Cardiopulmonary cerebral resuscitation of the foal

Post-partum cardiopulmonary cerebral resuscitation of the foal is outlined by Emma Conlon, veterinary nursing student and Karen Dunne MA CertEM (StudMed) MVB, veterinary nursing lecturer, Dundalk Institute of Technology

Cardiopulmonary cerebral resuscitation (CPCR) is carried out on foals once they are born if breathing and normal blood circulation are not present. The procedure includes a combination of manual ventilation, thoracic compressions and drugs if needed. Once it is decided that CPCR is required, it needs to be started quickly and carried out correctly for it to be successful. Therefore, it is important that all staff members are familiar with each step of the procedure and that a CPCR kit is always available. Training clients on how to perform CPCR is also beneficial as they can begin the procedure while waiting for veterinary assistance.

INTRODUCTION

Cardiopulmonary cerebral resuscitation (CPCR) is a procedure used to restore spontaneous breathing and blood circulation in the foal. It combines manual ventilation, thoracic compressions and the administration of drugs (Slovis, 2014).

To successfully manage a critically-ill foal that requires CPCR, it is vital to recognise any warning signs and to be aware of factors that may predispose the foal to needing CPCR. Factors that can affect the foal's ability to breath on its own are listed in Table 1 and include, but are not limited to, inadequate lung development, surfactant deficiency, viral or bacterial infection, placenta abnormalities, *in utero* hypoxia, dystocia, caesarean sections, premature placental separation and meconium aspiration (Munsterman, n.d.).

Maternal Factors	Foal Factors
Placentitis	Perinatal hypoxia
Premature-placental separation	Early severing or twisting of umbilical cord
Uterine artery hemorrhage	Primary lung disease
Dystocia	Septic shock
Caesarian section	Acid-base disturbances
Twin pregnancy	Electrolyte imbalances
Prolonged gestation	Hypoglycemia
Body-wall hernia	Hypothermia
Systemic disease (colitis, colic)	Surfactant deficiency
	Meconium aspiration
	In utero hypoxia

Table 1: Factors predisposing a foal to CPCR (adapted from Javsicas and Giguere 2008; Munsterman n.d.; Jokisalo and Corley 2014).

Clinical signs that show new born foals will require CPCR include apnoea, asystole, a heart rate of less than 50 beats per minute (Jokisalo and Corley, 2014), a respiratory rate of less than ten breaths per minute, muscle flaccidity and no response to tactile stimulation (Slovis, 2014). A foal-resuscitation flow chart, as seen in Figure 1 is a useful tool to have to determine if CPCR is required and when to stop (Corley, n.d.).

Slight asphyxia of the foal will occur during normal parturition. This is necessary for a successful transition to extra-uterine life. However, if this asphyxia gets worse due to problems such as inadequate lung development, infection, placenta abnormalities or surfactant deficiency, it will lead to primary asphyxia which is the foal breathing *in utero*. Secondary asphyxia, which is a second gasping phase, will then occur if the foal's breathing is still not effective. Eventually, the foal will enter secondary apnoea which is irreversible unless CPCR is carried out (Munsterman n.d.).

