



Beyond ATLS: Pregnancy-Specific Modifications in Trauma Resuscitation

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Disclosures



- Principal Investigator
 - R18HS026169: Advances in Patient Safety through Simulation Research grant
 - 1R18HS029639-01: Adaptation of an Evidence-Based Curriculum to Teach the Prevention, Evaluation and Treatment of Maternal Medical Emergencies for Pre-hospital & Hospital Healthcare Workers in Rural Context
 - 1R18HS029814-01: Implementation of a Maternal Resuscitation Curriculum in a Regionalized Perinatal Health System: Maximizing the Chain of Survival to Reduce Maternal Health Inequities
- Member, Varda5, LLC, owns exclusive sublicense for OBLS

Learning Objectives



- Learning objective #1: Discuss the prevalence of trauma in pregnancy and physiologic changes of pregnancy that impact care of the pregnant trauma patient
- Learning objective #2: Describe the management of pregnant women with minor and major trauma – at the time of event as well as subsequent prenatal care
- Learning objective #3: Describe steps in resuscitation of traumatic maternal cardiac arrest

Trauma in Pregnancy: Why It Matters



- Leading cause of non-obstetric maternal mortality
 - Occurs 6-7% pregnancies (1 in 12 women)

https://www.cdc.gov/maternal-mortality/php/data-research/index.html#cdc_research_or_data_summary_res_data-the-data, accessed 5/3/2026
Mendez-Figueroa AJOG 2013

Underlying Causes of Pregnancy-Related Deaths

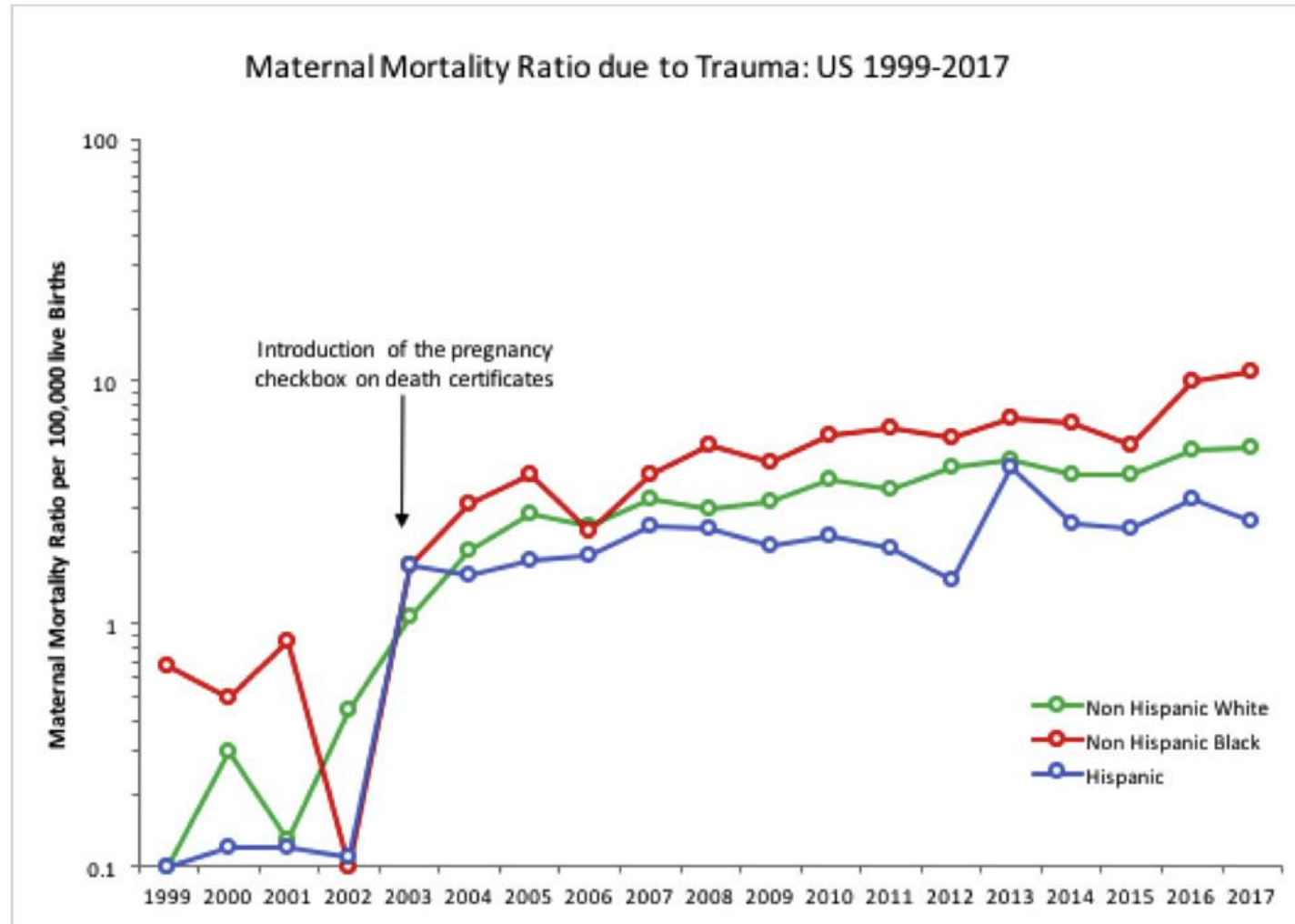
Data From Maternal Mortality Review Committees in 38 U.S. States, 2020

Condition	Number of pregnancy-related deaths	
	Number	%
Mental health conditions ^d	115	22.5
Cardiovascular conditions	85	16.6
<i>Cardiomyopathy</i>	35	6.8
<i>Other cardiovascular conditions^e</i>	50	9.8
Infection	84	16.4
<i>COVID-19</i>	54	10.6
Hemorrhage	57	11.2
Embolism	44	8.6
Hypertensive disorders of pregnancy	36	7.1
Amniotic fluid embolism	19	3.7
Injury	11	2.2
Cerebrovascular accident	10	2.0

Figure 2. MMR and Rate Ratios for trauma related maternal deaths by race from 1979-2017

Years 1979-2017	Maternal Deaths	MMR associated with Trauma	
Totals			
Overall births	152,268,131		
Overall maternal deaths	29,088		19.1
Deaths due to trauma within 42 days	2142		1.41
Deaths due to trauma within 365 days	2119		14.4
Deaths due to trauma within 365 days		Unadjusted RR	Adjusted RR
1999-2000	19 (0.24)	Reference (1.00)	Reference (1.00)
2009-2010	216 (2.65)	14.16 (8.94, 22.54)	15.58 (9.67, 25.12)
2016-2017	273 (3.49)	21.61 (13.64, 34.23)	26.69 (16.61, 42.87)

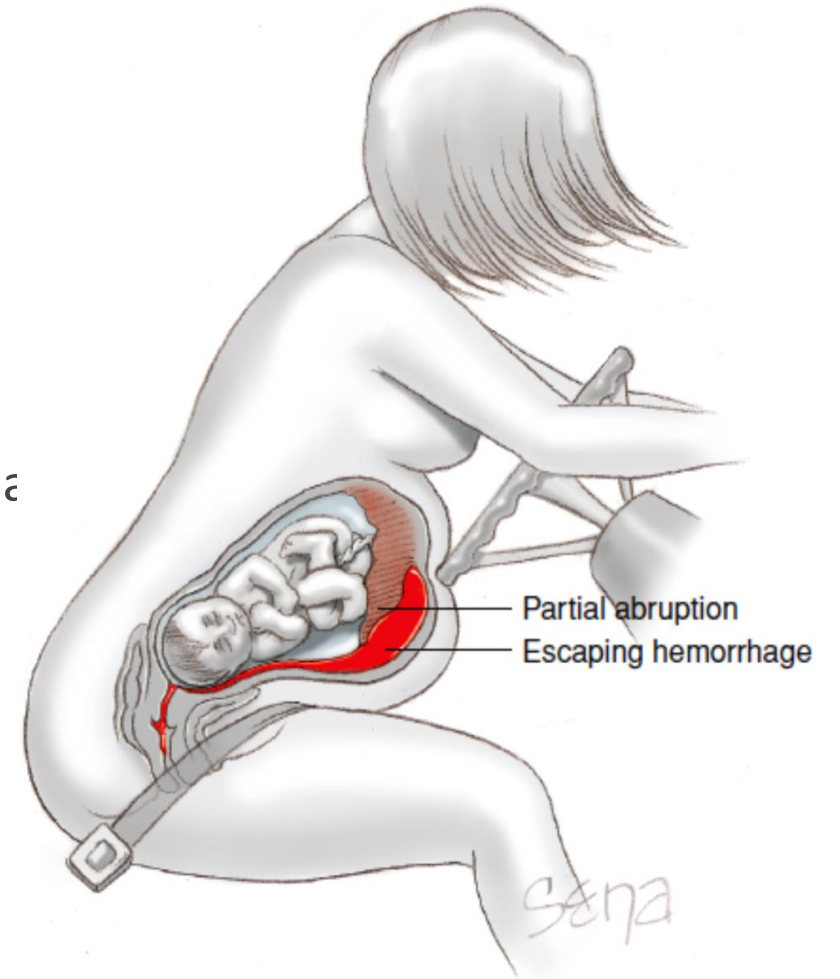
Maternal Mortality Rates due to Trauma in U.S. 1999 - 2017



Trauma in Pregnancy: Challenges



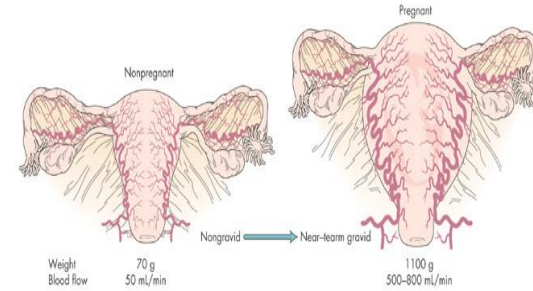
- ✓ Distorted anatomy altering surgical management
- ✓ Two+ patients require evaluation and management
- ✓ Difficult airway
- ✓ Physiologic changes of pregnancy
- ✓ Younger population (hemorrhage check may show late signs)
- ✓ Limited experience in Eds
- ✓ Limited professional guidelines
- ✓ Outcomes depends on:
 - ✓ early recognition
 - ✓ Maternal resuscitation



Pregnancy Physiology: CV Changes



- ↑ Blood volume, 10% to uterus
- ↓ SVR, ↑ HR
- Cardiac workload significantly increased
- Systolic ejection murmurs grade I-II are normal
- Aortocaval compression → ↓ venous return
- Hormones of pregnancy impeded vascular responsiveness <https://obgynkey.com/emergency-hysterotomy/>



Parameter

Heart rate (HR)

Stroke volume (SV)

Cardiac output (CO)

Systemic vascular resistance (SVR)

Oncotic pressure

Values in Pregnancy

↑ 20%

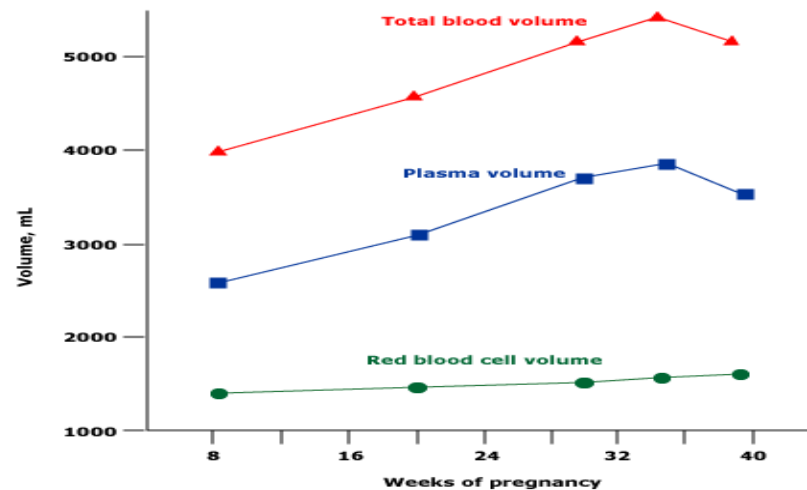
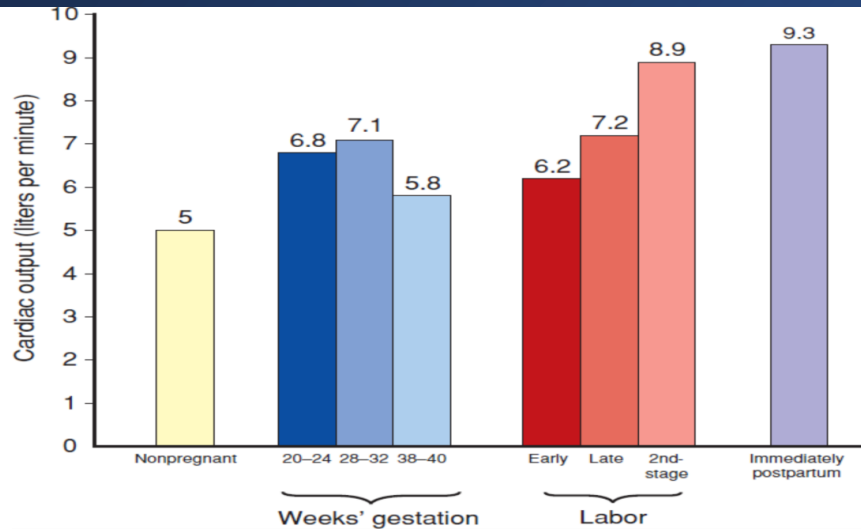
↑ 30%

