British Association of Perinatal Medicine

"During Lillie's birth, the doctors explained that they would be doing a delayed cord clamping but while doing this they would make her warm, safe and care for her during that time. They made sure I knew what was happening and I wasn't worried at all during that minute and Lillie was very happy! And I knew this would help with saving her life."

Amie, parent to Lillie, born at 28 weeks gestation.

Optimal Cord Management in Preterm Babies

A Quality Improvement Toolkit

Aims, Evidence, Rationale and Best Practice

December 2020

in collaboration with

NNAP
National Neonatal Audit Programme

Optimal Cord Management: Toolkit Aim

Optimal Cord Management (OCM) is one of the key evidence-based peripartum interventions of the Perinatal Optimisation Care Pathway. This Toolkit focuses on providing support and resources to facilitate quality improvement (QI) around Optimal Cord Management. It contains evidence, best practice solutions, advice and techniques that support quality improvement in Optimal Cord Management for all babies who are likely to benefit from this key perinatal intervention. However, the central focus of this toolkit is supporting teams to overcome the unique challenges in delivering Optimal Cord Management in babies born less than 34 weeks gestation.

The aim of the toolkit is that:

All babies born <34 weeks gestation should have their umbilical cord clamped at least 60 seconds or more after birth, except when there are specific documented maternal or fetal conditions (see page 8) to justify earlier clamping.

This toolkit aims to provide practical suggestions to support multidisciplinary perinatal teams in improving compliance with the above aim to improve outcomes for preterm babies.

The toolkit group describe four core strategies to support the delivery of Optimal Cord Management:

1. Human factors and multidisciplinary perinatal team working
2. Provision of normothermia care
3. Supporting the onset of spontaneous breathing and lung inflation
4. Parent information and involvement

Rationale

- **Optimal Cord Management reduces death in preterm babies by nearly a third**
- **The number of babies needing to receive OCM to prevent a death is around 30-50 overall and may be as low as 20 in the least mature babies**

Optimal Cord Management is an evidence-based, simple and effective non-intervention for improving newborn outcomes. Preterm babies particularly benefit from this enhanced placental transfusion and physiological transition[12 13]. Meta-analyses of studies comparing Optimal Cord Management versus unindicated immediate clamping show a 28% risk reduction for mortality in preterm babies ≤32 weeks gestation with a number needed to benefit of 33 (95% CI 25 to 100, p=0.005)[12 13]. In infants of 28 weeks gestation or less, the number needed to benefit reduces to 20[12].

In addition Optimal Cord Management confers other benefits to the preterm infant such as reducing the need for blood transfusion by around 10% [12-14] and improving mean blood pressure with a reduction in the need for inotropes[13 14].

Based on this evidence, the World Health Organisation (WHO) recommends waiting 60 seconds before clamping the cord in preterm babies and clearly states that immediate umbilical cord clamping is generally contraindicated[15].

Despite clear evidence of harm, available figures suggest continuing use of the unindicated intervention of early clamping. For example, the Canadian Neonatal Network in 2018 reported only 51% of infants born at less than 29 weeks gestation received at least 30 seconds of placental transfusion before the cord was clamped[16]. Furthermore, from 2020 the NNAP will report on rates of cord clamping at or after 1 minute for infants < 32 weeks[1]. Current data from quarter 3 2020, suggests a national rate of 34.6% so there is likely to be significant scope for improvement. Therefore there is an increasing need for perinatal teams to improve access to Optimal Cord Management so that all preterm babies can benefit.

This imperative has led to Optimal Cord Management being adopted as a key focus in perinatal improvement programmes including MatNeoSIP, the MCQIC-SPSP and the PERIPrem Care Bundle of the West of England AHSN[2 3 7].

This QI toolkit focusses on Optimal Cord Management defined by waiting for a minimum of 60 seconds before clamping the cord and provides users with a framework to understand the local context for QI, to understand enablers and barriers to implementation and to facilitate the embedding of Optimal Cord Management into perinatal team culture in order to achieve the aim of less babies being harmed by immediate cord clamping. Other methods of cord management have been studied and will be explained below.

A summary of the evidence and key drivers for Optimal Cord Management is provided in Appendix 3.

Contraindications to optimal cord management:

There are almost no indications for early cord clamping, nor contraindications to Optimal Cord Management.

- The need for maternal resuscitation in the face of massive, acute haemorrhage would be a rare, justifiable reason to proceed with early clamping of the cord.
- A ruptured vasa praevia, snapped cord or other trauma to the cord vessels which will result in haemorrhage from the baby are also reasons for early cord clamping.

Special Circumstances:

Complete placental abruption:

Where the placenta is delivered at the same time as the baby, it could be held above the baby, with gentle application of pressure to the placenta, and then clamped at 60 seconds before the placenta is lowered. Umbilical cord milking could also be considered in this situation.

Short Cord length

A short cord length might interfere with the management of the mother or baby but can usually be addressed with optimal positioning. It should not be considered as an automatic indication for early cord clamping, nor a contraindication to Optimal Cord Management.

Umbilical cord milking

Although it is not physiological, milking the umbilical cord 2-4 times towards the baby has been studied as an alternative to waiting for at least 60 seconds before clamping the cord[17-19]. Meta-analyses of studies using cord milking show similar benefits to waiting for 60 seconds, with increased survival by 27% compared to immediate clamping of the cord with no difference in major morbidities[13 14]. Based on this evidence, many key perinatal organisations recommend the use of cord milking before clamping the cord but only if Optimal Cord Management is deemed not feasible[20-23]. **However in reality there are very few situations in which a minute of waiting cannot be achieved.**

Additionally, concerns regarding the safety of cord milking have been raised following the results of one randomised controlled trial which showed an increased incidence of IVH associated with cord milking in babies less than 28 weeks gestation[24]. An association with severe IVH has also been shown in a large retrospective Canadian cohort of infants less than 33 weeks[25]. Moreover, physiological studies in newborn lambs undergoing cord milking suggest significant pressure and flow alterations in the main cerebral artery which may explain this increased risk[26]. A recently published meta-analysis concluded that umbilical cord milking significantly increased the risk of severe IVH compared to optimal cord management[27]. However, uncertainty regarding the association of severe IVH and umbilical cord milking persist due to difficulties in interpretation of this data.

