch)

Pre- and post-ductal saturations helpful

• higher in the legs => TGA

• Higher in the right arm => persistent pulmonary hypertension

100% oxygen test can be helpful
Baby Jai

Mother had mild PIH, so induced at K38, Vacuum assisted delivery
ROM interval 11hrs
Apgars 6\(^1\), 8\(^5\) (PPV via mask)
Normal male, weight 2900g
Baby Jai

36 hrs age - jaundiced.
• Attributed to cephalohaematoma

48hrs age temp 38.2°C
• Attributed to environmental cause (blanket, cuddles with mum)
Baby Jai

60 hrs age:
• Baby more jaundiced
• Now feeding poorly and “lethargic”

Temp 38.9°C

5 hours later, commenced antibiotics (no culture)
Baby Jai – readmitted

Very jaundiced
Lethargic, poor suck
Tachycardic (215/min)
Respiratory distress
Neurologically abnormal:
  • Irritable, high-pitched cry
  • Hypertonic (fists clenched, limbs extensor)
  • Episodic vertical nystagmus
  • Poor Moro
Differential Diagnosis

Respiratory
Sepsis (bacterial or viral)
Inborn error of metabolism
Bilirubin encephalopathy
Cardiac lesions
Trauma
Baby Jai

Septic shock
  o Profound hypotension
  o Multiple organ failure
  o DIC
  o Severe neutropenia & thrombocytopenia

Developed severe cerebral oedema and brain death within next 36hrs

Post-mortem CSF culture: E coli
Chorioamnionitis

PTL, Intact membranes

PPROM

DiGiulio Semin Fetal Neonatal Med 2012
Symptomatic chorioamnionitis & early onset neonatal infection

Group B Strep
Gram negative enteric organisms

- E. coli
- Haemophilus
- Klebsiella
- Enterobacter
Group B Strep

- Carried by 10-30% women
- Vaginal colonization may be transient, intermittent or chronic
- 40-70% of infants of colonised women acquire organism
- Without an antibiotic prophylaxis strategy, 1-2% of infants of colonised mothers will become infected (1-6 per 1000 babies)
- Higher risk of infection in preterm, but > half of cases occur in term babies
Maternal risk factors for EOGBSD

- Preterm birth (<37 weeks)
- ROM > 18 hours
- Maternal temp > 38°C
- Positive maternal GBS culture
- GBS bacteruria
- Previous infant with GBS
Presentation with prelabour rupture of the membranes (PROM) or labour

GESTATION?

≥37 WKS

Term PROM?

YES

NO

Term PROM?

YES

NO

Preterm PROM?

YES

NO

Vaginal culture and 10 day course of Erythromycin

LABOUR <37wks

NO

LABOUR

RISK FACTORS PRESENT?

• Membranes ruptured ≥18hrs prior to delivery
• GBS colonisation this pregnancy
• GBS bacterium: this pregnancy
• Previous infant with EC LoisD

RISK FACTOR PRESENT?

• Maternal temperature ≥38°C

YES

YES

NO

DELIVERY: Follow guideline for prevention and management of neonatal early onset sepsis

POSTPARTUM: Notify paediatric staff of maternal pyrexia within 24 hours of birth.

INTRAPARTUM ANTIBIOTICS

PROPHYLAXIS

COMMENCE

When delivery is anticipated, aim for at least one dose 4 hours pre delivery

LOAD

Penicillin 1.2g, IV

MAINTENANCE

Penicillin 0.5g, IV q4-6h until delivery

SUSPECTED PENICILLIN ALLERGY

Clindamycin 900mgs, IV q8h until delivery

TREATMENT ANTIBIOTICS (SUSPECTED CHORIOAMNIONITIS)

Follow appropriate treatment regimen

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### 4.2 Flowsheet for Neonatal Management

**ALL NEWBORN ARE AT RISK OF INFECTION**
irrespective of maternal risk factors and intrapartum chemoprophylaxis. Therefore this flowchart applies to ALL neonates

**Signs of infection, especially RESPIRATORY DISTRESS**
- Suspected chorioamnionitis (e.g. maternal temp ≥38deg) or previous EOB/GSD infant
- Other risk factors
- No risk factors

**Minimum investigations -**
- FBC
- Blood culture
- Commence antibiotics (within 30mins of decision)
- Other investigations -
  - LP if positive BC or clinical signs (if feasible)
  - Gastric aspirate, skin swabs if clinician preference