↑ by more than 40%

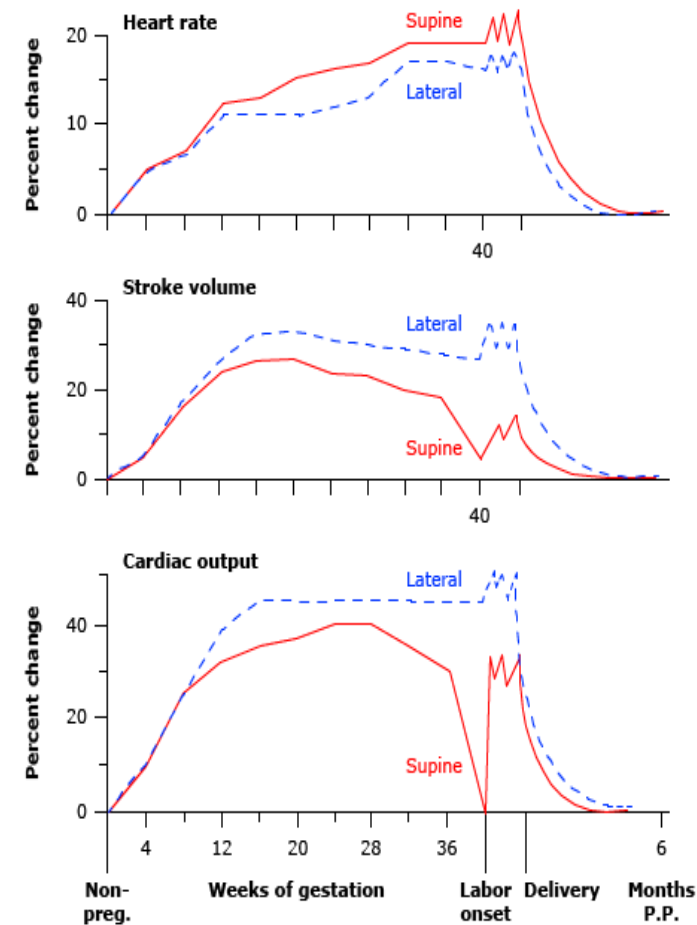
↓ by more than 30%, nadir at 32 weeks

↓ due to hemodilution and decreased serum albumin

Physiologic Changes in Pregnancy Cardiovascular



Systemic hemodynamics during normal pregnancy



Physiologic Changes in Pregnancy (Clotting Factors)



Parameter	Non-pregnant	Term Pregnant
Activated PTT (sec)	31.6 ± 4.9	31.9 ± 2.9
Fibrinogen (mg/dL)	256 ± 58	473 ± 72
Factor VII (%)	99.3 ± 19.4	181.4 ± 48.0
Factor X (%)	97.7 ± 15.4	144.5 ± 20.1
Plasminogen (%)	105.5 ± 14.1	136.2 ± 19.5
tPA (ng/mL)	5.7 ± 3.6	5.0 ± 1.5
Antithrombin III (%)	98.9 ± 13.2	97.5 ± 33.3
Protein C (%)	77.2 ± 12.0	62.9 ± 20.5
Total protein S (%)	75.6 ± 14.0	49.9 ± 10.2

Pregnancy Physiology: Respiratory Changes



Respiratory Rate (RR)

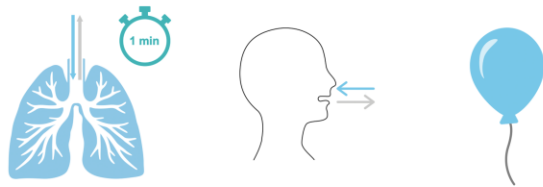
- ✓ Usually unchanged or slightly increased.
- ✓ Normal: 12–20 breaths per minute.
- ✓ However, tidal volume and minute ventilation increase due to progesterone-driven respiratory center sensitivity to CO₂ → RESPIRATORY ALKALOSIS

↓ Functional residual capacity by 20%

↑ Edema in airway leading due to hormone changes and increased blood volume

↑ O₂ consumption by 20%

Elevated diaphragm



Minute ventilation = respiratory rate (RR) × tidal volume (V_T)

Clinical Implications:

- ✓ Normal end tidal CO₂ in pregnancy: 30-35 mmHg
- ✓ When PaCO₂ values are > 42mmHg, evaluate for respiratory decompensation
- ✓ Lower threshold for intubation due to potential for aspiration and rapid hypoxia

ANTICIPATE MORE DIFFICULT AIRWAY

- ✓ preoxygenate prior to intubation
- ✓ most experienced should intubate
- ✓ Be prepared for cricothyrotomy

Pregnancy Physiology: Other Changes



Gastrointestinal

- ✓ ↑ progesterone relaxes lower esophageal sphincter (LES) and rises uterine pressure.
- ✓ ↑ aspiration risk

Breast tissue

- ✓ Can be more dense, larger
- ✓ May interfere with lateral AED pad placement

Mechanisms of Injury



- MVC (most common)
- Falls and slips
- Assault/IPV
- Penetrating trauma

TABLE 2

Estimated incidence/prevalence of injury by type of trauma during pregnancy

Mechanism of injury	Estimated incidence/prevalence in pregnancy	Study design	Estimated incidence/prevalence outside of pregnancy
Motor vehicle crashes	207/100,000 live births ¹¹	Population-based cohort	1104/100,000 women ^{c99}
Falls and slips	48.9/100,000 live births ²⁴	Retrospective case-control	3029/100,000 women ¹⁰⁰
Burns	0.17/100,000 person-years ²⁷	Retrospective case-control	2.6/100,000 person-years ²⁷
Accidental poisoning	N/A	N/A	N/A
Domestic violence	8307/100,000 live births ¹⁰¹	Review	5239/100,000 women ^{c44}
Suicide ^a	2/100,000 live births ⁶¹	Retrospective cohort	8.8/100,000 population ^{c102}
Homicide	2.9/100,000 live births ⁶¹	Retrospective cohort	2.3/100,000 women ¹⁰⁰
Penetrating trauma ^b	3.27/100,000 live births ^{c62}	N/A	3.4/100,000 women ^{c62}
Toxic exposure	25.8/100,000 person-years ¹⁰³	Retrospective cohort	115.3/100,000 person-years ¹⁰⁴

Literature relating to incidence of burns during pregnancy is limited to most severe cases admitted to burn units and referral centers. Rate for accidental poisoning during pregnancy could not be calculated from available published literature. Domestic violence incidence includes all forms of partner violence: sexual, physical, and psychological.

N/A, not available.

^a Rates exclude attempted suicides. Attempted suicide rate during pregnancy is approximately 40/100,000 pregnancies⁶⁵ and during postpartum period is 43.9/100,000 live births⁶⁶; ^b Rates include only causes leading to fatality; ^c Rates calculated using 2009 US data from Centers for Disease Control and Prevention.

Mendez-Figueroa. Trauma in pregnancy. *Am J Obstet Gynecol* 2013.



MVC and pregnancy

- 207 per 100,000 pregnancies
 - 92,500 women injured annually
 - Fetal mortality
 - 1.4/100,000
 - Maternal mortality
 - 3.7/100,000
- 87% receive medical care, majority admission >20 weeks gestation
- Risk factors: use of intoxicants, improper seat belt use
 - ½ pts reported having received proper seat belt use from prenatal care provider



Seat Belt Use in Pregnancy



- County Prenatal Clinical Survey, n=450, 92% response rate
- 73% rate of correct use
- Reasons for lack of use:
 - Discomfort (53%)
 - Forgetfulness (37%)
- 10% believed seatbelts are harmful
- 1/3 unsure of effects seatbelt on fetus

McGwin 2004 J Trauma

How to Wear Your **Seat Belt** While **Pregnant**

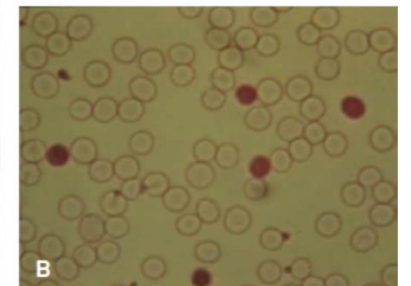
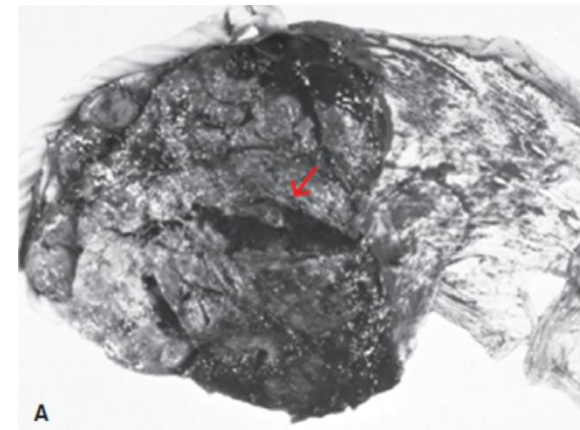
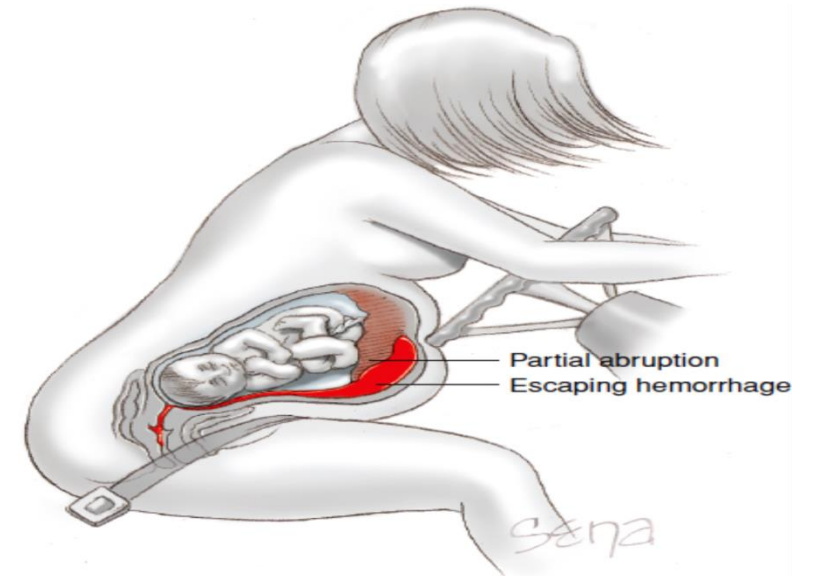


1. ALWAYS wear your seat belt... even in the back seat.
2. Lift belly up - make sure lap belt is low & flat on tops of thighs
3. Pull upwards on shoulder belt to make lap belt snug
4. Shoulder belt lays between breasts
5. Tilt steering wheel upwards, if possible
6. Keep vehicle seat as upright as possible: reclining increases the chance of the lap belt pressing on the uterus in a crash.
7. Slide front seat as far back as possible - to sit as far away from airbag

MVC and pregnancy



- Obstetrical concern → Strain on uterus → placental abruption
- “Contrecoup” and shear-force strain
- Among severely injured women (ISS >12), placental abruption occurs in as many as **40% of cases**



Slips/Falls in Pregnancy



- Overall 49 per 100,000 deliveries
- 1 in 4 women will fall at least once in pregnancy
- Complications proportional to force and body part impacted
 - Fracture lower extremity most commonly associated injury when hospitalized (40%)
 - 3% fetal loss due to falls
- Of 639 hospitalized pregnant women after fall
 - PTL, RR 4.4
 - Abruption, RR 8
 - Fetal distress, RR 2.1
 - Fetal hypoxia, RR 2.9

Domestic Partner Violence/Intimate Partner Violence and Pregnancy



- >60 studies from >20 countries: rates 1-57% (22% in general female population)
- Risk factors:
 - substance abuse, low maternal education level, low socioeconomic status, unintended pregnancy, h/o DV in prior pregnancy, h/o witnessed violence as child, unmarried
- Adverse pregnancy outcomes:
 - SAB, NICU admission, PTB, low birthweight
- Strong association between peripartum depression and antenatal DV
 - Prospective cohort 13,617mom/baby dyads 42 months pp
 - Antenatal depression OR 4.02
 - Postpartum depression OR 1.7

Penetrating Trauma



- Of 321 women with abdominal trauma
 - 9% Penetrating injuries
 - 77% GSW, 23% stab wounds
- Altered pattern of injury
 - Visceral injury 15-40% (compared to 80-90% non-pregnant)
 - Below fundus
 - High fetal mortality rate: 40-70%
 - Lower maternal mortality rate: 4-7%
 - Above fundus
 - Bowel and solid organ injury



Minor Trauma



TABLE 3
Associated risk and test characteristics of predictors of the composite adverse pregnancy outcome

Predictor variable	Unadjusted RR	95% CI	Sensitivity	Specificity	Positive predictive value	Negative predictive value
Positive KB	2.12	0.70-6.42	4.1%	98.5%	40.0%	81.2%
Fibrinogen <200	2.64	0.64-10.78	2.0%	99.5%	50.0%	81.0%
>5 contractions/h	0.71	0.42-1.19	41.7%	47.8%	15.7%	77.8%
Abdominal pain	1.04	0.46-2.39	10.2%	90.3%	24.3%	81.6%
Anterior placenta	1.00	0.60-1.67	40.8%	59.2%	19.2%	80.8%
Direct abdominal trauma	1.32	0.70-2.50	18.4%	86.4%	20.0%	80.9%

Cahill. Minor trauma in pregnancy. Am J Obstet Gynecol 2008.