Cord milking is often undertaken when there is a perceived acute concern that maternal or baby safety may be compromised by a delay of 60 seconds. In practice, the majority of these concerns are unsubstantiated by published evidence. For this reason, this toolkit group strongly recommends that units work to overcome barriers to Optimal Cord Management so that this intervention can be delivered as a standard of care for all babies. **We recommend that units should only reserve umbilical cord milking for those rare situations such as maternal collapse requiring resuscitation where cord clamping is required to be expedited for maternal safety. In these cases, the reason must be documented.**

Multiple gestations

Studies of multiple births have demonstrated feasibility of providing Optimal Cord Management to twins and triplets[28-30]. Thus, multiple births should not be routinely excluded from Optimal Cord Management. The plan for delivery should be considered on an individual basis with a decision made by an experienced perinatal team ahead of birth.

Prolonged stabilisation during fetal to neonatal transition

Studies examining initial stabilisation during Optimal Cord Management have included widely varying methodologies and no firm conclusion can yet be made at this time regarding safety or benefit[13 14]. Over 90% of preterm babies will start to breathe during Optimal Cord Management with or without gentle stimulation[31 32]. However, some units now undertake initial stabilisation with the cord intact routinely (mother-baby dyad intact) and have reported favourably on feasibility and safety[18 19]. Where concerns about neonatal wellbeing during Optimal Cord Management cannot be addressed by comprehensive staff education and support at the time of birth, units may wish to explore providing stabilisation with the cord intact by liaising with other teams who already have standard operating procedures and data to support implementation and safety.

Parents

Qualitative studies using interviews with parents have reported overall positive feedback and support for Optimal Cord Management[33]. Mothers report that they felt they could contribute to their preterm baby's care when they received Optimal Cord Management[34]. Parents who are present during stabilisation with the cord intact report that they feel reassured by the procedure and that communication is improved[35].

How to use this toolkit

This toolkit is not intended to be read as a guideline which mandates a standard practice for all units. Instead it is a practical resource from which units can improve compliance rates of Optimal Cord Management, by selecting the most suitable approach for their own particular context as the improvement solution for each unit may be different. For example, the equipment available in each unit may vary and therefore the use of this toolkit needs to be adapted according to the local setting.

Some units may have already implemented various ways of providing Optimal Cord Management which will have helped to improve preterm outcomes. Those teams are encouraged to continue to develop their pathways and offer support and advice to other teams. Networks may also be able to facilitate the sharing of good practice and implementation of consistent practices.

Optimal Cord Management: Implementation Evidence and Resources

Implementation evidence

Table 1 provides evidence of the elements of successful implementation of Optimal Cord Management in preterm babies including identified enablers and barriers and lists other resources to support implementation. In addition two systematic reviews provide an overview of published quality improvement initiatives related to Optimal Cord Management from around the world[36 37].

Table 1. Elements used in successful implementation of Optimal Cord Management	Supporting reference(s) hyperlinked
Improving staff awareness of Optimal Cord Management including targeted education, constructive feedback sessions and simulation	38-49
Decreasing resistance to change in Optimal Cord Management	40 49
Addressing obstetric concerns with Optimal Cord Management	32 42 49-51
Addressing paediatric concerns with Optimal Cord Management	42 47 49-53
Addressing logistical difficulties in Optimal Cord Management	38 47 49 53
Delivery room checklists, brief and debrief tools for Optimal Cord Management	40 49 53 54
Multidisciplinary collaboration around Optimal Cord Management	38 39 42 44 46 48-50 53 54
Protocol development including Optimal Cord Management guidelines, standard operating procedures, pit stop techniques	38-46 48-50 53 54
Use of Optimal Cord Management champions	40 49 50 53
Use of QI methodology including addressing context specifically in relation to Optimal Cord Management	38-40 47 53 54

Organisations and resources supporting or incentivising QI in Optimal Cord Management

- BloodtoBaby Campaign[55]
- Maternity and Neonatal Safety Improvement Programme, NHS England[2]
- Perinatal Wellbeing Package, Maternity and Children's Quality Improvement Collaborative, Scottish Patient Safety Programme[8]
- NNAP Online[1]
- NICE guideline [NG25]: Preterm labour and birth[56]
- PERIPrem care bundle, West of England Academic Health Sciences Network[7]

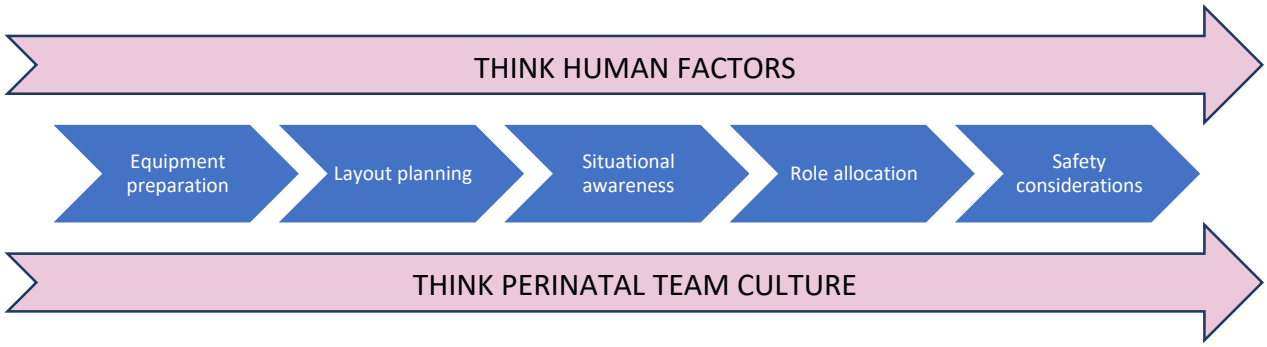
Achieving Optimal Cord Management: Core Strategies for Best Practice

The following core strategies have been identified by the members of the Optimal Cord Management toolkit group (Appendix 1), using evidence-based interventions and examples of best practice from high-performing units and networks, to provide a framework that is best designed to achieve a high rate of Optimal Cord Management with a low rate of adverse consequences. Units and networks who wish to improve rates of Optimal Cord Management should review each of these core strategies to identify how to achieve best practice.

