VetTalk
CPR Case Series

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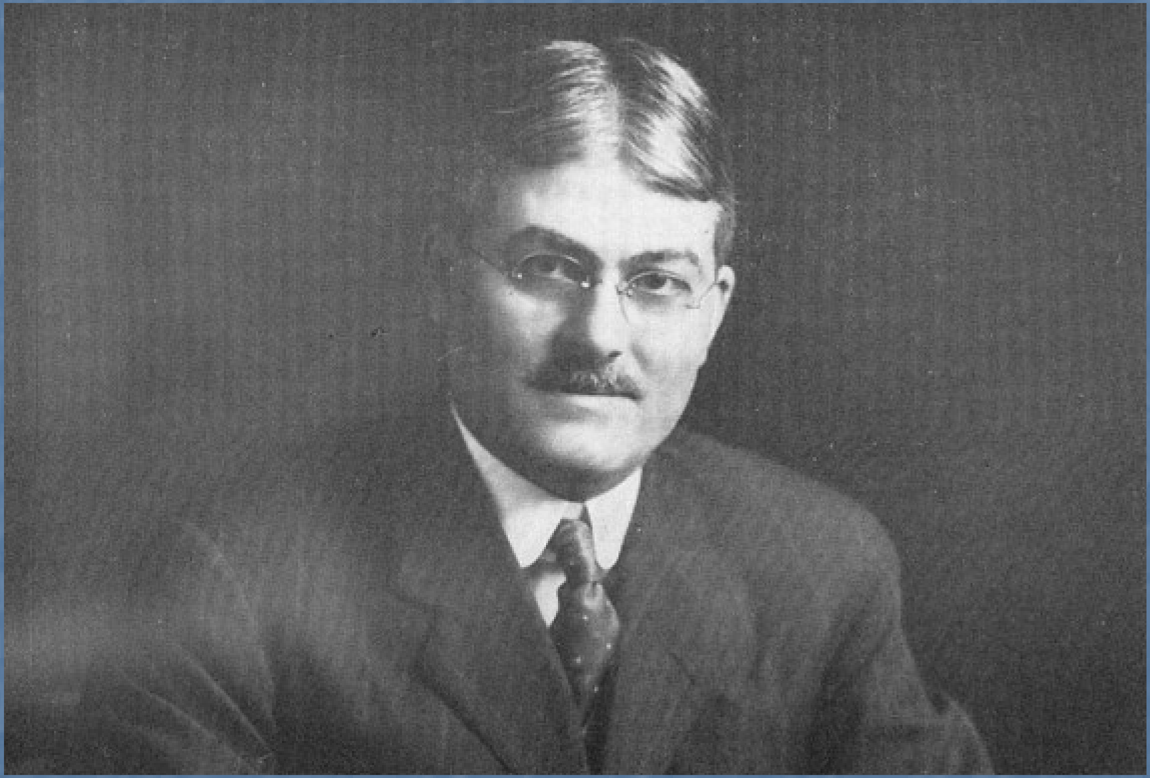
Just because we can…

doesn't mean we should!

CPR Steps

- Immediate recognition
- Emergency response team
- Advanced life support
  - Effective chest compressions
  - Correct ventilation
    - Airway, Ambu
  - Drugs
    - Venous access
  - Monitoring
    - ECG, capnography
  - Defibrillation
- Post resuscitation care

Epinephrine



George Washington Crile

Re… Chair 1800

…or 1899

1993 - 2013

- Total episodes 137 in neonates
  - 84 Foals
  - 17 Kids
  - 12 Lambs
  - 24 Piglets, Calves, Crias, Donkey foal, fawn
- At birth 93 – high risk births
  - 6% of 1568 attended births
- After birth 44
  - 1.6% of 2644 neonatal admissions

Definitions

- Only foals
- Required both
  - Respiratory support – ventilation
  - Cardiovascular support – chest compressions and/or drugs
- Excluded EXIT cases if not resuscitated after birth
- Excluded cases if resuscitation attempts < 5 min
- Did include cases with Apgar = 0 if resuscitation attempted
- At Birth vs. After Birth
- ROSC = return of spontaneous circulation
  - For at least 20 minutes
  - Arrest to ROSC defines an episode
- Survival
  - To hospital discharge