- Prospective cohort 3 yrs, n=317
- “Minor” trauma excluded life-threatening injuries, any injuries greater than bruising/lacs/contusions = ISS 0
- Falls (48%), MVC (29%), assaults (87%)
- 14% patients with regular contractions 1st 4 hrs
- 1 abruption = 35 wks, fall from standing → abruption 41 wks
- Of the predictors – no single variable sensitive/specific to predict clinical outcomes.

Obstetrical Risks of Trauma in Pregnancy

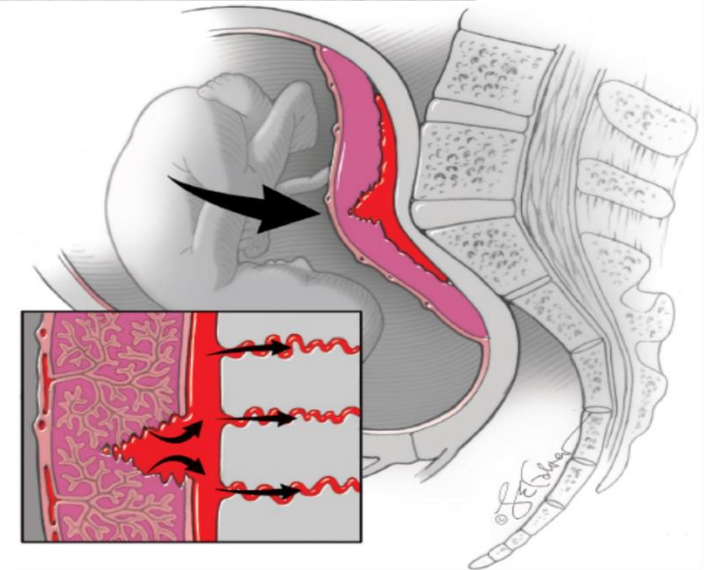
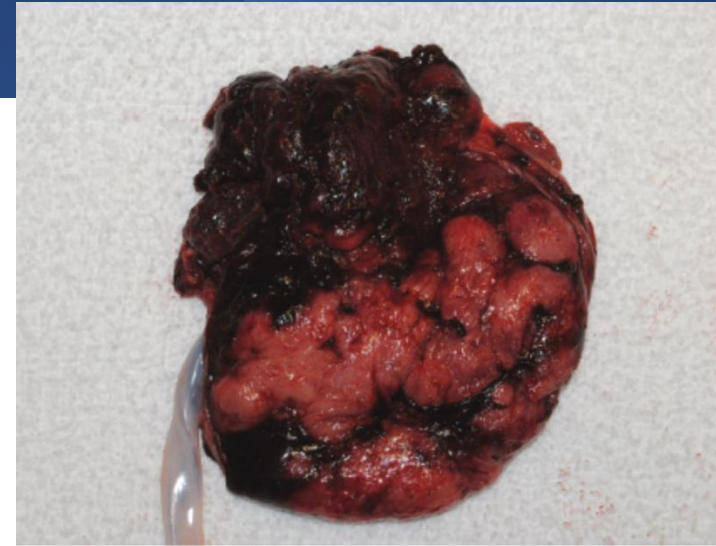


- Miscarriage
- Preterm premature rupture of membranes
- Preterm birth
- Uterine rupture
- Cesarean delivery
- Placental abruption
- Stillbirth
- Neonatal demise

Abruption



- Catastrophic events with blunt trauma:
 - include abruption and placenta tear
- Deformation elastic myometrium around inelastic placenta
- 1-6% “minor injuries”, 50% “major injuries”
- Considerable force → placental fracture
- More likely to be concealed (no VB) with increased risk of coagulopathy compared to non-traumatic abruption
- Si/sxs: VB, uterine TTP, fetal tachycardia, late decelerations, acidosis, fetal death



Preterm Labor



- Incidence following trauma <5%
- Causes
 - Uterine injury → destabilization of lysosomal enzymes → PG production
 - Premature rupture of membrane
 - Abruptio

Uterine Rupture



- 0.6% injuries during pregnancy
- More likely in prior scarred uterus, associated with direct impact significant force
- 75% cases involve the fundus
- Fetal mortality approaches 100%
- Maternal mortality 10% (usually due to severity of injuries)



(a)



(b)

Fetal Deaths Related to Maternal Injury



- Retrospective study of fetal deaths
- 16 states (55% of US live births), 15,000 Fetal Deaths
- 240 traumatic fetal deaths, 3.7 per 100,000 live births
- Causes:
 - MVC (20%); firearm (6%); falls (3%)
 - 27 maternal deaths (11%)

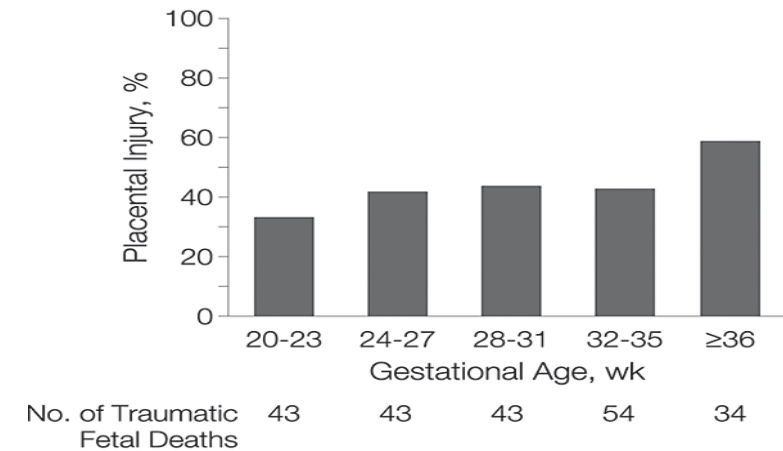


Table 3. Rate Ratio (RR) for Selected Medical Factors, Fetal Deaths Compared With Normal Live Births*

Selected Medical Factors	Frequency (%) Among Fetal Trauma Deaths	Frequency (%) Among US Live Births†	RR of Trauma to Live Births (95% Confidence Interval)
Fever	5 (2.1)	61 850 (1.6)	1.3 (0.5-3.1)
Abruptio placenta	48 (20.0)	22 062 (0.6)	35.1 (26.4-46.6)
Placenta previa	2 (0.8)	12 915 (0.3)	2.5 (0.6-9.8)
Other excessive bleeding	8 (3.3)	21 142 (0.6)	5.8 (2.9-11.7)
Breech/malpresentation	5 (2.1)	146 431 (3.8)	0.5 (0.2-1.3)

*Selected medical factors are shown only for conditions with counts of 5 or more.

†Data from Ventura et al.²⁸

Management of Trauma in Pregnancy



RULE #1

Mother first – fetus second

Maternal stabilization = fetal survival



Management of Trauma in Pregnancy



- *With few exceptions, treatment priorities in injured pregnant women are directed as they would be in non-pregnant patients*
- DON'T BREAK THE ROUTINE...
 - Basic rules of resuscitation CABs...
- LEFT LATERAL TILT... ensure large uterus is positioned off the great vessels to diminish its effect on vessel compression and decreased cardiac output

Primary Survey



ABCs

- A** ✓ Early airway control: Aspiration risk
- B** ✓ Oxygenation critical (fetal oxygen dependent on mother)
- C** ✓ Aggressive hemorrhage control
- D** ✓ GCS, neuro status (TBI is an independent predictor of fetal loss)
- E** ✓ Full exam (don't miss injuries)

Injury Severity Score (ISS) in pregnancy



- Maternal and fetal outcomes directly related to severity of injury
 - ISS ≥ 8 associated with increased risk of severe adverse pregnancy outcomes (ICU and death), AUC 0.990 ± 0.006
- Low ISS score does not rule out maternal/fetal morbidity or prolonged hospitalization
 - ISS > 3 predictive of short term adverse perinatal outcomes (NICU, PPRM, abruption, PTB < 37 wks, low birth weight and perinatal death)
- Poor predictor of adverse maternal or fetal outcome (abruption, preterm labor, preterm birth, fetal death)

Schiff MA et al., 2005

Cahill 2008

Dalton 2023 AJOG MFM

Secondary Survey



- After initial stabilization, assess pregnancy
 - During trauma evaluation, FHTs auscultated with Doppler or visualized with ultrasound
- Obstetrical exam
 - Fetal gestational age/position
 - Evaluate vaginal bleeding/PROM/cervical effacement
 - Assessment of fetal well being – evaluate fetus over time (continuous fetal monitoring at viability)
 - Reactive NST suggest good maternal perfusion!
- Red flags:
 - Vaginal bleeding
 - Abdominal pain
 - Uterine tenderness
 - Contractions
 - Non-reassuring fetal status

Timing of Fetal Assessment?



- Should fetal assessment be performed at the end of the primary survey versus at the end of the secondary survey?
 - No studies
 - The best early treatment of the fetus is resuscitation of the pregnant person

Fetal Monitoring



- Continuous fetal monitoring should be initiated after secondary survey (or during)
- Fetal well-being reflects maternal well-being = additional VITAL SIGN
- Ideal duration not established...
- Pearlman (199) prospective observation study n=85
 - Adverse pregnancy outcomes → 1st 4 hours CTX Q2-5 min
 - Sensitive but not specific for detecting immediate adverse perinatal outcomes
- Dahmus 1993 AJOG summarized data, n=605
 - Adverse pregnancy outcomes → frequent uterine contractions occurring greater than 6 times per hour in the 1st four hours
- Connolly (1997) no adverse outcomes in women with normal fetal heart rate tracings
- Weiner (2016) prospective trial after minor trauma (no complaints, normal US, reactive NST, no regular contractions)
 - 24 hrs obs vs no hospitalization – NO DIFFERENCE in complications or outcomes

Fetal Monitoring



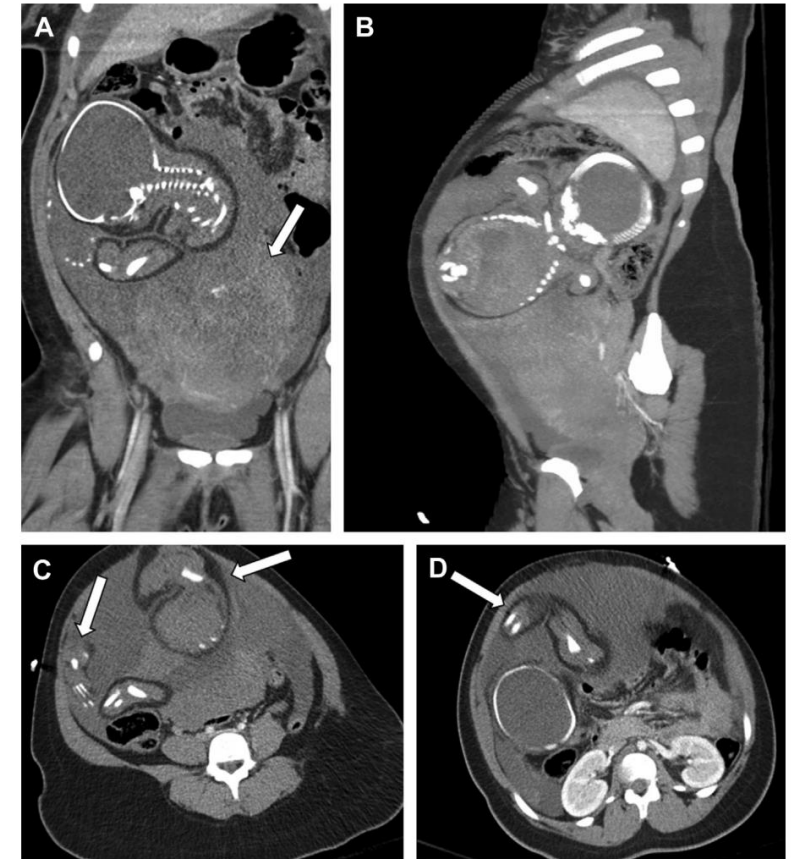
RECOMMENDATIONS:

- At gestational age at which delivery for neonatal resuscitation would be considered, external electronic fetal heart rate monitoring and cardiotocographic monitoring minimum 4-6 hours
- Extend 24 hours:
 - contractions > Q10 minutes within 4 hours
 - Si/sxs abruption: persistent uterine tenderness, vaginal bleeding
 - Non-reassuring fetal monitoring
 - ROM
 - Serious maternal injury → maternal vital sign
 - Uterine hypoperfusion → ARDS, cardiac arrhythmia

Medical Imaging



- **Do NOT withhold imaging** if indicated
 - CT is acceptable when needed
 - Ultrasound (FAST) helpful but limited



Rh Considerations in Trauma



- Rh-negative → **Rho(D) immune globulin**
- Rh sensitization can lead to **hemolytic disease of the fetus/newborn** in future pregnancies
- Consider **Kleihauer-Betke test**
 - help estimate the volume of fetal blood exposure and determine whether additional Rhogam dosing is needed, especially after major trauma.
- Even seemingly **minor trauma** can cause fetomaternal hemorrhage.
- Rhogam should ideally be given within **72 hours** of the traumatic event.