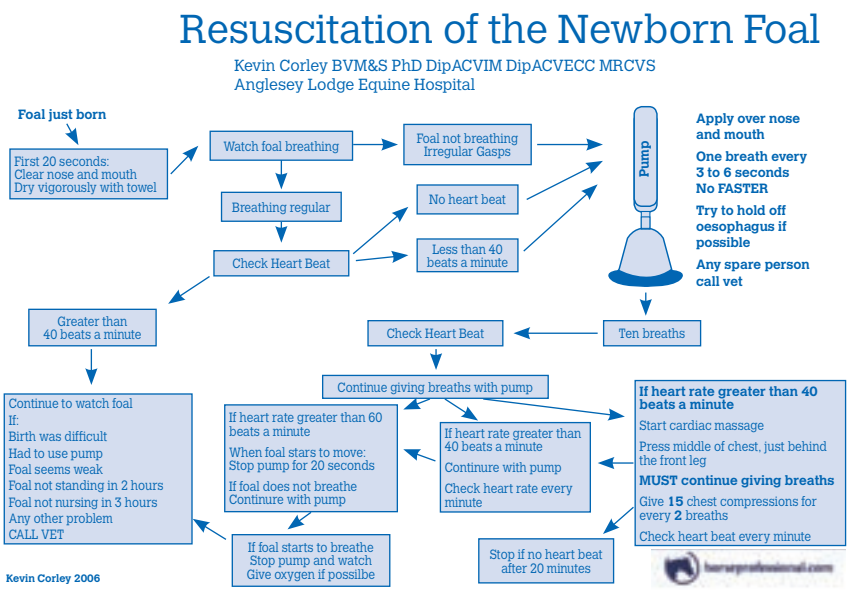

Figure 1: Resuscitation of the newborn foal flow chart (Corley n.d.).

FOAL ASSESSMENT

A physical examination of the foal should be carried out before performing any CPCR, including measuring normal parameters as mentioned in Table 2. The exam can begin as soon as the foal can be seen passing through the mare's pelvic canal (Munsterman n.d.). If, upon initial assessment, the foal has a strong regular heart rate of over 60 beats per minute and there is spontaneous breathing of over 60 breaths per minute, then CPCR is not required and instead the foal just needs to be observed (Dunkle, 2010).

Normal healthy foals will begin spontaneous breathing within one minute after birth. Sometimes this may not happen due to undeveloped lungs, respiratory tract infection, dystocia, or other factors listed in Table 1. If this is the case, CPCR is required (Kirby and Gelatt, n.d.).

Age	Heart rate	Respiratory rate	Rectal temperature
Birth	60-80 beat/ minute	Gasping breaths	37-39°C
0-2 hours	120-150 beats/ minute	40-60 breaths/ minute	37-39°C
12 hours	80-120 beats/ minute	30-40 breaths/ minute	37-39°C
24 hours	80-100 beats/ minute	30-35 breaths/ minute	37-39°C

Table 2: Normal parameters for the newborn foal (Shepherd, 2010).

It is normal for the foal's breathing rate to be high within the first hour of life (Kirby and Gelatt n.d.). Once breathing normally, foals should have a respiratory rate of 60-80 breaths per minute and have a heart rate of 60-70 beats per minute, but this can be higher (Javsicas and Giguere, 2008). Upon auscultation, the heart should have a normal rhythm (Munsterman n.d.). Arrhythmias due to atrial fibrillation or premature atrial or ventricular contraction are sometimes heard and are only an issue is they persist after the first few days of life (Kirby and Gelatt, n.d.).

Bradycardia of less than 40 beats per minute is normal during forceful contractions and the heart rate should increase to a normal rate once the foal's thorax has passed the mare's birth canal. If the heart rate does not increase, immediate assistance is needed (Kirby and Gelatt, n.d.).

It is normal for a foal to be born with slightly cyanotic mucous membranes that will resolve to a normal pink colour within minutes. If this does not occur, it is a sign for intervention (Kirby and Gelatt, n.d.). The foal should develop a righting reflex within five minutes after birth which enables the foal to stay in a normal upright position (Dunkle, 2010). This can be assessed by placing the foal in sternal recumbency and seeing if he or she can stand upright.

Physical stimulation is needed if the foal does not breathe or move within the first minute of being born. This can be done by vigorously rubbing the body with clean, dry towels or straw. If this does not work, then the foal requires CPCR immediately (Munsterman, n.d.).

The modified appearance, pulse, grimace, activity, and respiration (Apgar) scoring system for foals can be used, as shown in Table 3, to determine if a foal needs CPCR or not. CPCR is indicated if the foal scores a two or three. (Munstermann n.d.).

	Score 1	Score 2	Score 3
Heart Rhythm and Rate	Regular, >60 beats per minute	Irregular, <60 beats per minute	Absent

Table 3: Modified Apgar scoring system for equine neonates (Munsterman n.d.).

PREPARATION

CPCR is most successful when the people involved are prepared.Therefore, CPCR should always be anticipated when the mare and foal are presenting common issues that require CPCR (Dunkle 2010), as described in Table 1.

The best way to stay prepared is to always have a CPCR kit at hand that is fully stocked with clean and fully-working equipment and in-date medications. The equipment needed is listed in Table 3 (Javsicas and Giguere, 2008; Dunkle, 2010).