Rhythms

- Nonperfusing bradycardia - Brady
  - Apnea leading to bradycardia – Apnea/Brady
- Shockable rhythm – V-fib or V-tach
  - Ventricular fibrillation – V-fib
  - Nonperfusing ventricular tachycardia - V-tach
- Asystole – cardiac standstill
- Pulseless Electrical Activity - PEA

All Episodes

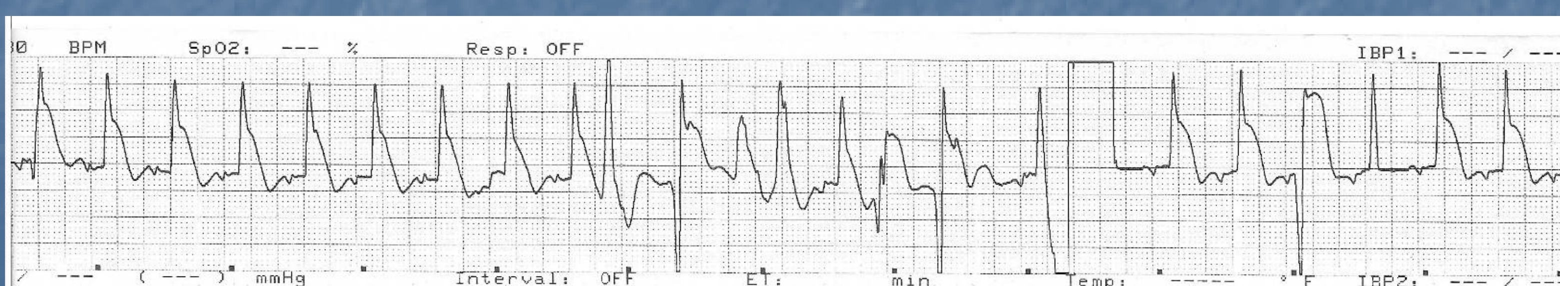
Rhythm	Episodes	ROSC	Survival
All episodes	84	41 (49%)	15 (20%)
Cardiac Arrest	49 (63%)	17 (35%)	5 (11%)
Non—perfusing Brady	29 (37%)	24 (83%)	10 (42%)
At Birth	46 (56%)	25 (54%)	12 (31%)
After Birth	38 (45%)	17 (45%)	4 (11%)

Etiology
After Birth Resuscitation

	Case	ROSC	Survival
All	36 (38)	17 (45%)	3 (9%)
Primary Cardiac Arrest	15 (42%)	8 (53%)	2 (14%)
Primary Respiratory Arrest	10 (28%)	5 (50%)	1 (20%)
Primary Shock	11 (31%)	4 (36%)	0