Whole Blood/Massive Transfusion



- Recent trauma and transfusion literature: use of low-titer O-positive whole blood in females of childbearing potential because of blood shortages and survival benefits.
- Estimated alloimmunization risk after Rh-positive transfusion in Rh-negative females ranges from roughly 3–20%.
- Modern reviews emphasize that while alloimmunization is important, the **immediate mortality benefit of rapid hemorrhage control and transfusion outweighs future pregnancy risks** in unstable trauma patients

Delivery



- Dependent on fetal gestation age, fetal condition, extent of injury and when delivery would improve maternal well-being (large uterus hinders adequate treatment or evaluation of intraabdominal injury)
- C-section
 - Viable fetus in distress
 - Uterine trauma
- IUFD – vaginal delivery preferred
- Trauma laparotomy does not mandate C-section

What if patient remains pregnant after trauma?



Women hospitalized for trauma 9 months preceding delivery (N=7822)	OR 9% CI
Placental abruption	1.6 (1.3-1.9)
Preterm labor	2.7 (2.5-2.9)
Maternal Death	4.4 (1.4 – 14)

Retrospective cohort study CA ICD-9. El Kady 2004 Am J Obstet Gynecol

- Sperry et al 10 year retrospective cohort at UTSW Level 1, n=773 women discharge home after trauma with viable fetus
- Preterm Delivery RR 1.9 (1.1-1.3), Low Birthweight RR 1.8 (1.04 – 1.32) with higher risk with increasing ISS score and earlier gestation
- **Trauma during pregnancy is risk factor for poor pregnancy outcome**

Traumatic Cardiac Arrest / Obstetric Life Support (OBLS)

- Traumatic cardiac arrest (gunshot wounds or motor vehicle crashes) is one of the leading causes of maternal cardiac arrest
- Recognition of pregnancy helps with gestational age (GA)-dependent modifications to CPR, leading to optimization of maternal outcome



OBSTETRIC LIFE SUPPORT

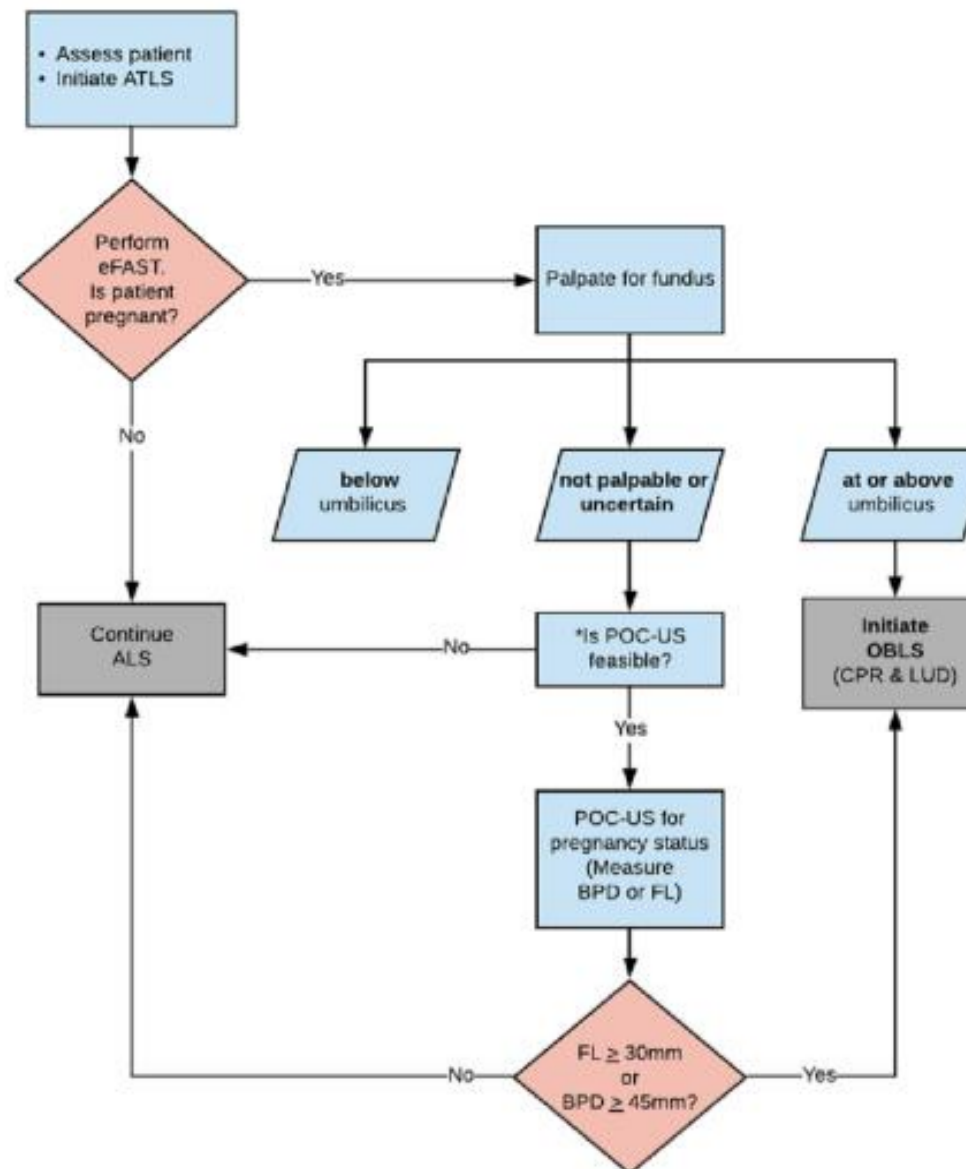


Traumatic cardiac arrest in reproductive age female. No pulse, no response

Abbreviations

ALS - Advanced Life Support
 AFE - amniotic fluid embolism
 ARDS - acute respiratory distress syndrome
 ATLS - Advanced Trauma Life Support
 BDP - biparietal diameter
 benzos - benzodiazepenes
 CPR - cardiopulmonary resuscitation
 ECPR - extracorporeal cardiopulmonary resuscitation
 eFAST - extended focused assessment with sonography in trauma
 EGA - estimated gestational age
 FL - femur length
 LUD - left uterine displacement
 OBLS - Obstetric Life Support
 K - potassium
 POC-US - point-of-care ultrasound
 RCD - resuscitative cesarean delivery
 ROSC - return of spontaneous circulation
 TTM - targeted temperature management

B - Bleeding
 A - Anesthesia
 A - AFE
 C - Cardiovascular/cardiomyopathy
 C - Clot/cerebrovascular
 T - Trauma
 O - Overdose (magnesium sulfate/opioids/other)
 L - Lung injury/ARDS
 I - Ions (glucose/K+)
 F - Fever (sepsis)
 E - Emergency hypertension/eclampsia





Special Considerations: EFAST-OB

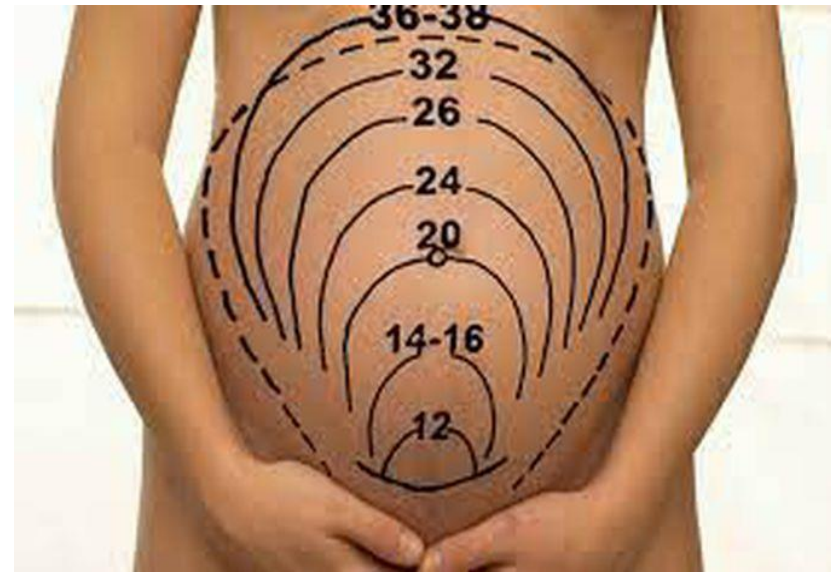
- Current eFAST protocols used in the setting of trauma do not incorporate exam of abdominopelvic area to detect pregnancy in reproductive-age people
- OBLS incorporates POC-US of abdominal pelvic area into eFAST protocols to identify pregnancy



Special Considerations: EFAST-OB



- If pregnancy identified and fundus is palpated at the umbilicus or higher → proceed with OBLS





Special Considerations: EFAST-OB



- If pregnancy identified and unable to appreciate fundal height due to maternal habitus, a quick estimation of gestational age can be done:

Approximates 20+ weeks

- $BPD \geq 45$ mm
- $FL \geq 30$ mm

“45 to stay alive, 30 to get dirty!”