Core strategies to support Optimal Cord Management:

1. Human factors and multidisciplinary perinatal team working
2. Provision of normothermia care
3. Supporting the onset of spontaneous breathing and lung inflation
4. Parental information and involvement

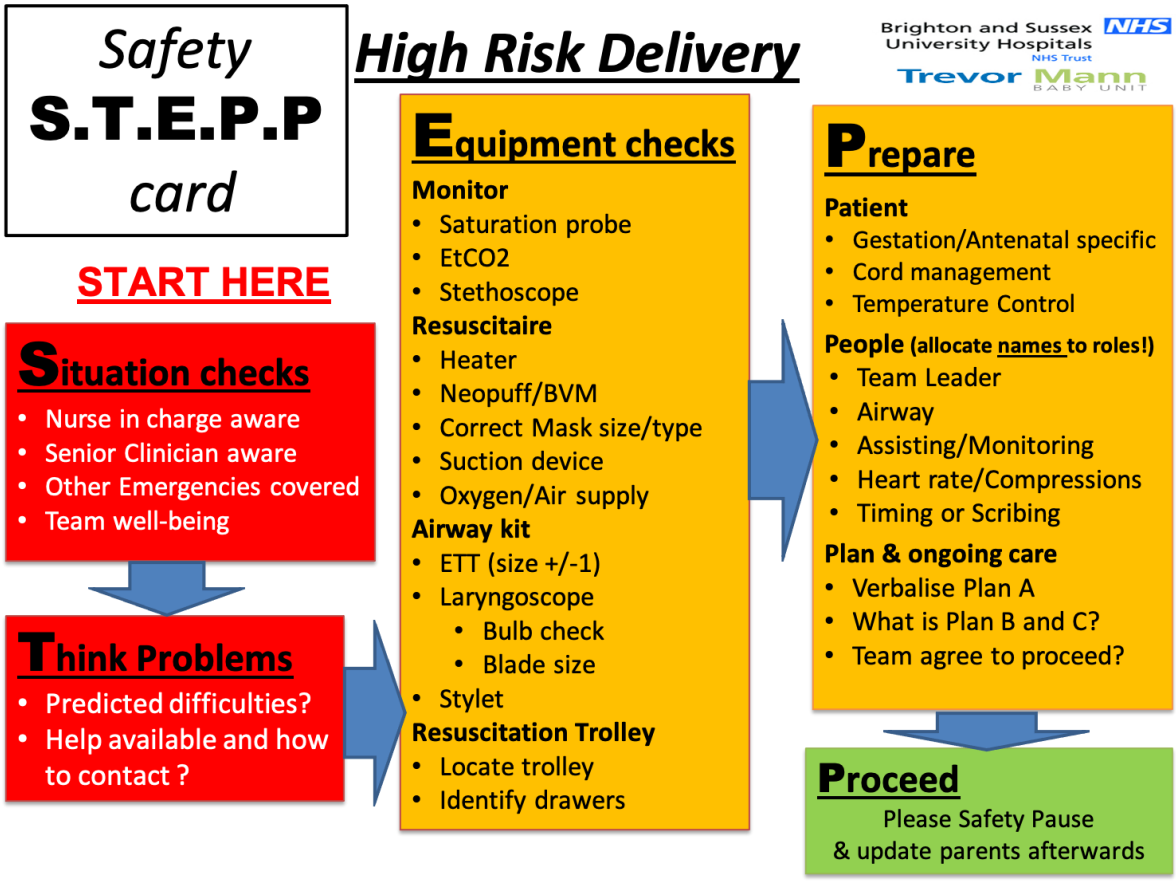
1. Human factors and multidisciplinary perinatal team working



A multidisciplinary team approach with high quality communication across the perinatal team is essential at the birth of a preterm baby. Team performance in such high acuity situations is important to outcomes, and team behaviours such as information sharing, vigilance, management of workload and leadership correlate strongly with the quality of resuscitation[57]. Situational awareness training using the Situational Awareness Programme for Everyone (SAFE) Toolkit may be a valuable activity for perinatal teams to undertake[58].

At birth, Optimal Cord Management and ongoing stabilisation require multiple inputs from multiple individuals and perinatal teams may find it useful to employ a pit-stop model with checklists and well-orchestrated tasks to improve efficiency and safety in the delivery room[59]. Situational awareness can be ensured by performing a pre-resuscitation huddle using the STEPP model. Checklists such as a STEPP card (provided courtesy of Brighton and Sussex University Hospitals NHS Trust Neonatal Human Factors team, Lead Dr Cassie Lawn) can be used to guide the team huddle prior to birth (Figure 1).

Figure 1: Example of a STEPP card for high risk births



2. Provision of normothermia care

Meta-analysis does not demonstrate an increased risk for hypothermia in preterm babies who receive Optimal Cord Management at birth[13]. Although not statistically significant, admission temperature is slightly higher compared to those who have early cord clamping. A study of Optimal Cord Management in near-term lambs reported better temperature control in those undergoing Optimal Cord Management versus early cord clamping[46].