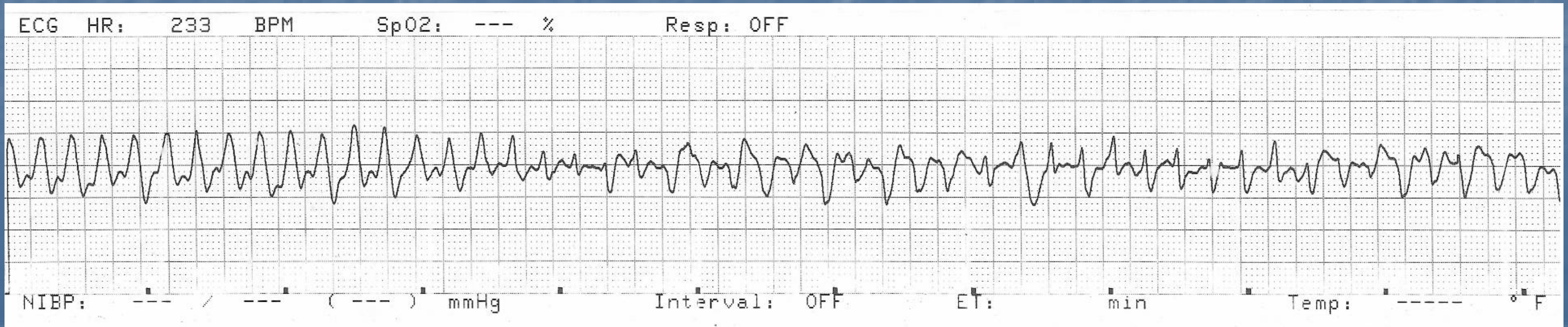
All Episodes
Initial Rhythms

Rhythm	Episodes	ROSC	Survival
All episodes	84 (78)	41 (49%)	15 (20%)
Brady	44 (56%)	30 (68%)	12 (32%)
Apnea/Brady	21 (27%)	13 (62%)	4 (22%)
V-fib	8 (10%)	4 (50%)	0
V-tach	5 (6%)	3 (60%)	1 (20%)
Shockable	13 (17%)	7 (54)	1 (8%)
Asystole	15 (19%)	1 (7%)	0
PEA	5 (6%)	3 (60%)	2 (50%)



Episodes
All Rhythms

Rhythm	Episodes	ROSC	Survival
All cases	84 (78)	41 (49%)	15 (20%)
Brady	51 (65%)	33 (65%)	12 (27%)
Apnea/Brady	21 (27%)	13 (62%)	4 (22%)
V-fib	25 (32%)	8 (32%)	0
V-tach	14 (18%)	7 (50%)	3 (21%)
Shockable	32 (41%)	13 (41%)	3 (10%)
Asystole	24 (31%)	1 (4%)	0
PEA	9 (12%)	4 (44%)	2 (25%)

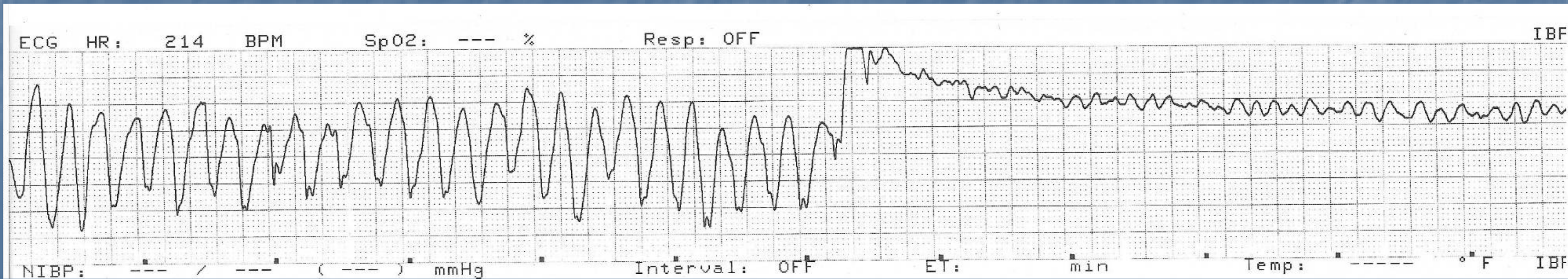


At Birth Resuscitation
All Rhythms

Rhythm	Cases	ROSC	Survival
All	43 (46)	25 (54%)	12 (26%)
Brady	24 (56%)	19 (79%)	10 (53%)
V-fib	9 (21%)	2 (22%)	0
V-tach	7 (16%)	4 (56%)	3 (43%)
Shockable	14 (33%)	6 (43%)	3 (23%)
Asystole	12 (28%)	1 (8%)	0
PEA	7 (16%)	2 (29%)	1 (17%)