OBSTETRIC LIFE SUPPORT

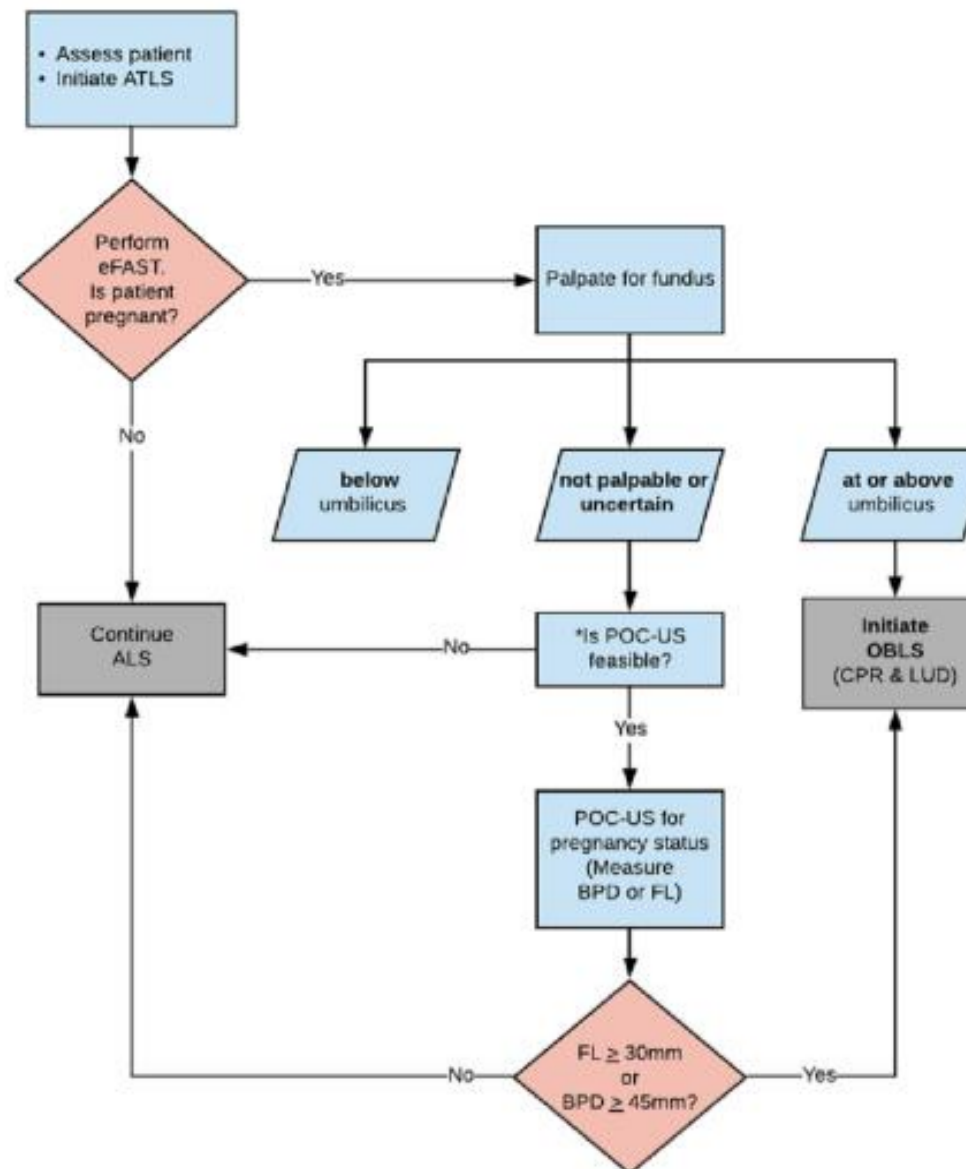


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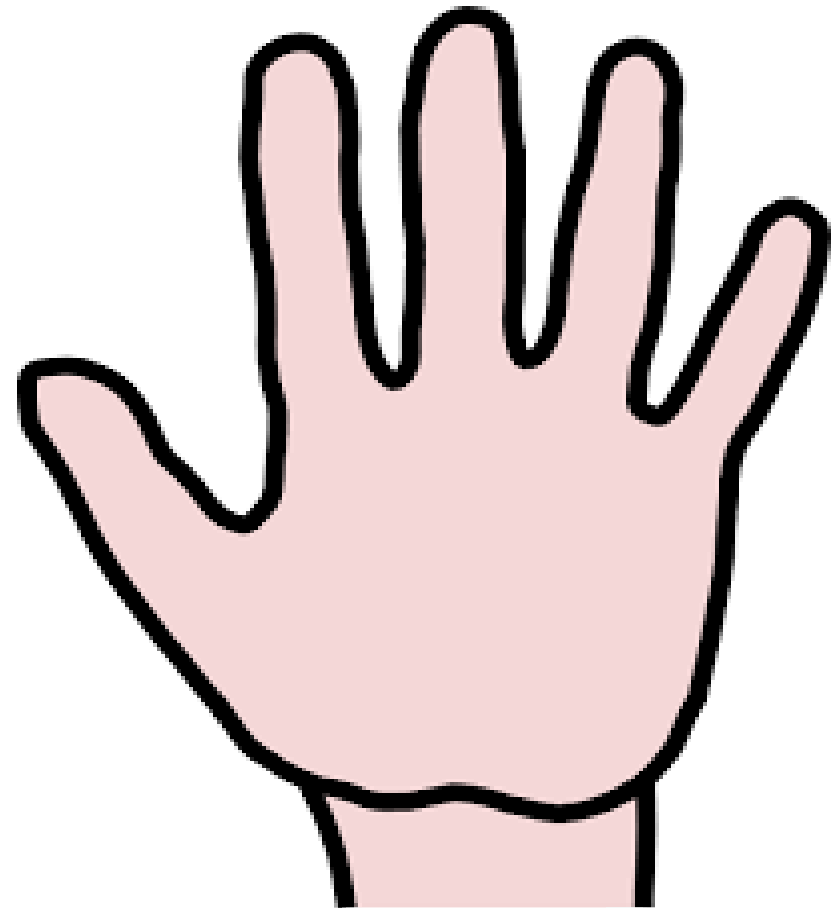




ALIVE @ 5 Cognitive Aid

Coding the Pregnant Patient

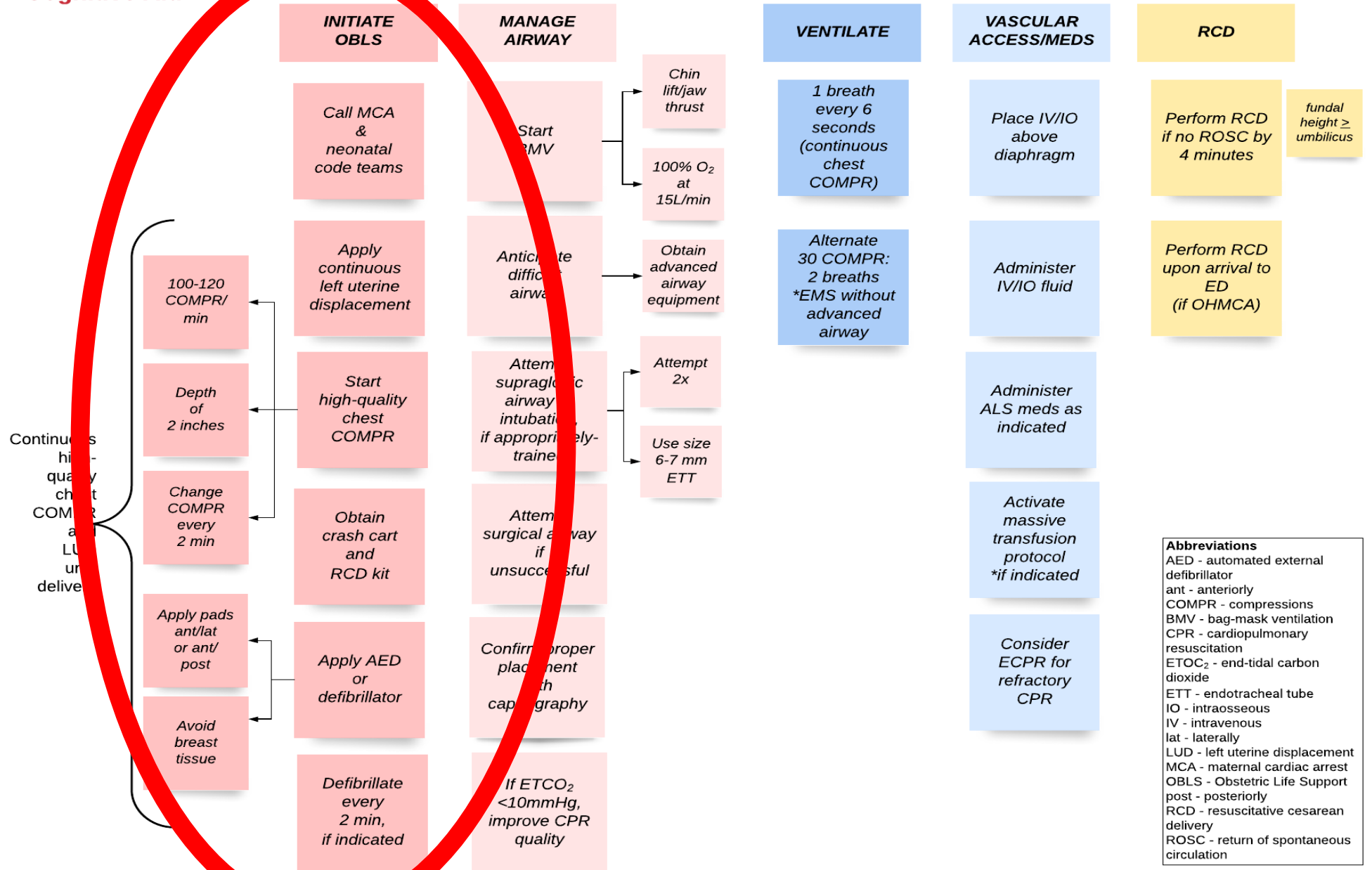
- **A**ctivate OBLS
- **L**eft uterine displacement
- **I**V placement above diaphragm/**I**ntubate early
- **V**erify gestational age and equipment
- **E**xtract fetus and placenta at 4 minutes



OBLS Cognitive Aid

OBSTETRIC LIFE SUPPORT

Cognitive Aid



Continuous high-quality chest COMPR at 100-120/min and LUD until delivery

100-120 COMPR/min
 Depth of 2 inches
 Change COMPR every 2 min
 Apply pads ant/lat or ant/post
 Avoid breast tissue

VENTILATE

- 1 breath every 6 seconds (continuous chest COMPR)
- Alternate 30 COMPR: 2 breaths *EMS without advanced airway

VASCULAR ACCESS/MEDS

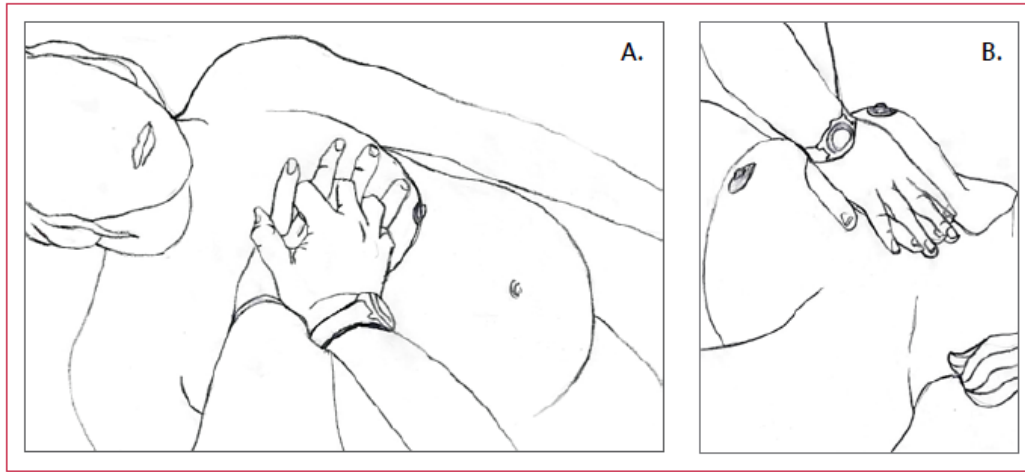
- Place IV/IO above diaphragm
- Administer IV/IO fluid
- Administer ALS meds as indicated
- Activate massive transfusion protocol *if indicated
- Consider ECPR for refractory CPR

RCD

- Perform RCD if no ROSC by 4 minutes
 - fundal height ≥ umbilicus
- Perform RCD upon arrival to ED (if OHMCA)

- Abbreviations**
- AED - automated external defibrillator
 - ant - anteriorly
 - COMPR - compressions
 - BMV - bag-mask ventilation
 - CPR - cardiopulmonary resuscitation
 - ETOC₂ - end-tidal carbon dioxide
 - ETT - endotracheal tube
 - IO - intraosseous
 - IV - intravenous
 - lat - laterally
 - LUD - left uterine displacement
 - MCA - maternal cardiac arrest
 - OBLS - Obstetric Life Support
 - post - posteriorly
 - RCD - resuscitative cesarean delivery
 - ROSC - return of spontaneous circulation

Key Points of High-Quality CPR: Chest Compressions



A. Proper hand placement in a pregnant patient

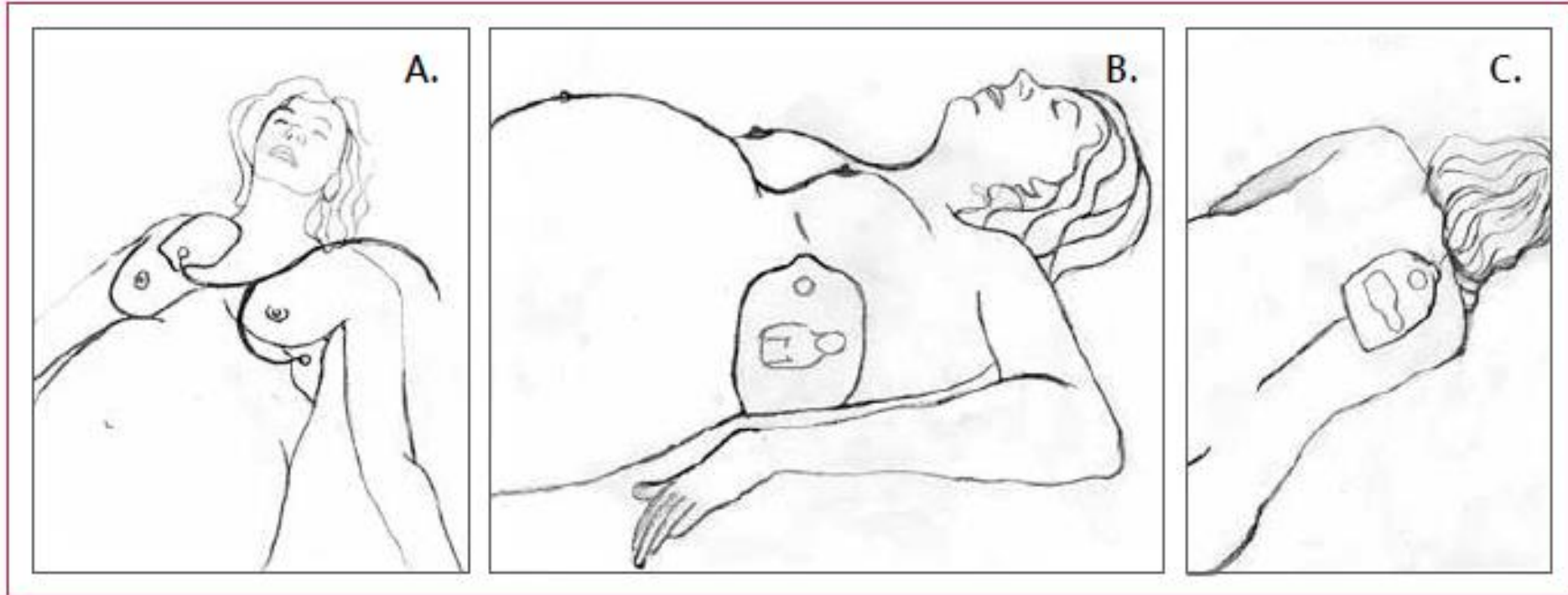
B. If breast tissue is in the way, as can occur with large, pendulous breasts, slightly rotate hand position to a more vertical position towards the patient's head to allow the proper delivery of downward force.