Regular practice of CPCR at the beginning of each foaling season by all staff members will ensure everyone knows how to perform each role (Dunkle, 2010).

Educating clients and showing them how to perform CPCR is a good idea as veterinary staff may not always be present when a mare begins to foal (Slovis, 2014).

AIRWAY

The first step in performing CPCR is to establish an airway. Clear any fluid or foetal membranes from the nasal and oral cavities. It is important to remove any meconium present before the foal breathes to avoid aspiration. This can be achieved by suctioning the airway (Munsterman n.d.).

The suctioning can be carried out with a bulb syringe or a mechanical suctioning machine if available. Suctioning the nares and oral cavity should only be performed for five to 10 seconds at a time. Suctioning for longer periods of time can stimulate the vagus nerve which can cause bradycardia (Javsicas and Giguere, 2008). Once the foal begins to breathe independently the suctioning should stop (Munsterman n.d.).

Positioning the head lower than the body can help drain any fluid. Slapping, swinging or hanging the foal by the hindlimbs is not recommended as it is likely to injure the foal (Javsicas and Giguere, 2008).

Nasotracheal intubation is performed to ensure that there is a patent airway. Generally, size 7-12mm endotracheal tubes that are 55cm long are used. The widest one possible should be used. When inserting the tube, place the foal in lateral or sternal recumbency and ensure that the head and neck are fully extended. The tube is inserted ventrally to the ventral meatus and then rotated before entering the trachea. There should be little resistance when placing the tube into the trachea.

Correct placement can be assessed by feeling for expired air at the end of the tube when the thorax is compressed. The tube is advanced as far as possible to reduce dead space (Slovis, 2014). Palpate the ventral neck to ensure the tube has not entered the oesophagus. Applying gentle pressure from the dorsal to the larynx, when inserting the tube, helps to ensure that it enters the trachea. Once it is in the correct position, the cuff is inflated with a syringe and the tube is tied in place by a quick release knot tied behind the foal's ears (Javsicas and Giguere, 2008).

Nasotracheal intubation is the preferred choice as orotracheal intubation can cause injury to the oral cavity by the foal chewing on the tube once resuscitated. However, if nasotracheal intubation is unsuccessful after two attempts, or not an option due to bleeding, turbinate bone injury or other complications, orotracheal intubation can be carried out with the same equipment (Slovis, 2014).

BREATHING

A self-inflating resuscitation bag is then attached to the endotracheal tube and used to ventilate the foal (Javsicas and Giguere, 2008) at a rate of 10-20 breaths per minute (Jokisalo and Corley, 2014). Normal room air is sufficient, but 100% oxygen can be used if it is available (Javsicas and Giguere, 2008). Once breathing is spontaneous, it is recommended to provide oxygen at 8-10L/minute if using a nasotracheal tube (Munsterman, n.d.).

Avoid over-inflation of the lungs, as this can cause an increase in intrathoracic pressure which can lead to decreased perfusion (Slovis, 2014). To avoid over inflation, it is possible to get resuscitation bags with airway pressure measurements indicated on them. Generally, a pressure of 20cmH2O is recommended (Javsicas and Giguere, 2008).

Once the heart rate is above 60 beats per minute and is stable, ventilation can be stopped (Slovis, 2014). Assessment of the patient during CPCR is important as it can indicate how well the technique is working and when it is appropriate to stop (Javsicas and Giguere, 2008). Ventilation can be stopped periodically to check for spontaneous respiration (Madigan, 2013). The foal's peripheral pulse should also be evaluated in the femoral artery to assess circulation. Evaluate its strength, rate and rhythm (Galvin, 2008). The foal's pupil size and pupillary light reflex is also checked with a pen torch and is an easy way to assess blood flow to the brain (Javsicas and Giguere, 2008). Dilated, fixed pupils indicate an extreme lack of oxygen and poor circulation (Slovis, 2014), while normal-sized pupils that respond to the light by constricting indicate sufficient blood flow to the brain (Javsicas and Giguere, 2008). During this assessment, CPCR should not be stopped for longer than 10 seconds (Slovis, 2014).