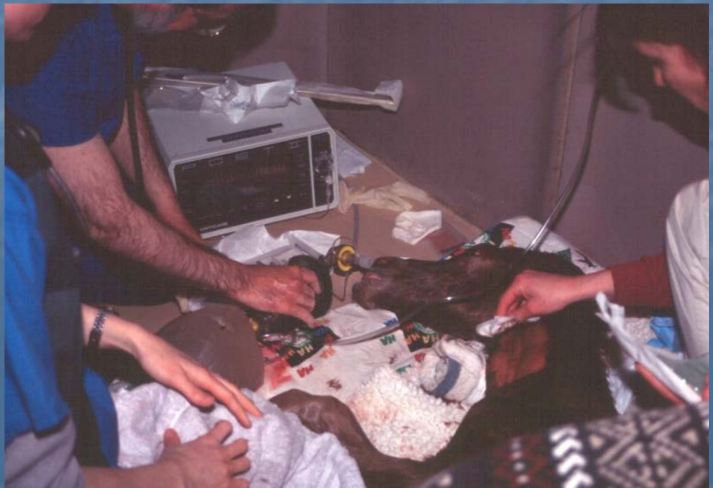
After Birth Resuscitation All Rhythms

Rhythm	Cases	ROSC	Survival
All	35 (38)	17 (45%)	3 (8%)
Brady	27 (77%)	14 (52%)	2 (8%)
V-fib	16 (46%)	6 (38%)	0
V-tach	7 (20%)	3 (43%)	0
Shockable	18 (51%)	7 (39%)	0
Asystole	12 (34%)	0	0
PEA	2 (6%)	2 (100%)	1 (50%)



CPR

Technique	Episodes	Birth Resuscitations	Neonatal Resuscitations
Episodes	84	46	38
Chest Compressions	70 (83%)	38 (83%)	32 (84%)
Ventilation	83 (99%)	45 (97%)	38 (100%)
Defibrillation	24 (29%)	7 (15%)	17 (45%)
Epinephrine	79 (98%)	43 (99%)	36 (97%)



Defibrillation

- Attempts
  - Series c   n-shockable
  - 1-12 sh
  - 3-15 sh
- During 2   est
  - 37 defil
  - 26 succ
  - ROSC 7   revive

Drugs

Drug	Cases	ROSC	Survival
Epinephrine	79	38 (20%)	14 (19%)
High Dose Epinephrine	24	8 (33%)	2 (9%)
Vasopressin	25	13 (52%)	5 (21%)
Lidocaine	15	7 (47%)	2 (15%)
Bretylium	8	3 (38%)	0
Atropine	10	6 (60%)	1 (13%)

Outcomes
Cardiac Arrest vs. No Cardiac Arrest

- Nonperfusing Bradycardia only
  - Cases – 29
  - ROSC – 24 (83%)
  - Survival - 10 (34%)
- Cardiac Arrest
  - Cases 49
  - ROSC – 17 (35%)
  - Survival – 5 (10%)

Outcomes
Cardiac Arrest vs. No Cardiac Arrest

- 44 (90%) deaths – Cardiac Arrest Cases
  - 34 (77%) could not revive
  - 5 (11%) because of underlying disease
  - 3 (7%) because of sequela (CNS)
  - 3 (7%) economic euthanasia

- 19 (66%) deaths – Nonperfusing Bradycardia
  - 10 (53%) because of underlying disease
  - 5 (26%) could not revive
  - 5 (26%) economic euthanasia
  - 0 because of sequela (CNS)

Summary
Dogma Upheld

- These foals are trying to die - few will be saved
- At birth better outcome (31%) than after birth (11%) (OR 4.1)
- 64% could not be revive during arrest
  - 23% died/euthanized because of underlying disease
- V-fib, asystole as initial rhythm or anytime
  - Bad news

Summary
Dogma Upheld

- Initial rhythm bradycardia has good outcome (32%)
  - Likelihood of ROSC uncomplicated bradycardia (80%, OR 9)
  - Likelihood of survival uncomplicated bradycardia (42% OR 4.6)
  - Early treatment of bradycardia before cardiac arrest
- Uncomplicated bradycardia associated with primary respiratory arrest (OR 13)