The first minute is a potential risk period for thermoregulation as there may be a delay in transferring a wet baby to an external heat source and thus both evaporation and convection can be important properties of heat loss during the period of OCM. Nevertheless, rapidly transferring a baby who is relatively more 'hypovolaemic' by clamping the cord too early may also add to hypothermia. Optimal Cord Management is consistent with good thermal practices, such as putting the baby in a bag, drying, putting a hat on, and/or bringing an external heat source to the bedside. Teams should identify the risks, undertake a risk assessment before birth, and put in place measures to minimise hypothermia as below.

Users of this toolkit should refer to the BAPM Normothermia Toolkit to ensure optimal thermal care during Optimal Cord Management[60]. Key measures to be undertaken during Optimal Cord Management are described in Table 2.

Table 2. Key thermal measures to be undertaken during OCM

- Ensure a warm draught-free environment of 24-26°C: this may require temporary elevation of theatre temperature in anticipation of Optimal Cord Management. As this may be uncomfortable for those scrubbed up, this will need prior engagement with theatre staff
- If the following are being used:
    - Ensure warmed (sterile) towels are available for holding the baby during Optimal Cord Management and for later transfer to the stabilisation area
    - Ensure (sterile) plastic bag or thermal suit available for use if gestation requires it
    - Ensure that the heat source is activated on the stabilisation trolley
    - Ensure transwarmer or other thermal mattress activated at the appropriate time. Note safety concerns related to adjunct use of transwarmer with radiant heater[61]
- If birthweight or gestation requires it, put the baby into a plastic bag or thermal heat suit immediately at birth and from the onset of Optimal Cord Management. Otherwise use warm and dry with towels while stimulating the baby
- Cover the baby's head as soon as possible using a wool hat or the relevant part of the plastic thermal suit
- Check temperature after Optimal Cord Management is complete ideally with continuous temperature monitoring and maintain normothermia thereafter

3. Supporting the onset of spontaneous breathing and lung inflation

Observations on the physiologic onset of breathing at birth

Once born, the preterm baby should receive multiple stimuli to encourage the onset of breathing whilst still attached by the umbilical cord. Two studies of Optimal Cord Management observed that 90% or more of all included babies started to breathe before 60 seconds, thus the majority of babies will not need additional respiratory support during the first minute of Optimal Cord Management[31 32]. Proponents of physiological-based cord clamping oppose the idea of any time-based cord clamping and favour a baby-led approach, where the timing of cord clamping is determined by the behaviour and onset of spontaneous respiration of the baby as well as waiting for cord pulsations to cease. Until this debate has been resolved, we propose to adhere to the WHO guidance of using a **minimum** interval of one minute for deferring cord clamping. Stabilisation should start with gentle but deliberate stimulation, good thermal care and optimal positioning so that the airway is patent and does not get obstructed, while actively encouraging the onset and maintenance of spontaneous respiration. The WHO Care of the Newborn Pathway can be used as a guide[62].

Optimal timing of providing respiratory support at birth

The onset of spontaneous breathing and lung inflation during Optimal Cord Management can be supported in different ways. Of note, there is insufficient evidence to recommend which is best, but the following two strategies have been adopted with success by perinatal teams around the UK:

Optimal timing of providing respiratory support at birth

a) Airway patency should be ensured by optimising head position. Gentle but deliberate stimulation and encouragement to support spontaneous breathing and providing measures for optimising thermal stability whilst the infant is still attached to the mother by the cord[38]. Such measures in themselves will take around 60 seconds. If undertaken calmly and methodically they will also provide reassurance to team members. Once transferred to a resuscitaire, respiratory support can be provided as per NLS guidance ideally via a T-piece resuscitator or, if unavailable, a self-inflating bag[20 63 64].

b) Whilst most preterm babies breathe at or shortly after birth, it has been suggested that some will require additional support with breathing. For those teams advocating the need to incorporate early respiratory support into Optimal Cord Management (i.e. respiratory support whilst the cord is intact), CPAP and positive pressure ventilation (PPV) are only likely to be effective once the larynx is patent and the airway unobstructed[65 66]. During newborn stabilisation, this is most effectively ensured on a stable surface where the head position and mask fit can be controlled. In most delivery units in the UK currently, this will be the traditional resuscitaire which should be positioned close to the mother's bed, if additional respiratory support is to be provided. Experience from research centres[67 68] and from quality improvement initiatives has shown that with careful planning and a dedicated multi-disciplinary team approach, practice change towards early respiratory support is possible[69 70]. Expert guidance on how to plan and undertake early respiratory support in Optimal Cord Management within the context of a QI project will be available from specific members of this BAPM toolkit group at bapm@rcpch.ac.uk. More resources, such as a drill for Optimal Cord Management can be found on the PERIPrem website[71]. A particular focus for education in these centres is the need to ensure that Optimal Cord Management still takes place in the context of precipitate birth where the neonatal team may not be present at the time of birth to provide early respiratory support. **Immediate cord clamping should NOT be the alternative to stabilisation with the cord intact when the neonatal team are not present.**