Foal-resuscitation kit equipment	
Essential	**Optional**
Clean towels	Oxygen cylinder and flow meter
Bulb syringe	Heat lamp
Endotracheal tubes 7-12mm in diameter and 55cm in length	ECG monitor
Conforming bandage (for tying endotracheal tube)	$ETCO_2$ monitor
Syringe (to inflate the cuff)	Electrical defibrillator
Self-inflating resuscitation bag	Mask resuscitator
Stethoscope	
Watch/clock	
Pen torch	
Adrenaline 1mg/ml (1:1,000)	
Various-sized syringes and needles for medication administration	
S14 and 16 intravenous catheters	
Clippers	

Table 4: Equipment for a Foal Resuscitation Kit (adapted from Javsicas and Giguere,2008; Dunkle, 2010).

CIRCULATION

It is common for ventilation to be enough to resuscitate the foal and for thoracic compressions to not be necessary. However, if after 30 seconds of ventilation, there is still no heartbeat, or if it is less than 50 beats per minute, then thoracic compressions are required (Jokisalo and Corley, 2014).

Compression rates of 100-120 per minute are recommended (Jokisalo and Corley, 2014). The foal should be assessed after the first minute, as described above, to determine the effects of the thoracic compressions and any drugs provided. After the first assessment, the thoracic compressions should be stopped every two to three minutes to see if the foal is responding (Munsterman, n.d.).

To perform the thoracic compressions, position yourself on

the foal's dorsal aspect at the level of the thorax (Corley, 2010). Hands are placed on top of each other, caudal to the foal's triceps and at the highest point of the thorax. The entire upper body is used, and it is important to keep elbows locked and shoulders over the foal's thorax (Javsicas and Giguere, 2008). The hands should move down 3-5cm for each compression. The thorax should be depressed 40% and then allowed to fully expand again during each compression (Munsterman, n.d.). Towels or sandbags supporting the thorax can assist with the compressions (Javsicas and Giguere, 2008).

While the compressions are being performed, another person needs to be providing breaths at a rate of 10-20 per minute (Jokisalo and Corley, 2014). These two roles can be alternated between the two people to avoid them getting tired (Munsterman, n.d.). If there is only one person available to perform CPCR than they should perform 15 thoracic compressions, followed by two breaths (Corley, 2010).

A small number of foals can be born with fractured ribs, so, the entire rib cage needs to be palpated before thoracic compressions are carried out. This is required as the ribs most commonly fractured, ribs 3-8, are located directly over the heart. Thoracic compressions to these fractured ribs could potentially puncture the heart. If a foal does present with fractured ribs, the affected side should be placed down during compressions. (Munsterman, n.d.). If ribs are broken on both sides, than the side with more fractures is placed on the ground (Corley, 2010).

DRUGS

Medications are administered usually after 30-60 seconds if the foal is still non-responsive after thoracic compressions. Adrenaline is the most commonly-used drug during CPCR. It causes peripheral vasoconstriction and increased aortic pressure during diastole. These effects, combined with ventilation and thoracic compressions, help with restoring coronary perfusion (Javsicas and Giguere, 2008).

Adrenaline can be given intravenously at a dose rate of 0.01-0.02mg/kg or, if present, through a nasotracheal tube at a dose rate of 0.05-0.1mg/kg (Munsterman, n.d.). Intracardiac administration is not advised as it may cause myocardial lacerations, ventricular tachycardia and coronary vessel thrombosis (Madigan, 2017). Administration can be repeated every two to three minutes in conjunction with the thoracic compressions and then the foal's response assessed, as mentioned above (Munsterman, n.d.).

Both atropine and doxapram are contraindicated for resuscitation in foals (Munsterman, n.d.). Atropine is not used as, at low doses, it can worsen the bradycardia and, at high doses, it can cause tachycardia, increasing the cardiac muscles' demand for oxygen, which will cause the situation to deteriorate (Palmer, n.d.). Doxapram is contraindicated

due to its effects on cerebral blood flow, causing an increase in oxygen demand which can be detrimental in a foal with poor circulation (Dunkle, 2010).

