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A practical approach to anaesthesia for abdominal wall defects in neonates

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Ventral Body Wall defects in neonates are either major defects such as gastroschisis and omphalocoele, bladder exstrophy, cloacal exstrophy, or minor (hernias). For the purposes of this exercise the latter will be excluded, although the principles of neonatal anaesthesia obviously apply to this group as well.

It is important to appreciate that these are often NOT isolated defects and the patient should be evaluated properly for co-existing conditions and syndromes.

Origin of Abdominal Wall Defects

The midgut herniates through the umbilical ring at around the 6th week of foetal development due to the rapid enlargement of the liver and growth of the gut itself. At around 10 weeks of gestation the abdominal cavity has enlarged sufficiently to accommodate the midgut and it reduces into the abdominal cavity. In omphalocoele, this return to the abdomen does not occur and the gut is located within the umbilical ring.

Gastroschisis has a different aetiology and is thought to be primarily related to an abnormality of fusion of the abdominal wall or a weakness in the wall itself which allows the bowel to prolapse into the amniotic fluid cavity. Risk factors for gastroschisis include smoking, recreational drug use, young maternal age, poor socio-economic status and toxins like benzene.[1] Whereas omphalocoele is typically midline, gastroschisis defects are almost universally NOT midline defects and most commonly occur to the right of the midline. Up to 60% are premature and there is a high association with other congenital defects including chromosomal abnormalities, other syndromes including Beckwith Weidemann, Goltz, CHARGE and other non-syndromic multiple congenital abnormalities.[2]

Surgical management

These children should ideally be diagnosed prenatally and, since the uterus provides the best and most economical transport unit, should be delivered in a centre where there is sufficient expertise (i.e. in the presence of a paediatric surgical centre).[1] Initially neonates with gastroschisis were treated as surgical emergencies. Currently the surgical options for gastroschisis include primary closure or delayed closure (using a preformed silo sutured or attached to the defect). However, there are some scenarios where emergency surgery is required – presence of volvulus, infection or other neonatal compromise, and the use of the "silo" should be viewed as a temporising measure until the child is adequately resuscitated and prepared for theatre. This is particularly true in the (sadly common) scenario of undiagnosed gastroschisis born at a peripheral unit.

Surgery for correction of omphalocoele is less urgent in that the bowel is "covered" and the risk of infection and dehydration is lower. Having said this, however, most patients will be presented for surgery within the first days of life. They present significant challenges to the paediatric anaesthesiologist. The more challenging condition is gastroschisis and this will be concentrated on.

Anaesthetic approach

The majority of the considerations relate to neonatal anaesthesia as a whole, with a few specifics along the way.

- Pre-op assessment and preparation
  - Detailed history – pregnancy, delivery weight, APGAR scores, gestational age, family history of anaesthetic issues.
  - Airway – tube size, depth, difficulty in tube placement if already intubated. External anatomy of airway – looking for associated congenital conditions which may complicate airway management.
  - Respiratory status – nature of ventilator support, oxygenation – is the ventilatory support mode compatible with transport to theatre?
  - Cardiovascular – neonates with gastroschisis may be significantly fluid depleted and/or septic and careful evaluation of the cardiovascular state is critically important. Beware of associated congenital cardiac lesions – full echo evaluation may be difficult to have done prior to surgery. Attempt to evaluate the circulatory status looking at core-peripheral temperature gradients, acid base status, and capillary refill time. Consideration

should be given to initiating inotropes if needed *prior* to transport[3] as this will decrease workload later on. Venous access should be checked and confirmed.

- Investigations – hb, blood gas, cross match all are useful. CXR, Echo are nice to have but should not unnecessarily delay surgery.