4. Parental information and involvement

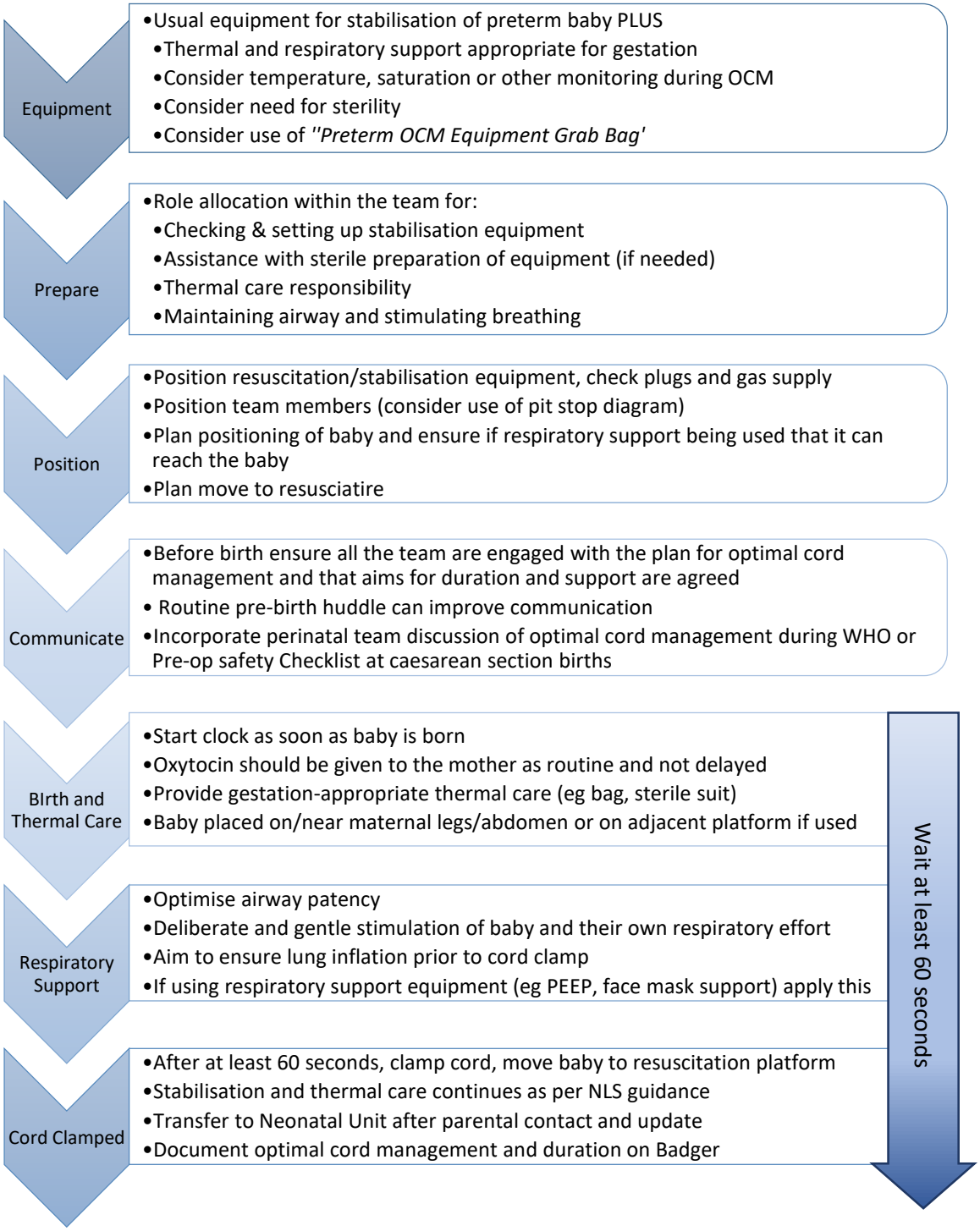
Parents should receive information about Optimal Cord Management at the time of antenatal counselling about their imminent preterm birth, along with information about early breast milk expression, the stabilisation process and the start of their neonatal journey. Some units have developed parent leaflets to support verbal information or a 'parent passport' of perinatal optimisation interventions which includes information about Optimal Cord Management. Such a document like that used within the PERIPrem Care Bundle programme is parent-held and can improve communication between professionals and between units about interventions already received and those planned[7].

During Optimal Cord Management, parents should be given reassurance about their baby's wellbeing and be encouraged to touch or even hold their baby with clean hands where this is possible. Where this is not possible, photographs should be offered.

Optimal Cord Management: Best Practice Flowchart

The following flowchart has been adapted from Greater Glasgow and Clyde Paediatric Guideline on optimal cord management. It is an example of what might be considered best practice. Units may choose to adapt this to support improvement activity or as a process flowchart for staff use in the delivery suite.

Figure 2. Best Practice Flowchart for Optimal Cord Management



References

1. NNAP Online. National Neonatal Audit Programme: Royal College for Paediatrics and Child Health; [Available from: https://nnap.rcpch.ac.uk

2. Maternity and Neonatal Safety Improvement Programme: NHS Improvement; [Available from: https://improvement.nhs.uk/resources/maternal-and-neonatal-safety-collaborative/

3. Maternity and Children's Quality Improvement Collaborative- Scottish Patient Safety Programme [Available from: https://ihub.scot/improvement-programmes/scottish-patient-safety-programme-spsp/maternity-and-children-quality-improvement-collaborative-mcqic/neonatal-care/

4. Saving Babies' Lives Care Bundle Version 2: COVID-19 information. Appendix I: Implications of COVID-19 on reducing preterm births: NHS England, 2020.

5. Neonatal Service Quality Indicators: Standards relating to structures and processes: British Association of Perinatal Medicine; 2017 [Available from: https://www.bapm.org/resources/11-neonatal-service-quality-indicators-standards-relating-to-structures-and-processes-2017.

6. Quality Improvement in Child Health Strategic Framework: Royal College of Paediatrics and Child Health [Available from: https://www.rcpch.ac.uk/resources/quality-improvement-child-health-framework-supporting-delivery-high-quality-care). .

7. PERIPrem Care Bundle: West of England Academic Health Sciences Network 2020 [Available from: https://www.weahsn.net/our-work/transforming-services-and-systems/periprem/periprem-project/.

8. Preterm Perinatal Wellbeing Package: Maternity and Children Quality Improvement Collaborative, Scottish Patient Safety Programme. Health Improvement Scotland; [Available from: https://ihub.scot/media/5311/20180808-preterm-web.pdf

9. Implementing the Recommendations of the Neonatal Critical Care Transformation Review: NHS England; 2019 [updated 2019. Available from: https://www.england.nhs.uk/publication/implementing-the-recommendations-of-the-neonatal-critical-care-transformation-review/.