Summary
Dogma Refuted

- 20% of these cases can be sent home
- Only 3 cases had neurologic sequela
- Only 4 cases had repeat episodes (2 each)
- Defibrillation very effective in converting rhythm (70%)
  - But may not result in ROSC
- Primary cardiac arrest, respiratory arrest and shock all important etiologies
  - Primary cardiac arrest – increased risk of V-fib (OR 6.2)
  - ROSC and survival not associated with etiology

Summary
Dogma Refuted

- No matter what the rhythm (except asystole)
  - ROSC in 40 - 65%
- Survival not associated with length CPR
- Epinephrine – is it helpful?
  - High dose epi does not influence outcome
  - Drugs in general don't influence outcome
- Initial apnea not always lead to Bradycardia
  - But to asystole, V-fib, PEA

VETTALKS ON CUTTING EDGE RESEARCH IN CRITICAL CARE: CPR CASE SERIES

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All of us who treat critically ill neonates find ourselves from time to time caring for patients who develop acute cardiopulmonary arrest. When this happens we all face the question of whether or not we should initiate Cardiopulmonary Resuscitation (CPR). Beyond the ethical question of whether or not it is humane to revive a neonate dying of a serious underlying disease is the question of the futility of the effort versus the likelihood of success. Over the past few years at meeting like this, on professional email lists and in informal conversations with colleagues I have heard it stated that CPR is futile as it is "never successful." My recollection of our past experiences is quite the opposite. That although by their nature, any case requiring CPR is dying and has a high likelihood not to survive hospitalization, CPR can revive some such cases and some of these may survive. Of course our memories often lie to us and recollections of outcomes can be colored by an overly optimistic or pessimistic selective memory. So I decided to look back at the cases requiring CPR we have seen over the past 20 years. This is easier said than done as such cases are not coded so can't be searched for in our medical record database and if they don't make it out of the recovery stall when being born from a dystocia/C-section may not even be a assigned a medical record. Fortunately it has been my routine to assign a "scribe" to take minute by minute notes during births and cardiac arrest resuscitations when extra hands are available (a luxury often found working in an academic setting) or when there are no extra hands to carefully record the events in as much detail as possible minutes after the event. I maintain copies of these clinical notes and it is from those notes, my personal notes and copies of correspondence that the information for this case series was taken. As a consequence I attended and directed almost all of the CPR efforts in this series.

As with any retrospective case series involving therapeutic interventions the techniques used have been modified over the past 20 years so this is far from a homogeneously treated group. Although some parts of the CPR routine has remained the same such as cardiac compression technique and measuring effectiveness of increasing cardiac output with capnography, other parts have changed with time such as ventilation techniques, shock delivery timing and drug choices, dosages and delivery techniques. Over the years the CPR technique has been changed in response to practical anecdotal experience, evidence based studies in other species and especially from studying the International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations which is revised every 5 years. The more recent effort in small animal intensive care (Reassessment Campaign on Veterinary Resuscitation RECOVER) has also been helpful. Clinical techniques are continually evolving as our experience and understanding increases. The following is a brief description of highlights of our current techniques.