- Effective chest compressions of 100-120/minute, with chest compressions of 2 inches or 1/3 of chest depth with full recoil of chest
- Minimize interruptions of chest compressions.
- Pulse and rhythm checks should be <10 seconds and performed every 2 minutes.
- Switch CPR compressors at least every 2 minutes to avoid fatigue.

Key Points of High-Quality CPR: Left Uterine Displacement



Key Points of High-Quality CPR: Defibrillation Pad Placement



A. Right anterior position

B. Left anterolateral position

C. Posterior position

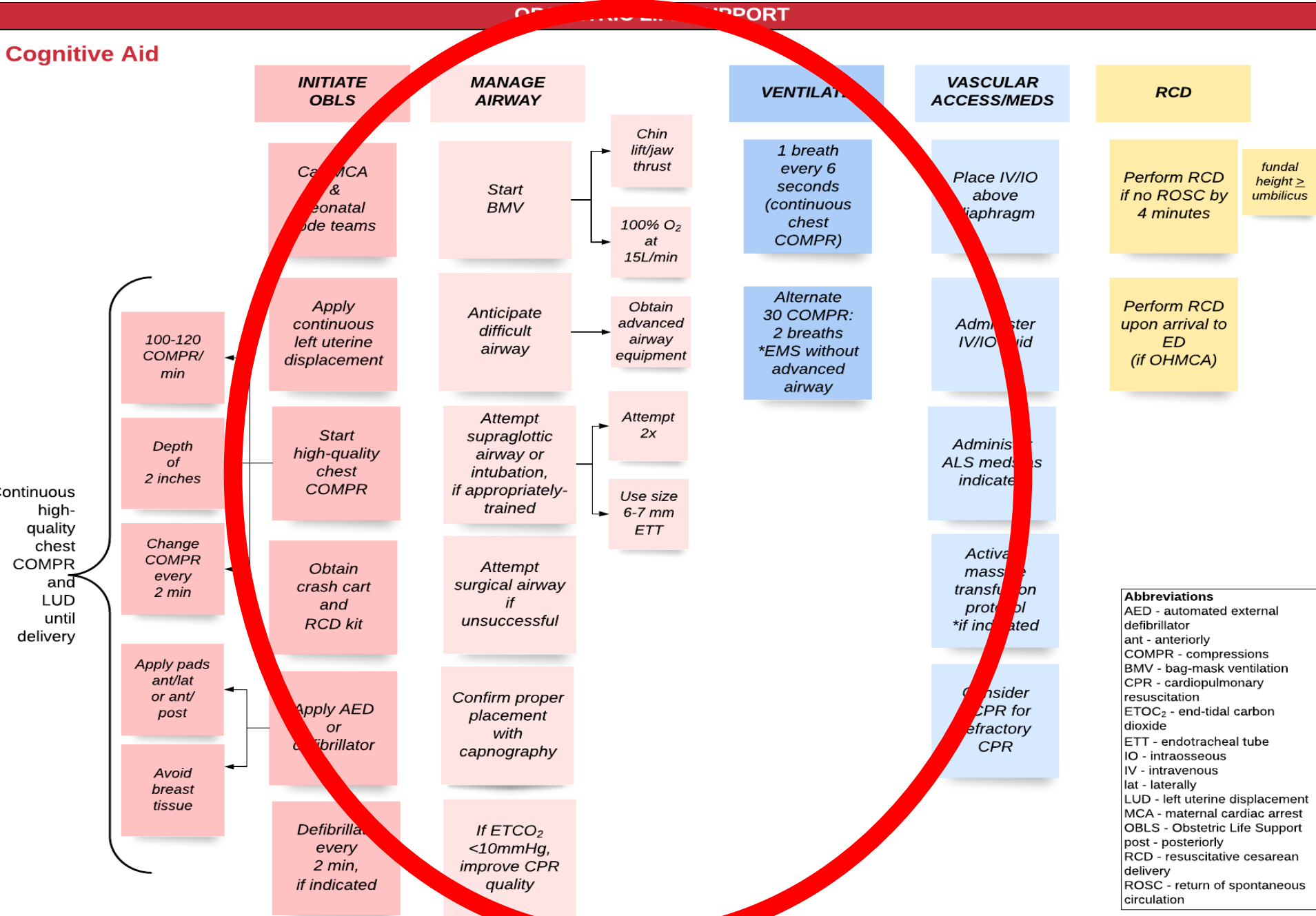
*Posterior pad placement is not recommended in patients with suspected spinal cord injury, to limit movement and potential further injury

Key Points of High-Quality CPR: Defibrillation in Pregnancy



- **Defibrillate immediately when a shockable rhythm is identified (VF or pulseless VT). Continue high-quality CPR immediately after each shock.**
- **Use the same energy doses as standard ACLS—pregnancy does not change defibrillation dosing.**
 - **Biphasic defibrillator (most common)**
 - Initial shock: 120–200 J (*use manufacturer recommendation; if unknown → 200 J*)
 - Subsequent shocks: same or higher energy (often escalate to max)
 - **Monophasic defibrillator (rare)**
 - All shocks: 360 J
- **Do not delay shocks for fetal monitoring or obstetric procedures.**
- **Defibrillation is safe in pregnancy and does not harm the fetus when pads are correctly placed.**

OBLS Cognitive Aid



Key Points of High-Quality CPR: Airway and Ventilation

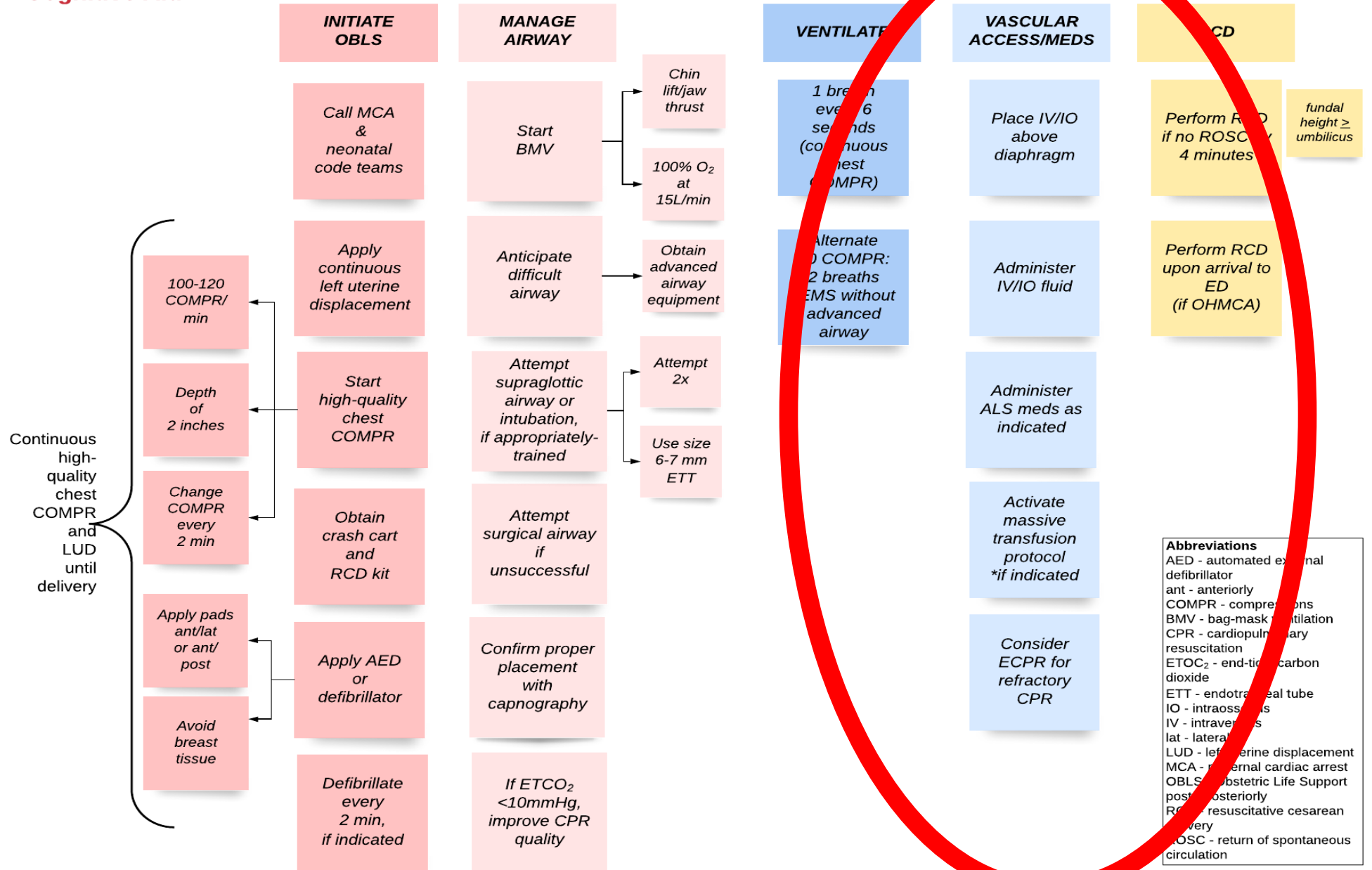


- Start BMV: 30:2 compression/ventilation ratio
 - avoid over-ventilating patient.
- Anticipate difficult airway --> most experienced laryngoscopist!
 - Attempt supraglottic airway or intubation 2x
 - Use size 6-7 mm ETT
- Early advanced airway: Focus on one breath every 6 seconds
- Confirm proper placement with capnography
 - $ETCO_2 < 10$ ---> Improve quality of CPR

OBS Cognitive Aid

OBSTETRIC LIFE SUPPORT

Cognitive Aid



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- Depth of 2 inches
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VENTILATE

- 1 breath every 6 seconds (continuous chest COMPR)
- Alternate 10 COMPR: 2 breaths EMS without advanced airway

VASCULAR ACCESS/MEDS

- Place IV/IO above diaphragm
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- RCD - resuscitative cesarean delivery
- ROSC - return of spontaneous circulation

Key Points of High-Quality CPR



- IV/IO above diaphragm and administer IV fluids
- Medications are the same as ACLS, with possible exception of fibrinolytics

Monitor High-Quality CPR Using End Tidal Capnography



- This is your **CPR Vital Sign**
- Measures the concentration of carbon dioxide (CO₂) at end of person's exhalation
- Used to monitor CPR effectiveness
- Normal values in pregnancy 30-35 mmHg, slightly lower than non pregnant