10. Saving Babies Lives' Version 2. A care bundle for reducing perinatal mortality: NHS England; 2019 [Available from: https://www.england.nhs.uk/wp-content/uploads/2019/07/saving-babies-lives-care-bundle-version-two-v5.pdf.

11. Perinatal Management of Extreme Preterm Birth Before 27 weeks of Gestation. A BAPM Framework for Practice: British Association of Perinatal Medicine; 2019 [Available from: https://www.bapm.org/resources/80-perinatal-management-of-extreme-preterm-birth-before-27-weeks-of-gestation-2019.

12. Fogarty M, Osborn DA, Askie L, et al. Delayed vs early umbilical cord clamping for preterm infants: a systematic review and meta-analysis. *Am J Obstet Gynecol* 2018;218(1):1-18. doi: 10.1016/j.ajog.2017.10.231 [published Online First: 2017/11/04]

13. Rabe H, Gyte GM, Díaz-Rossello JL, et al. Effect of timing of umbilical cord clamping and other strategies to influence placental transfusion at preterm birth on maternal and infant outcomes. *Cochrane Database Syst Rev* 2019;9(9):Cd003248. doi: 10.1002/14651858.CD003248.pub4 [published Online First: 2019/09/19]

14. Seidler AL, Gyte G, Rabe H, et al. Umbilical Cord Management for Newborns < 34 week's gestation: a meta-analysis. *Pediatrics 2021;147(3):e20200576*

15. WHO Guideline: Delayed Umbilical Cord Clamping for Improved Maternal and Infant Health and Nutrition Outcomes Geneva: World Health Organization. Copyright © World Health Organization 2014.

16. The Canadian Neonatal Network 2019 Annual Report on 2018 Data.

17. Rabe H, Jewison A, Alvarez RF, et al. Milking compared with delayed cord clamping to increase placental transfusion in preterm neonates: a randomized controlled trial. *Obstet Gynecol* 2011;117(2 Pt 1):205-11. doi: 10.1097/AOG.0b013e3181fe46ff [published Online First: 2011/01/22]

18. Duley L, Dorling J, Pushpa-Rajah A, et al. Randomised trial of cord clamping and initial stabilisation at very preterm birth. *Arch Dis Child Fetal Neonatal Ed* 2018;103(1):F6-f14. doi: 10.1136/archdischild-2016-312567 [published Online First: 2017/09/20]

19. Brouwer E, Knol R, Vernooij ASN, et al. Physiological-based cord clamping in preterm infants using a new purpose-built resuscitation table: a feasibility study. *Arch Dis Child Fetal Neonatal Ed* 2019;104(4):F396-f402. doi: 10.1136/archdischild-2018-315483 [published Online First: 2018/10/05]

20. Draft 2020 European Resuscitation Council Guidelines for Newborn Resuscitation and Support of Transition of Infants at Birth. https://api.resuscitation2020.eu/asset-document/35-Draft%20NLS%20Guidelines%20for%20Public%20Comment%2019Oct20.pdf.

21. Wyckoff MH, Wyllie J, Aziz K, et al. Neonatal Life Support 2020 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. *Resuscitation* 2020;156:A156-a87. doi: 10.1016/j.resuscitation.2020.09.015 [published Online First: 2020/10/26]

22. Sweet DG, Carnielli V, Greisen G, et al. European Consensus Guidelines on the Management of Respiratory Distress Syndrome – 2019 Update. *Neonatology* 2019;115(4):432-50. doi: 10.1159/000499361

23. Ghirardello S, Di Tommaso M, Fiocchi S, et al. Italian Recommendations for Placental Transfusion Strategies. *Front Pediatr* 2018;6:372. doi: 10.3389/fped.2018.00372 [published Online First: 2018/12/19]

24. Katheria A, Reister F, Essers J, et al. Association of Umbilical Cord Milking vs Delayed Umbilical Cord Clamping With Death or Severe Intraventricular Hemorrhage Among Preterm Infants. *Jama* 2019;322(19):1877-86. doi: 10.1001/jama.2019.16004 [published Online First: 2019/11/20]

25. El-Naggar W, Afifi J, Dorling J, et al. A Comparison of Strategies for Managing the Umbilical Cord at Birth in Preterm Infants. *J Pediatr* 2020;225:58-64.e4. doi: 10.1016/j.jpeds.2020.05.018 [published Online First: 2020/05/23]

26. Blank DA, Polglase GR, Kluckow M, et al. Haemodynamic effects of umbilical cord milking in premature sheep during the neonatal transition. *Arch Dis Child Fetal Neonatal Ed* 2018;103(6):F539-f46. doi: 10.1136/archdischild-2017-314005 [published Online First: 2017/12/07]

27. Balasubramanian H, Ananthan A, Jain V, et al. Umbilical cord milking in preterm infants: a systematic review and meta-analysis. *Archives of Disease in Childhood - Fetal and Neonatal Edition* 2020;105(6):572. doi: 10.1136/archdischild-2019-318627

28. Ram Mohan G, Shashidhar A, Chandrakala BS, et al. Umbilical cord milking in preterm neonates requiring resuscitation: A randomized controlled trial. *Resuscitation* 2018;130:88-91. doi: 10.1016/j.resuscitation.2018.07.003 [published Online First: 2018/07/10]

29. Jegatheesan P, Belogolovsky E, Nudelman M, et al. Neonatal outcomes in preterm multiples receiving delayed cord clamping. *Arch Dis Child Fetal Neonatal Ed* 2019;104(6):F575-f81. doi: 10.1136/archdischild-2018-316479 [published Online First: 2019/03/22]

30. Ruangkit C, Bumrungphuet S, Panburana P, et al. A Randomized Controlled Trial of Immediate versus Delayed Umbilical Cord Clamping in Multiple-Birth Infants Born Preterm. *Neonatology* 2019;115(2):156-63. doi: 10.1159/000494132 [published Online First: 2018/11/28]