**MATERNAL RISK FACTORS FOR NEONATAL INFECTION**
- ROM ≥ 18 hours
- Intrapartum or immediate post-partum fever ≥ 38°C
- GBS colonisation this pregnancy
- GBS bacteriuria this pregnancy
- Previous infant with EOB/GSD
- Preterm labour and birth at <37 weeks

**No signs of infection**
- Inadequate intrapartum antibiotics
- Adequate intrapartum antibiotics
- Routine care

**Gestational age <37w**
- FBC & Observe for 48 hours
- Abnormal FBC or symptomatic infant
  - Blood culture and commence antibiotic treatment

**Gestational age ≥37w**
- Discharge after 24hrs if normal discharge criteria met and parents can comply with instructions for home observation of signs of infection.
- Observe for at least 48hrs in hospital if criteria for discharge cannot be met (IDC 2021)

**Signs of infection include:**
- Unexpected need for resuscitation, respiratory distress, (oxygen requirement, grunting or chest recession), temperature instability, poor peripheral perfusion, apnoeic episodes, lethargy, seizures, poor feeding, abdominal distension, hypoglycaemia, hypotension, metabolic acidosis.
Queensland EOGBSD cases

- 60% had no maternal risk factors for EOGBSD
- Where there were risk factors, low compliance (6%) with guidelines for intrapartum antibiotics given for preterm birth
- Overall low compliance (10%) for all maternal and neonatal risk factors
Herpes
Herpes

Incubation period is 5-21 days, so most infants are healthy at first and present at few days to weeks of age

Insidious onset, often subtle at first

In 85% cases the mother has no knowledge of having genital herpes

Most babies do not have vesicles / bullae at presentation (up to 40% never do)

HIGH INDEX OF SUSPICION
Herpes

3 Presentations:

• Disseminated 25% - present in 1\textsuperscript{st} week (>day3).
  o Clues:
    o Respiratory distress - pneumonitis
    o Hepatitis, DIC, thrombocytopenia
    o Lethargy

• CNS -35% – present 1\frac{1}{2}-3 weeks of age
  o Clues:
    o Seizures, irritability, reduced responsiveness
    o Apnoea, bradycardia

• Localised – 40% – present day 5/6
  o SEM (skin, eyes, mouth) – vesicles / chorioretinitis
  o 70% cases will progress if untreated
Baby Isaac

- 3820 g, 41 weeks
- Home on day 4, fully breastfed
- Readmitted day 7, jaundiced, lethargic, history of poor feeding at breast, blood glucose 1.9 mmol/L

- Bilirubin 381 nmol/L,
- Liver function tests normal
- Normal blood group and haematology

- Provisional diagnosis: breast feeding jaundice
Baby Isaac

Adequate response to phototherapy, complementary feeds and lactation support

When glucose 1.9 mmol/L

Cortisol  208  (normal >200 nmol/L when hypoglycaemic)

Growth hormone 11  (normal >20 mU/L when hypoglycaemic)

TSH   1.4 (low)

free T4  8.4 (low)

T3  3.8 (low)
Baby Isaac

Seen in endocrine clinic after discharge
Low T4 and TSH confirmed,
Synacthen test (for adrenal function) : normal response
Bilirubin had risen again to 300 nmol/L

Diagnosis: Hypopituitarism
Treatment: cortisol and thyroxine. (Bilirubin → 33)

Outcome - Normal
Why is jaundice important?
Jaundice

Coombs positive – Rh or other isoimmunisation

Coombs negative, unconjugated:
• ABO incompatibility
• Breastfeeding
• Sepsis
• Inborn errors of metabolism
• Hypopituitarism
• G6PD deficiency
• Hereditary spherocytosis
• Crigler-Najjar

High conjugated = hepatitis
• Idiopathic neonatal hepatitis
• TORCH
• Biliary atresia
• α1-antitrypsin deficiency
Kernicterus

Bilirubin encephalopathy. Affects basal ganglia
• Lethargy
• Rigidity
• Opithotonus
• High-pitched cry
• Fever
• Convulsions

50% mortality
Survivors have choreo-athetoid cerebral palsy, intellectual disability, high freq sensorineural deafness
Bilirubin Production