(P)ETCO₂ or waveform capnography should be ≥ 10 mmHg with effective CPR

If (P)ETCO₂ is < 10 mmHg, CHANGE something

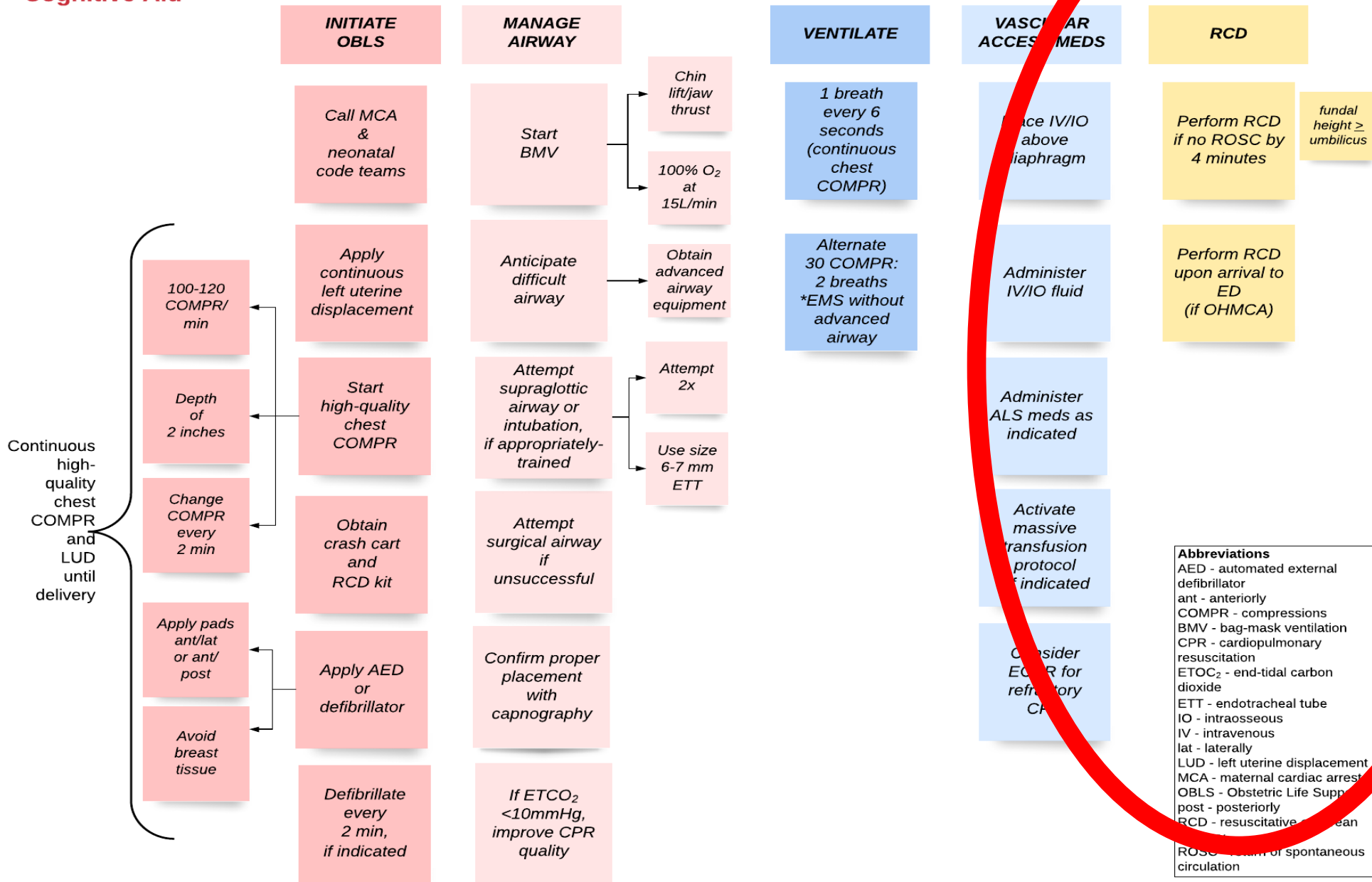
- chest compressions
- LUD
- check airway

If (P)ETCO₂ is $\geq 30-35$ mmHg \rightarrow ROSC

OBLS Cognitive Aid

OBSTETRIC LIFE SUPPORT

Cognitive Aid



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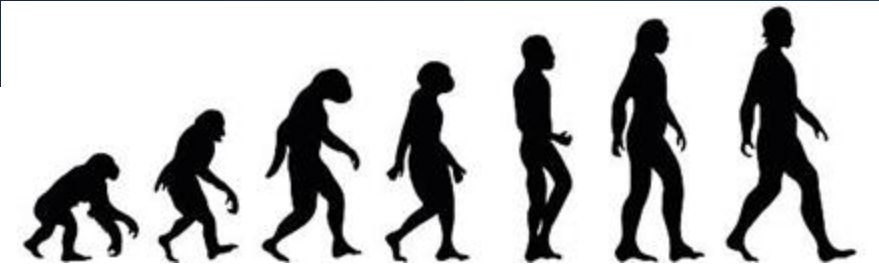
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- post - posteriorly
- RCD - resuscitative decompression
- ROSC - return of spontaneous circulation

Resuscitative Cesarean Delivery



- Trauma leading cause of maternal cardiac arrest AND resuscitative cesarean delivery

EVOLUTION



Resuscitative hysterotomy...
Perimortem cesarean delivery

**Resuscitative c
(RCD)**



Activate BLS

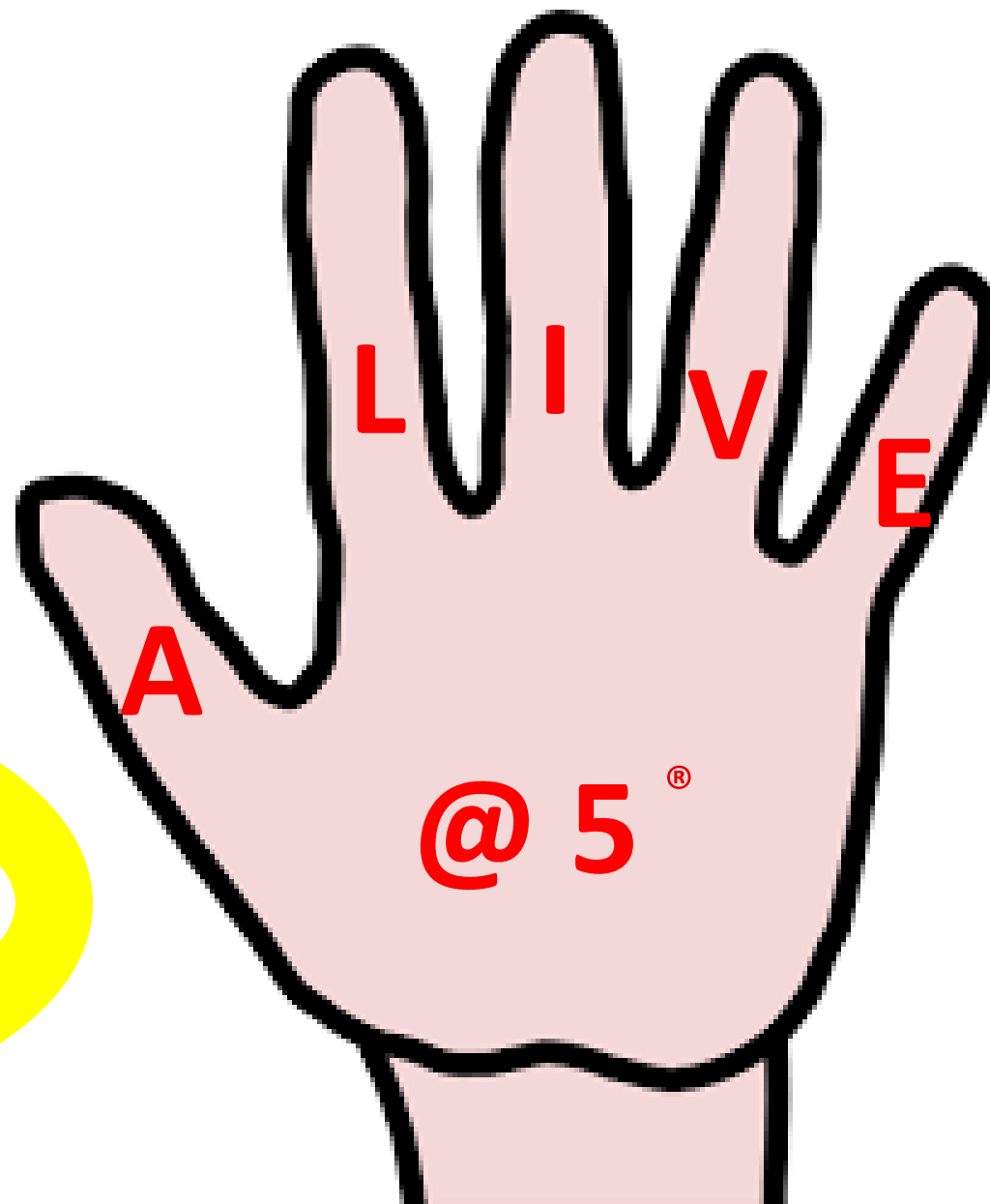
Left uterine displacement

IV placement above
diaphragm/Intubate early

Verify placement

equipment

Extract fetus and placenta
at 4 minutes



WHERE SHOULD RCD OCCUR?



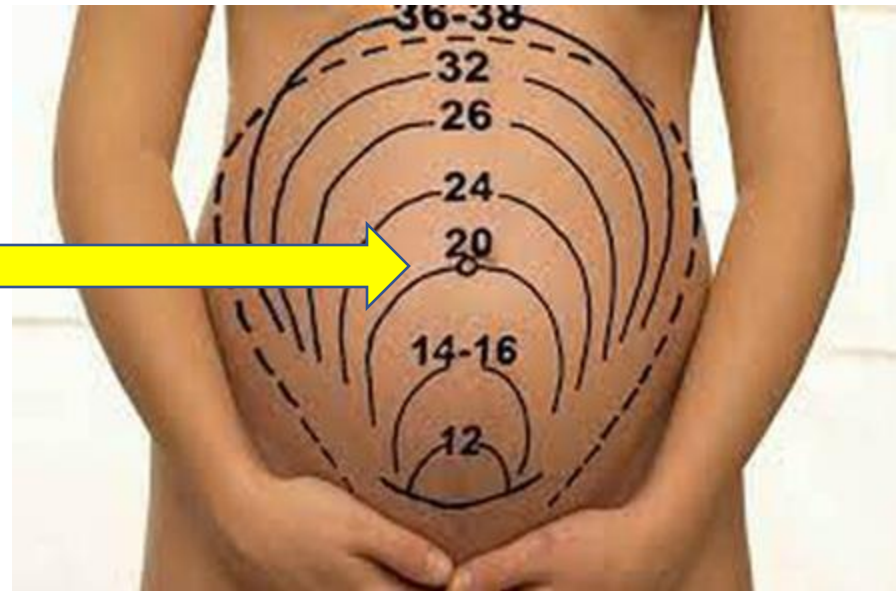
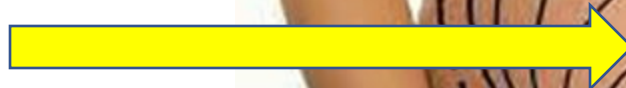
At the site of arrest



WHICH PATIENTS ARE ELIGIBLE FOR RCD?



Fundus of uterus is palpable at or above the umbilicus



<https://medizy.com/feed/31536649>

HOW DOES RCD WORK?