31. Katheria A, Poeltler D, Durham J, et al. Neonatal Resuscitation with an Intact Cord: A Randomized Clinical Trial. *J Pediatr* 2016;178:75-80.e3. doi: 10.1016/j.jpeds.2016.07.053 [published Online First: 2016/10/30]

32. Murphy MC, McCarthy LK, O'Donnell CPF. Crying and breathing by new-born preterm infants after early or delayed cord clamping. *Arch Dis Child Fetal Neonatal Ed* 2020;105(3):331-33. doi: 10.1136/archdischild-2018-316592 [published Online First: 2019/05/16]

33. Ayers S, Sawyer A, Düring C, et al. Parents report positive experiences about enrolling babies in a cord-related clinical trial before birth. *Acta Paediatr* 2015;104(4):e164-70. doi: 10.1111/apa.12922 [published Online First: 2015/02/03]

34. Sawyer A, Rabe H, Abbott J, et al. Parents' experiences and satisfaction with care during the birth of their very preterm baby: a qualitative study. *Bjog* 2013;120(5):637-43. doi: 10.1111/1471-0528.12104 [published Online First: 2013/01/08]

35. Katheria AC, Sorkhi SR, Hassen K, et al. Acceptability of Bedside Resuscitation With Intact Umbilical Cord to Clinicians and Patients' Families in the United States. *Front Pediatr* 2018;6:100. doi: 10.3389/fped.2018.00100 [published Online First: 2018/05/15]

36. Anton O, Jordan H, Rabe H. Strategies for implementing placental transfusion at birth: A systematic review. *Birth* 2019;46(3):411-27. doi: 10.1111/birt.12398 [published Online First: 2018/09/29]

37. Liyanage SK, Ninan K, McDonald SD. Guidelines on Deferred Cord Clamping and Cord Milking: A Systematic Review. *Pediatrics* 2020;146(5) doi: 10.1542/peds.2020-1429 [published Online First: 2020/10/23]

38. Hoyle ES, Hirani S, Ogden S, et al. Quality improvement programme to increase the rate of deferred cord clamping at preterm birth using the Lifestart trolley. *Arch Dis Child Fetal Neonatal Ed* 2020;105(6):652-55. doi: 10.1136/archdischild-2019-318636 [published Online First: 2020/05/01]

39. Aliyev G, Gallo AM. Implementation of Delayed Cord Clamping in Vigorous Preterm Neonates. *J Obstet Gynecol Neonatal Nurs* 2018;47(6):803-11. doi: 10.1016/j.jogn.2018.09.003 [published Online First: 2018/10/08]

40. Gams RL, Popp KK, Cramer J, et al. How to Engage Your Team to Implement Delayed Cord Clamping. *Nurs Womens Health* 2017;21(6):489-98. doi: 10.1016/j.nwh.2017.10.003 [published Online First: 2017/12/11]

41. Pantoja AF, Ryan A, Feinberg M, et al. Implementing delayed cord clamping in premature infants. *BMJ Open Qual* 2018;7(3):e000219. doi: 10.1136/bmjoq-2017-000219 [published Online First: 2018/10/03]

42. McAdams RM, Backes CH, Hutchon DJ. Steps for implementing delayed cord clamping in a hospital setting. *Matern Health Neonatol Perinatol* 2015;1:10. doi: 10.1186/s40748-015-0011-8 [published Online First: 2015/01/01]

43. Liu LY, Feinglass JM, Khan JY, et al. Evaluation of Introduction of a Delayed Cord Clamping Protocol for Premature Neonates in a High-Volume Maternity Center. *Obstet Gynecol* 2017;129(5):835-43. doi: 10.1097/aog.0000000000001987 [published Online First: 2017/04/07]

44. Aziz K, Chinnery H, Lacaze-Masmonteil T. A single-center experience of implementing delayed cord clamping in babies born at less than 33 weeks' gestational age. *Adv Neonatal Care* 2012;12(6):371-6. doi: 10.1097/ANC.0b013e3182761246 [published Online First: 2012/11/29]

45. Rhoades JS, Bierut T, Conner SN, et al. Delayed Umbilical Cord Clamping at <32 Weeks' Gestation: Implementation and Outcomes. *American journal of perinatology* 2017;34(11):1048-53. doi: 10.1055/s-0037-1603591 [published Online First: 2017/05/25]

46. Rich D. Delayed Cord Clamping: A Multidisciplinary Approach. *Journal of Obstetric, Gynecologic, & Neonatal Nursing* 2015;44(s1):S9-S10. doi: 10.1111/1552-6909.12670

47. Sæther E, Gülpen FR, Jensen C, et al. Neonatal transitional support with intact umbilical cord in assisted vaginal deliveries: a quality-improvement cohort study. *BMC Pregnancy Childbirth* 2020;20(1):496. doi: 10.1186/s12884-020-03188-0 [published Online First: 2020/08/29]

48. Perrone B, Ghirardello S. Placental Transfusion Strategies in Italy: A Nationwide Survey of Tertiary-Care Delivery Wards. *Am J Perinatol* 2017;34(7):722-28. doi: 10.1055/s-0036-1597995 [published Online First: 2017/01/07]

49. Oddie S, Rhodes P. Barriers to deferred cord clamping in preterm infants. *Arch Dis Child Fetal Neonatal Ed* 2014;99(5):F391-4. doi: 10.1136/archdischild-2014-305968 [published Online First: 2014/06/07]

50. Bolstridge J, Bell T, Dean B, et al. A quality improvement initiative for delayed umbilical cord clamping in very low-birthweight infants. *BMC Pediatr* 2016;16(1):155. doi: 10.1186/s12887-016-0692-9 [published Online First: 2016/09/15]