Our experience on the optimal sequence of CPR priorities agrees with those recommended by the 2010 International Consensus on Cardiopulmonary Resuscitation. While the A-B-C sequence (Airway, Breathing, Chest compressions) is retained for birth resuscitation cases, the C-A-B (Chest compressions, Airway, Breathing) sequence is optimal for all other cases. At birth the most common cardiopulmonary arrest occurs when a nonperfusing bradycardia follows a period of apnea or a period of intrapartum asphyxia. In these cases initiation of ventilation will often rapidly convert the nonperfusing bradycardia without the need of cardiac compressions or drug therapy. In anticipation of this possible problem appropriate respiratory equipment is at hand for all attended births making rapid delivery of respiratory support our standard intervention (A-B-C). On the other hand when a neonates suffers cardiopulmonary arrest during hospitalization, even when anticipated it takes longer to organize the respiratory equipment so it has become our routine that the caregiver who identifies a nonperfusing rhythm begin cardiac compressions while simultaneously calling for respiratory and other vital equipment (C-A-B). Chest compressions are delivered to large neonates by kneeling between the front and hind legs with the neonate in lateral recumbency and withers against a brace (usually a wall) with the operator keeping his arms extended and using the upper body weight and bending at the hips to deliver the compression. In small neonates the 1 or 2 thumb technique is used where chest is squeezed between the thumb on one side of the chest and the fingers from the same hand on the other side. The chest is compressed at least 1/3 of its thickness and the rate is at least 100 per minute. Half of the duty cycle is compression and half allowing for full rib spring to return chest to full resting volume (full recoil). Pauses in cardiac compressions are kept to less than 10 sec. with at least 2 minutes of chest compressions between pauses. In large neonates capnography is used to determine cardiac output and by watching the effect of modifying compression technique on $ETCO_2$ values it helps optimize the compression technique to get the best cardiac output. Increases in $ETCO_2$ also signals return of spontaneous circulation (ROSC). Mouth-to-nose ventilation is used until endotracheal tube and self-inflating bag is available. Although the first breath at birth may have a short inspiratory pause to allow the lungs to reach FRC, as long as a nonperfusing cardiac rhythm is present the inspiratory time should be no more than 1-2 sec., tidal volume small and rate no more than 8 to 10 per minute. This ventilation technique is designed to maximize perfusion when performing chest compressions but with the inciting cause is respiratory failure some modifications may need to be made. When defibrillating a dose of 2 to 4 j/kg is delivered once with resuming cardiac compressions immediately and continuing at least 2 minutes before checking the rhythm and delivering a subsequent shock if needed. For large neonates we routinely use a paddle extension which can be placed on the downside chest and the second paddle is placed on the upside of the chest so the charge is directed through the body (through the heart). It is very important to clip the hair where the paddles are place and to use a conducting defibrillation gel (not ultrasound gel which is non-conducting!) to insure good body wall contact and decreased impedance at the electrode–chest wall interface. Our routine is to use 0.02 mg/kg epinephrine IV or IO whenever possible but there are situation where the only available route is intratracheal (IT) as when performing the EXIT procedure. When delivered IT we use 0.1 mg/kg dose of epinephrine as suggested in the 2010 International Consensus on Cardiopulmonary Resuscitation. Otherwise it is rare for our cases to receive high dose epinephrine except out of desperation. We also routinely use vasopressin, occasionally use lidocaine and rarely use atropine, calcium and bicarbonate during resuscitations.

Eighty three (83) neonates were identified as having received advanced life support between 1993 and 2013. To qualify a case had to require assisted ventilation and cardiac support (cardiac compressions and/or drugs). Neonates born while their mothers were anesthetized or under heavy sedation who required assisted ventilation but no specific cardiac support were not included. General conclusions will be presented here. More specifics will be reported during the talk. Foals make up 80% of the cases but other large animal neonates were also included in the series. Half of the cases were resuscitated at birth (2.9% of the attended births during the time period) and the others ranged from 1 hr. to 23 days old (1.4% of hospitalized critical neonates). The 83 cases had a total of 88 cardiac arrest episodes. CPR resulted in return of spontaneous circulation (ROSC) in about half of the episodes. The rhythm initially identified most often was a nonperfusing bradycardia, half of which were preceded by apnea. Asystole was the initial nonperfusing rhythm in about 20% of the cases and a nonperfusing ventricular tachycardia or ventricular fibrillation in about 10% of the cases. During CPR it is common for one arrhythmia to be transformed into another. Almost 70% of cases had a nonperfusing bradycardia sometime during CPR with over half of these associated with initial respiratory failure. ROSC was achieved in over 60% of these cases. A shockable rhythm (ventricular tachycardia or ventricular fibrillation) was present sometime in a third of the cases and ROSC was achieved in 40% of these cases. Asystole was present sometime in about 40% of cases but ROSC was only achieved in 10% of these cases. PEA occurred in about 10% of the cases with ROSC in about 40% of these cases.