Catabolism of senescent or damaged RBC

- Ineffective Erythropoiesis
- Other haeme proteins

75% haeme

Heme Oxygenase

Biliverdin Reductase

95% biliverdin

Bilirubin

Overwhelm albumin binding blood brain barrier

Kernicterus

- Very high bilirubin
- Some drugs
- Low serum albumin
- Asphyxia
- Acidosis
- Infection
- Prematurity

+ albumin
Jaundice

SBR level >72hrs of age, healthy term infant:
• 340 μmol/l → phototherapy
• 425 μmol/l → exchange transfusion

Unwell infant or haemolysis:
• 240 μmol/l → phototherapy
• 340 μmol/l → exchange transfusion

Fig. 2. Risk designation of term and near-term well newborns based on their hour-specific serum bilirubin values. The high-risk zone is designated by the 99th percentile track. The intermediate-risk zone is subdivided to upper and lower-risk zones by the 90th percentile track. The low-risk zone has been electively and statistically defined by the 40th percentile track. (Dotted extensions are based on <300 TSB values/epoch).
Baby William

- 3020 gram normal delivery at term
- Parents noted twitching movements arm early on day 2
- Clonic seizure observed by midwife late on day 2
- Admitted - blood glucose of 0.1 mmol/L
- Hypoglycaemia responded to repeated boluses of 10% dextrose, then glucose infusion up to 14 mg/kg/min, then glucagon infusion
- Only 2 more clinical seizures, but EEG monitoring showed status epilepticus for 12 hours, eventually controlled with 3 anticonvulsants
Baby William

When glucose low
• **Cortisol 844** (normal >200 nmol/L when hypoglycaemia)
• **Growth hormone 27** (normal >20 mU/L when hypoglycaemic)
• **Insulin level 14 mIU/L** (should be undetectable)

Diagnosis; persistent hyperinsulinaemic hypoglycaemia (likely due to genetic mutation)
T2 MRI images in second week

Bilateral hyper-intense areas in both occipital lobes and parietal lobes.
Eventually stabilised and discharged on oral diazoxide.
Genetic tests confirmed persistent hyperinsulinaemic disorder
Prognosis – uncertain but global developmental delay, epilepsy and cerebral palsy are all possible
When to be suspicious for inborn errors of metabolism

Acute illness following a period of normalcy
Lethargy and coma
Hypotonia, seizures (especially if hard to control), intractable hiccups
Apnea or respiratory distress
Sepsis, particularly with E. coli
Unusual odor
Jaundice
Vomiting
Poor cardiac output
Dysmorphic features
Organomegaly
Positive family history or parental consanguinity

= *always* be suspicious for inborn errors of metabolism!
“Intoxication” disorders

Amino acidopathies
- MSUD, tyrosinaemia type I

Most organic acidaemias
- methyl malonic, propionic, isovaleric acidaemias

Urea cycle defects

Sugar intolerances
- Hereditary fructose intolerance

- Presentation
  - symptom free interval
  - vomiting, lethargy, coma, liver failure
  - relentless deterioration
  - poor response to symptomatic therapy

- Diagnosis
  - plasma and urine analysis

- Many are treatable
Disorders of energy metabolism

Tend to involve liver, myocardium, muscle or brain

Predominant hypoglycaemia
- glycogenosis, gluconeogenesis disorders
- hyperinsulinism
- FAO disorders

Lactic acidaemias
- pyruvate carboxylase & dehydrogenase disorders
- Krebs cycle & respiratory chain disorders

• Presentation
  - hypoglycaemia (can be severe)
  - high lactate
  - severe hypotonia
  - myopathy
  - cardiomyopathy, arrhythmias etc.
  - SUDI
Disorders of complex molecules

- Lysosomal disorders
- Peroxisomal disorders
- Disorders of intracellular trafficking & processing (e.g. α-1-antitrypsin deficiency, CDG syndrome)
- Inborn errors of cholesterol synthesis

- Presentation
  - permanent, progressive course
  - unrelated to food intake
- Almost none are amenable to emergency treatment
Principles

Many disorders, limited repertoire of clinical signs
Finding underlying cause can be as important than symptomatic management
Queensland neonatal guidelines a good source of information

- Resuscitation
- Hypoglycaemia
- Hypoxic ischaemic encephalopathy
- Neonatal Abstinence
- Respiratory Distress
- Seizures
- Stabilisation for retrieval
- Group B Strep
Any attempt at resuscitation is better than no attempt.