51. Jelin AC, Kuppermann M, Erickson K, et al. Obstetricians' attitudes and beliefs regarding umbilical cord clamping. *J Matern Fetal Neonatal Med* 2014;27(14):1457-61. doi: 10.3109/14767058.2013.864275 [published Online First: 2013/11/13]

52. Jelin AC, Zlatnik MG, Kuppermann M, et al. Clamp late and maintain perfusion (CLAMP) policy: delayed cord clamping in preterm infants. *J Matern Fetal Neonatal Med* 2016;29(11):1705-9. doi: 10.3109/14767058.2015.1061496 [published Online First: 2015/07/03]

53. Bates SE, Isaac TCW, Marion RL, et al. Delayed cord clamping with stabilisation at all preterm births - feasibility and efficacy of a low cost technique. *Eur J Obstet Gynecol Reprod Biol* 2019;236:109-15. doi: 10.1016/j.ejogrb.2019.03.012 [published Online First: 2019/03/25]

54. Balakrishnan M, Falk-Smith N, Detman LA, et al. Promoting teamwork may improve infant care processes during delivery room management: Florida perinatal quality collaborative's approach. *J Perinatol* 2017;37(7):886-92. doi: 10.1038/jp.2017.27 [published Online First: 2017/04/14]

55. BloodtoBaby. Optimal Cord Clamping [Available from: https://www.bloodtobaby.com/what-is-bloodtobaby.

56. Preterm Labour and Birth: National Institute for Clinical Excellence; 2019 [Available from: https://www.nice.org.uk/guidance/ng25.

57. Thomas EJ, Sexton JB, Lasky RE, et al. Teamwork and quality during neonatal care in the delivery room. *J Perinatol* 2006;26(3):163-9. doi: 10.1038/sj.jp.7211451 [published Online First: 2006/02/24]

58. Situation Awareness for Everyone (S.A.F.E) toolkit: Royal College for Paediatrics and Child Health; [Available from: https://www.rcpch.ac.uk/resources/situation-awareness-everyone-safe-toolkit-introduction.

59. Vergales BD, Dwyer EJ, Wilson SM, et al. NASCAR pit-stop model improves delivery room and admission efficiency and outcomes for infants <27 weeks' gestation. *Resuscitation* 2015;92:7-13. doi: 10.1016/j.resuscitation.2015.03.022 [published Online First: 2015/04/22]

60. BAPM. Improving Normothermia in Very Preterm Infants: A Quality Improvement Toolkit. [published Online First: 2019]

61. BAPM. Safety Issue - Transwarmer Mattresses 2019 [Available from: https://www.bapm.org/posts/44-safety-issue-transwarmer-mattresses.

62. WHO Early Essential Newborn Care: clinical practice pocket guide. WHO 2014 ISBN 978 92 9061 685 6. [Available from: https://apps.who.int/iris/bitstream/handle/10665/208158/9789290616856_eng.pdf?sequence=1&isAllowed=y

63. Roehr CC, Davis PG, Weiner GM, et al. T-piece resuscitator or self-inflating bag during neonatal resuscitation: a scoping review. *Pediatr Res* 2020 doi: 10.1038/s41390-020-1005-4 [published Online First: 2020/06/12]

64. Roehr CC, O'Shea JE, Dawson JA, et al. Devices used for stabilisation of newborn infants at birth. *Arch Dis Child Fetal Neonatal Ed* 2018;103(1):F66-f71. doi: 10.1136/archdischild-2016-310797 [published Online First: 2017/10/29]

65. Kuypers K, Martherus T, Lamberska T, et al. Reflexes that impact spontaneous breathing of preterm infants at birth: a narrative review. *Arch Dis Child Fetal Neonatal Ed* 2020;105(6):675-79. doi: 10.1136/archdischild-2020-318915 [published Online First: 2020/05/01]

66. Crawshaw JR, Kitchen MJ, Binder-Heschl C, et al. Laryngeal closure impedes non-invasive ventilation at birth. *Arch Dis Child Fetal Neonatal Ed* 2018;103(2):F112-f19. doi: 10.1136/archdischild-2017-312681 [published Online First: 2017/10/22]

67. Knol R, Brouwer E, Vernooij ASN, et al. Clinical aspects of incorporating cord clamping into stabilisation of preterm infants. *Arch Dis Child Fetal Neonatal Ed* 2018;103(5):F493-f97. doi: 10.1136/archdischild-2018-314947 [published Online First: 2018/04/24]

68. Knol R, Brouwer E, van den Akker T, et al. Physiological-based cord clamping in very preterm infants - Randomised controlled trial on effectiveness of stabilisation. *Resuscitation* 2020;147:26-33. doi: 10.1016/j.resuscitation.2019.12.007 [published Online First: 2019/12/25]

69. Weeks AD, Watt P, Yoxall CW, et al. Innovation in immediate neonatal care: development of the Bedside Assessment, Stabilisation and Initial Cardiorespiratory Support (BASICS) trolley. *BMJ Innov* 2015;1(2):53-58. doi: 10.1136/bmjinnov-2014-000017 [published Online First: 2015/07/21]

70. Thomas MR, Yoxall CW, Weeks AD, et al. Providing newborn resuscitation at the mother's bedside: assessing the safety, usability and acceptability of a mobile trolley. *BMC Pediatr* 2014;14:135. doi: 10.1186/1471-2431-14-135 [published Online First: 2014/06/03]

71. PERIPrem Care Bundle: Delayed Cord Clamping. 2020

72. Perinatal Teamworking. The PReCePT2 Study.: The Health Foundation; [Available from: https://www.health.org.uk/improvement-projects/precept2-reducing-brain-injury-through-improving-uptake-of-magnesium-sulphate.

73. WHO recommendations on interventions to improve preterm birth outcomes France: World Health Organisation; 2015 [Available from: https://apps.who.int/iris/bitstream/handle/10665/183037/9789241508988_eng.pdf;jsessionid=966E028B4E46B3A246043A64E83F85EC?sequence=1.