- Transport to theatre
  - Probably the most hazardous time – careful consideration should be given to doing procedure in the NICU if the child is on advanced ventilatory modes, although this may not be the easiest environment for either the surgeon or the anaesthesiologist.
  - Appropriate monitoring must be maintained throughout transport.
  - Be aware that significant heat loss can occur during the transportation period and fanatical attention to detail is required to protect the neonate from hypothermia.
- Induction
  - Rapid sequence vs gas induction remains controversial – if there is an NG tube in situ suction it out (even if it is on free drainage).
  - Satisfactory pre-oxygenation can be achieved within 60 seconds[4] but despite adequate pre-oxygenation beware of rapid desaturation due to high basal metabolic rate and reduced FRC.
  - Beware of decompensation on induction – for this reason it may be prudent to do gas induction with sevoflurane although beware that prolonged high sevoflurane doses may also lead to cardiovascular decompensation.[3]
  - Intubation can be achieved with muscle relaxants or topicalisation of the airway with lignocaine.[5]
  - Despite increased sensitivity of neonates to NDMRs, their Vd is greater and as such dosing per kilogram is similar to adults.[3]
- General Principles
  - Avoidance of hypothermia
    - The anaesthetised neonate is at high risk of hypothermia. Add to this the significant surgical exposure and the likelihood of preoperative hypothermia in the gastroschisis scenario and temperature protection becomes a significant issue.
    - Ideally the surgery is performed on the warming bassinet but this is not always practical.
    - Underbody forced air warmers combined with adequate "waterproofing" of the neonate using plastic sheeting provides good hypothermia protection (beware HYPERthermia resulting from overenthusiastic application of warming – the use of a temperature probe is mandatory).
    - Warm fluids (both intravenous and surgical irrigation.)
  - Ventilation
    - Sadly, anaesthesia ventilators do not generally offer the options for ventilatory support that a good ICU ventilator will.
    - However, with attention to detail and careful ventilator setting, the goals of "non-injurious" ventilation can be achieved. Lung-protective ventilation can be achieved in neonates.[6]
    - Aim to minimise dead space as much as possible using appropriately sized connectors, HMEs, tubing.
    - In terms of ventilator mode, the default for most paediatric anaesthetists has been pressure-controlled ventilation to account for circuit compliance issues and leaks around un-cuffed ET tubes. A better option (if available) is one of the combined PCV/VCV modes, e.g. Pressure Controlled Volume Guaranteed Ventilation(PCV-VG; GE; Madison, WI) or Autoflow (Draeger Medical, Lübeck, Germany) which allow delivery of a square pressure waveform like PCV but ensure adequate volume delivery (like VCV).[6]
    - For gastroschisis and other "viscera relocation" procedures, there may be significant compliance changes as the bowel is replaced into the abdomen and closure is attempted. It is critical to assess oxygenation, tidal volume and $ETCO_2$ both prior to and following abdominal closure to assess the effects of decreased compliance. It may be necessary to stage closure if adequate ventilation is no longer possible at safe parameters.
    - Beware too of hyperventilation especially in the context of low perfusion pressures as this may negatively affect cerebral perfusion.
  - Cardiovascular
    - There is often significant fluid deficit (especially in the scenario of emergent gastroschisis repair).
    - This can be exacerbated by sepsis and circulatory effects of releasing a twisted segment of bowel.
    - Effective BP measurement is critical and BP cuff site and size must be chosen appropriately. Some neonates may require placement of arterial catheters.
    - Blood pressure targets remain controversial. Some units aim for a systolic BP equal to or greater than the gestational age in weeks – although it should be appreciated that organ perfusion is the goal and that BP and organ perfusion are not synonymous.[7]
    - Typical values for term neonates are ± 62 mmHg at birth and ± 72 mmHg at 7 days while those for premature babies rise rapidly after birth to the extent that it would appear that BP seems related to the duration of extra-uterine life.
    - There is no consensus on what constitutes neonatal hypotension – some would see an SBP of 45–50 mmHg or 20–30% decrease as being low.[7]
    - Moderate hypotension is common and is usually well tolerated, but below a certain level there will be a reduction in cerebral blood flow. MAP for the lower limit of the auto-regulatory range in term neonates is thought to be about 28–30 mmHg.[8]

- The role of NIRS (cerebral or somatic) is unclear at the moment.
- Options available to elevate BP are limited to fluids and inotropes and while fluid loss is often underappreciated there are dangers in fluid loading the neonatal myocardium. Inotropes used carelessly will damage the myocardium.
- Fluid management requires constant vigilance of blood loss, educated estimation of insensible losses from the significant surgical exposure (8–10 ml/kg/h being the usual figures quoted for laparotomy) – should be replaced with Ringer's Lactate.[3]
- There is little consensus on triggers for transfusion in the neonate, but note that underestimation of blood loss is common. 10% blood loss is thought to be a reasonable level to accept prior to transfusion.[9]

- Analgesic Strategies
  - Regional anaesthesia using caudal techniques is appropriate provided sepsis is not present and haemodynamic status allows.[3]
  - Aim to minimise intraoperative opiate use as neonatal enzyme systems are not yet mature.
  - The majority of these will be ventilated postoperatively which allows some leeway in analgesic strategies
    - Morphine infusion (ventilated only) – guideline is about 40 mcg/kg/h
    - Morphine boluses of 0.05–0.1 mg/kg 2 hourly (less ideal)
    - Paracetamol
      - 32–36/40 7.5 mg/kg/dose q8h max 25 kg/d
      - Term 10 mg/kg 4–6 hours max 30 kg/d

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