When only those cases requiring CPR at birth or within minutes of birth are considered again the most common initial arrhythmia was a nonperfusing bradycardia (about 60% of cases) with half preceded by apnea. ROSC was achieved in more than 90% of these cases. Asystole was the initial arrhythmia in about 25% of these cases. ROSC was only achieved in 10% of the cases with asystole. PEA occurred in 10% of the cases with ROSC achieved in half these cases. At some point during the birth resuscitation about 20% of the neonates developed a shockable rhythm. ROSC was achieved in just after half of these cases. ROSC was gained in over 60% of neonates during birth CPR.

When cases which arrested 1 or more hours after birth nonperfusing bradycardia was again the most common rhythm being the initial rhythm in 70% of the cases and occurring sometime during CPR in 80% of the cases. Again about half of these cases were preceded by apnea or respiratory failure. ROSC was possible in just under half of these cases. Asystole was the initial arrhythmia in almost a third of the cases and occurred sometime in these cases about 45% of the time. ROSC rarely occurred in cases with asystole. Although a shockable rhythm was only present initially in about 20% of cases, it developed sometime during resuscitation efforts in almost half of the cases. ROSC was achieved in about 40% of these cases.

When a shockable rhythm was identified (ventricular tachycardia or ventricular fibrillation) conversion was attempted by electrical defibrillation. The details from 32 defibrillation episodes were recorded. A defibrillation episode consisted of 1 or more shocks interspersed with CPR which was continued until the heart rhythm was converted to a non-shockable rhythm or resuscitation efforts were discontinued. The shockable rhythm was converted to a non-shockable rhythm 23 times (72% of the episodes) in 20 of the patients. Of these ROSC occurred in 40% of the neonates.

In cases of cardiac arrest occurring in hospitalized neonates after birth the inciting cause of the arrest appeared to be respiratory failure in about 40% of the cases, hypoperfusion from septic shock/cardiogenic shock in about 25% of the cases and an apparent primary cardiac event in about 25% of cases with the underlying cause in the remaining 10% of cases being uncertain.

Capnography was very useful in monitoring effectiveness of cardiac compressions and onset of ROSC but not in predicting futility. Fourteen percent of the cases where ROSC was achieved had an $ETCO_2 \leq 10$ mmHg at one point during the CPR and 7% had an $ETCO_2 \leq 5$ mmHg (basically undetectable) at one point during CPR.

In over half the episodes of cardiac arrest resuscitation successfully resulted in ROSC. Of the cardiac arrests occurring at birth ROSC was achieved in about 60% of the cases but in cardiac arrests not occurring at birth ROSC was achieved in less than 40% of the cases. Of all of the cases only 18% were discharged from the hospital. This is not unexpected as cardiac arrest primarily occurs in patients with the most severe underlying disease. Of the non-survivors 66% could not be revived during CPR, 21% died or were euthanized because of their underlying disease problems, 6% were euthanized because of neurologic disease which were likely sequela to the cardiac arrest and 7% were euthanized because of financial considerations.

CPR in neonates with cardiac arrest can be successful returning the patient to spontaneous circulation in about half the attempts. Neonates suffering cardiac arrest are among our most critical patients and so survival to hospital discharge is low. However, severe neurologic sequela, a significant morbidity in human medicine, is not common, occurring in only 6% of patients. Revival is most likely in neonates with nonperfusing bradycardia and least likely in neonates with asystole. Many patients have a variety of rhythms during resuscitation. A shockable rhythm may occur in at least a third of the neonates with cardiac arrest. These rhythms can be converted with defibrillation in most cases. If defibrillation is not readily available up to 20% of neonates undergoing birth resuscitation and up to 40% of patients undergoing resuscitation not associated with birth may not be revived.

Before CPR is undertaken the ethics of initiating the treatment needs to be considered. If treatment of the underlying disease processes leading to cardiac arrest is futile then initiating CPR is not humane. In such cases the decision not to resuscitate the patient if in cardiac arrest should be made before the arrest occurs. I feel strongly the clinician guided by medical knowledge of the problems the neonate faces is in a better position evaluate the futility of therapy and should make this decision on humane grounds rather than the owner who is primarily guided by emotions.

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