OTHER TREATMENTS

Fluid therapy is only needed during resuscitation if the foal is suffering from excessive haemorrhage. If fluids are given with no haemorrhage present, the foal is at risk of becoming hypervolaemic. If fluid therapy is needed, the foal can be given 20ml/kg of an isotonic, glucose-free fluid, such as 0.9% NaCl, over 20 minutes intravenously as a bolus. The foal's response is then assessed and up to three more boluses can be administered if needed. Once the foal has been fully resuscitated, glucose can be added to the fluids at a rate of 4-8mg/kg/minute. The addition of glucose can help with cardiac output, blood-glucose levels and reversing metabolic acidosis. (Munsterman, n.d.).

WHEN TO DISCONTINUE RESUSCITATION

CPCR is deemed to have been successful when spontaneous circulation is restored, and the foal can express normal behaviour such as nursing and walking (Slovis 2014). It is recommended to cease thoracic compressions after 10-15 minutes (Munsterman n.d.) if there is still no spontaneous respiration, circulation, pupillary light reflex and the foal has fixed, dilated pupils (Galvin, 2008). It is likely that the foal has suffered from cerebral hypoxia if unresponsive for this length of time (Munsterman n.d.).

AFTERCARE

If the resuscitation is successful and the foal is stable, it should be placed in an intensive care unit where it can be closely monitored and treated. This is important as repeated arrests are common within the first 24-48 hours (Dunkle, 2010). The foal will need a thorough physical examination, monitoring of hydration status and oxygen levels of their blood and tissues, electrocardiogram (ECG) monitoring, blood gas analysis, pulse oximetry, central venous pressure measurement and echocardiography, as this will give a thorough evaluation of the foal's cardiopulmonary system (Javsicas and Giguere, 2008).

Once CPCR has been successful, place the foal back with the mare in a clean stall and interfere only when needed. This will ensure that the pair are able to bond, and the mare will not reject the foal (Holtgrew-Bohling, 2016).

CONCLUSION

For the resuscitation of a neonatal foal to be successful, preparation is key. All necessary equipment needs to be working and readily available. Everyone involved must understand each role in the CPCR procedure and be able to carry out any aspect of it efficiently and effectively. This is important as the roles tend to alternate between ventilation, thoracic compressions and drug administration to prevent tiredness.

Training your clients in foal CPCR is beneficial as they can begin the process while waiting for veterinary assistance. It will also improve client-practice relationships as it shows that the practice is invested in the health of their animals. After successful CPCR, there is still risk of the foal having a repeat arrest or suffering from hypothermia due to its compromised thermoregulatory centre. Therefore, intensive nursing care and monitoring is required to ensure the foal becomes healthy and fully recovers.

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READER QUESTIONS AND ANSWERS

1: WHAT SIZE ENDOTRACHEAL TUBES ARE USED TO ESTABLISH AN AIRWAY IN A FOAL DURING CPCR?

A 7-12MM IN DIAMETER AND 55CM IN LENGTH.
B 8-10MM IN DIAMETER AND 50CM IN LENGTH.
C 7-12MM IN DIAMETER AND 50CM IN LENGTH.
D 8-10MM IN DIAMETER AND 55CM IN LENGTH.

2: WHAT IS THE PREFERRED METHOD OF INTUBATING A FOAL FOR CPCR?

A OROTRACHEAL INTUBATION.
B NASOTRACHEAL INTUBATION.

3: WHAT IS THE RECOMMENDED RATE FOR MANUAL VENTILATION DURING CPCR?

A 8-10 BREATHS PER MINUTE.
B 12-15 BREATHS PER MINUTE.
C 4-6 BREATHS PER MINUTE.
D 10-20 BREATHS PER MINUTE.

4: WHAT IS THE RECOMMENDED RATE OF THORACIC COMPRESSIONS DURING CPCR?

A 80-120 THORACIC COMPRESSIONS PER MINUTE.
B 100-120 THORACIC COMPRESSIONS PER MINUTE.
C 60-80 THORACIC COMPRESSIONS PER MINUTE.
D 80-100 THORACIC COMPRESSIONS PER MINUTE.

5: WHEN SHOULD CPCR BE STOPPED IF THERE IS STILL NO RESPONSE?

A AFTER 10-15 MINUTES.
B AFTER ONE HOUR.
C AFTER 30 MINUTES.
D AFTER 15-20 MINUTES.

ANSWERS: 1:A; 2:B; 3D; 4:B; 5:A