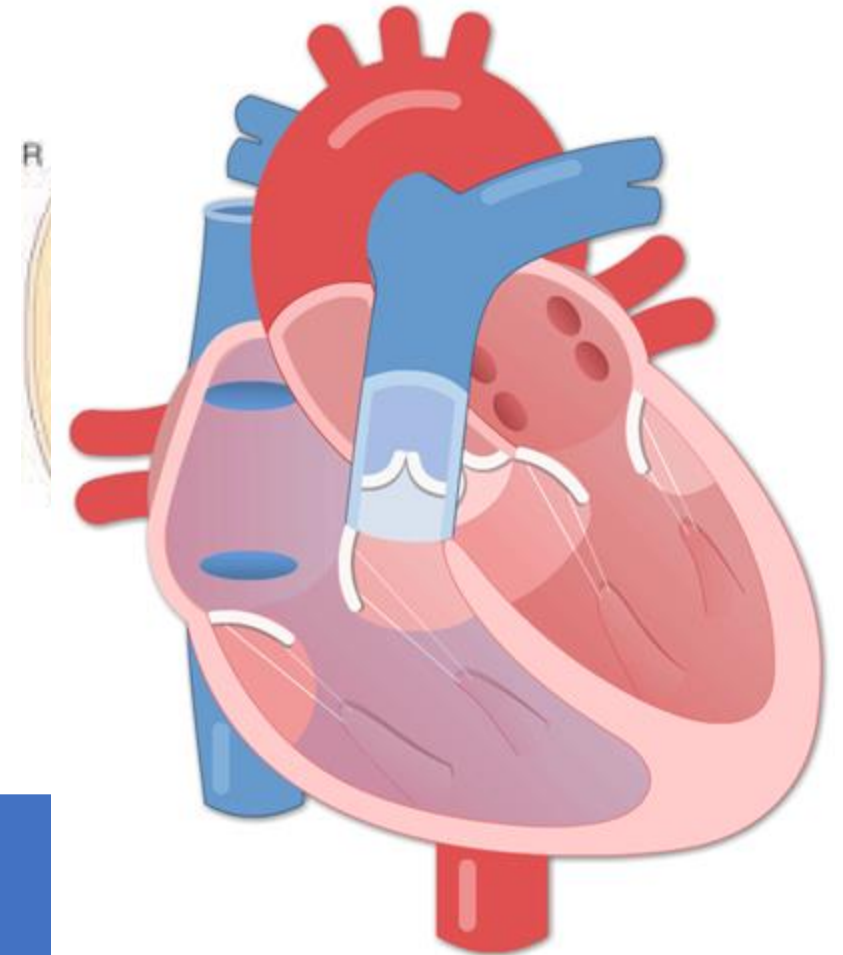


Reduces aortocaval compression
Autotransfusion

Increases preload

Increases maternal cardiac output

Increase in chest wall compliance



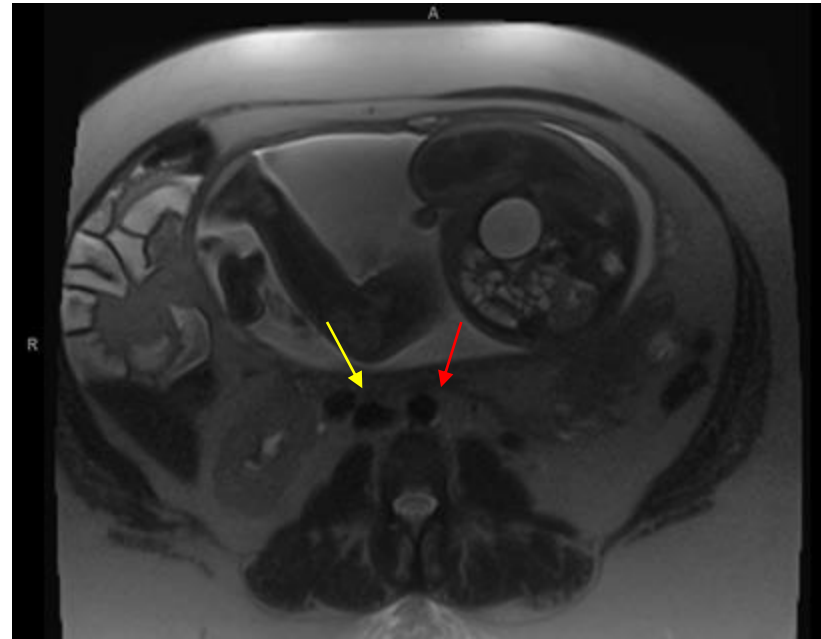
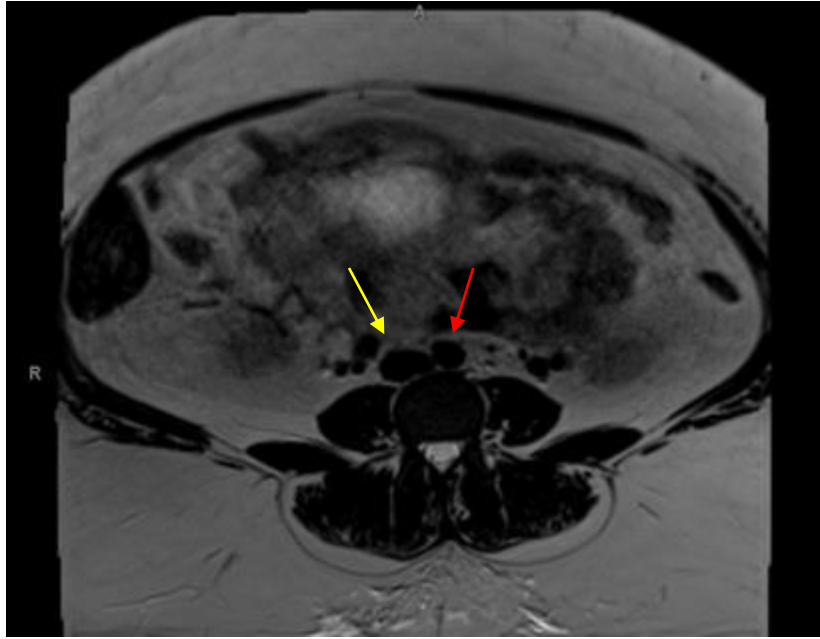
WHICH PATIENTS ARE ELIGIBLE FOR RCD?



HOT OFF THE PRESSES!

- ✓ 50 pregnant patients between 12-39 weeks had MRIs in supine position
- ✓ IVC compression evaluated

a)



b)

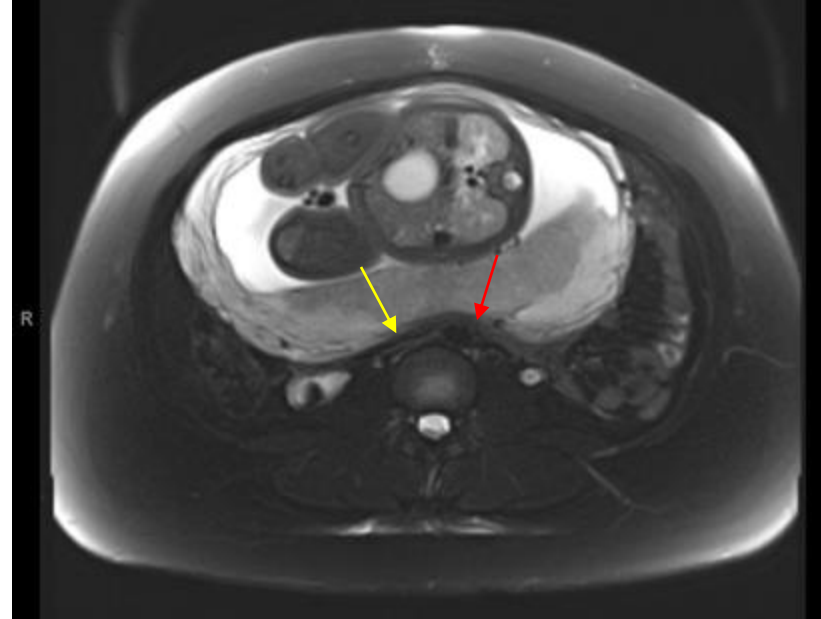
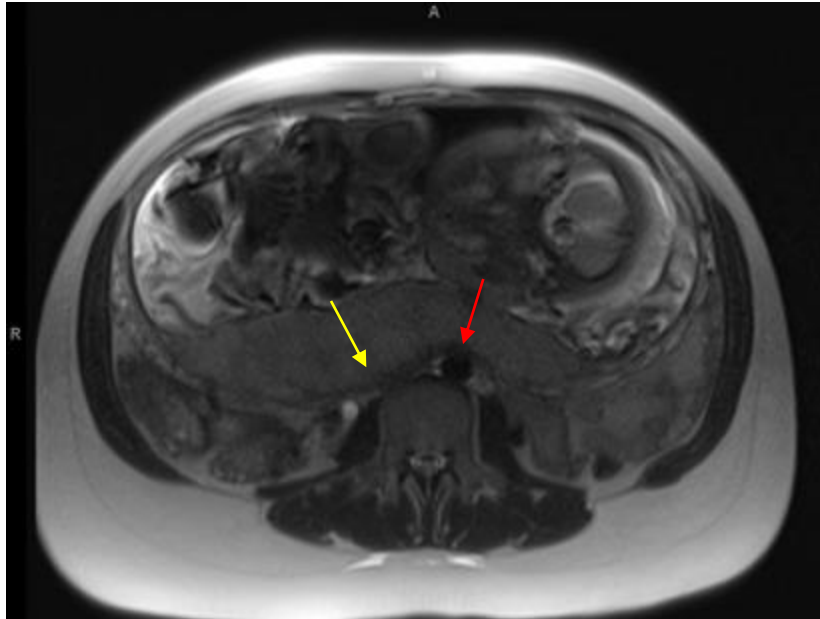


Figure.

a) Illustrative examples of no IVC

compression in pregnancies at 21+2 and 33+6 weeks; and

b) IVC

compression in pregnancies at 35+0 and 33+0 weeks.

*Yellow arrow – IVC; red arrow - aorta

WHICH PATIENTS ARE ELIGIBLE FOR RCD?



✓ 36% of patients between 12+0 – 19+6 weeks show signs of IVC compression in supine position

N	Gestational age (mean)	BMI (mean)	Mean left Aortic wall to right uterine wall overlap distance (mm)	IVC compression (percent)	Mean right uterine wall to right abdominal wall (mm)	Mean anterior aortic wall to anterior abdominal wall (mm)	Mean uterine width (mm)	Mean uterine depth (mm)	Mean uterine length (mm)
14	16.4	26.5	94.8	36	71.08	70.62	129.8	83.85	166.26
11	21.17	27.95	94.84	67	73.39	82.58	129.80	83.85	203.39
6	25.67	36.25	124.50	86	59.46	98.55	181.28	115.42	214.20
9	29.33	34.88	126.99	89	75.66	131.17	207.56	119.11	224.80
10	32.90	34.90	141.66	90	56.92	133.89	218.77	120.62	244.43

WHICH PATIENTS ARE ELIGIBLE FOR RCD?



- ✓ One-third of patients < 20 weeks who don't receive an RCD within 5 minutes may benefit from its performance!

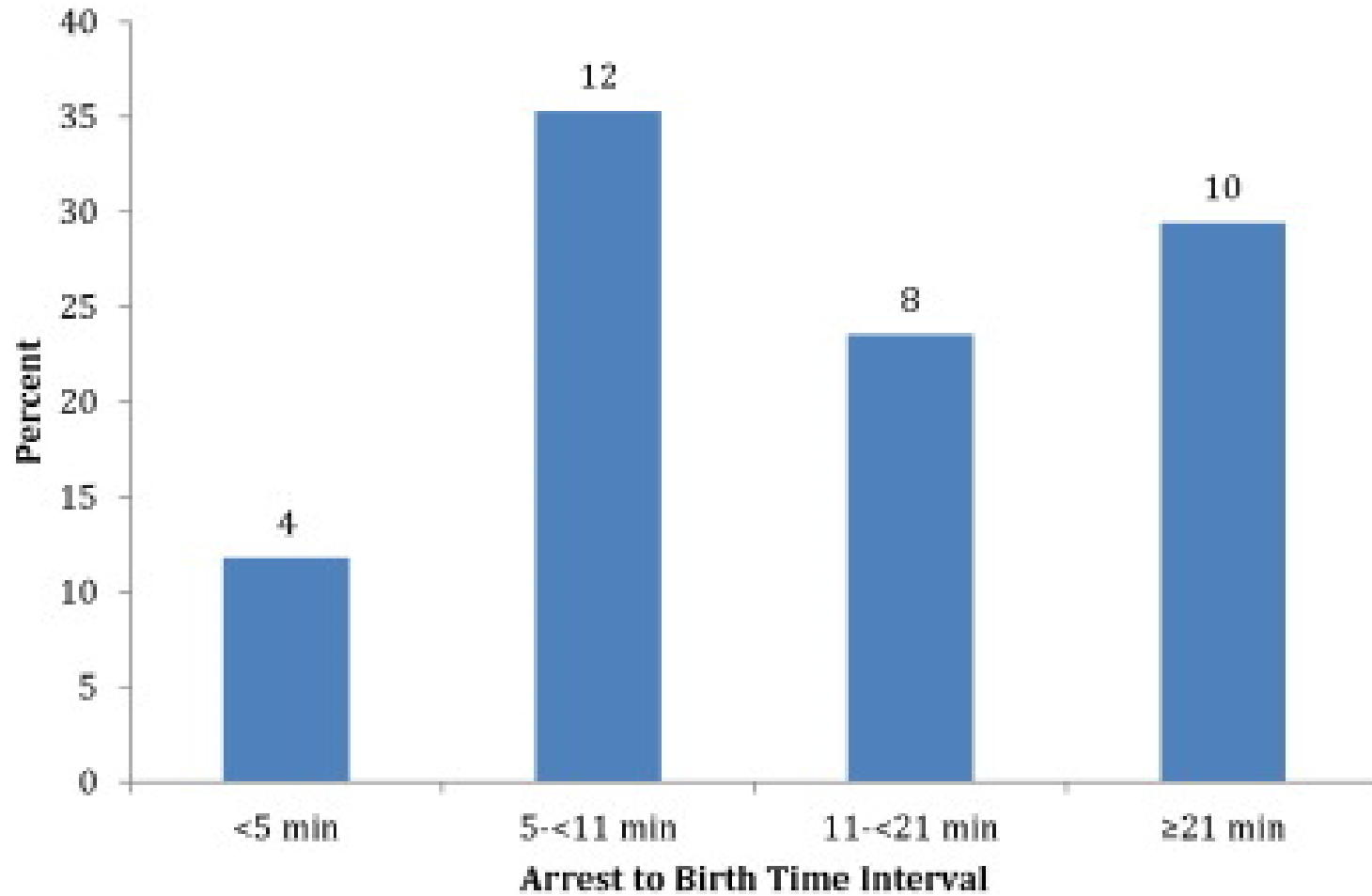
Where does “4-minute rule” come from?



- 1986 [?] Katz et al. describe a case of ROSC immediately following cesarean delivery of a patient who experienced maternal cardiac arrest^{Katz 1986}
- “Four-Minute Rule” was born, Katz et. al. cited the fact that adults begin experiencing anoxic brain damage 4 to 6 min into a cardiac arrest^{Katz 2012, Katz 2015}
- “Four-Minute Rule” adopted by the **American Heart Association** as well as the **European Resuscitation Council and the Society for Obstetric Anesthesia and Perinatology**^{Jeejeeboy, Drukker}

Katz 1986, Katz 2012, Katz 2015,
Jeejeeboy 2011, Drukker 2014

WHEN SHOULD IT BE DONE?



WHEN IS IT TOO LATE TO PERFORM?



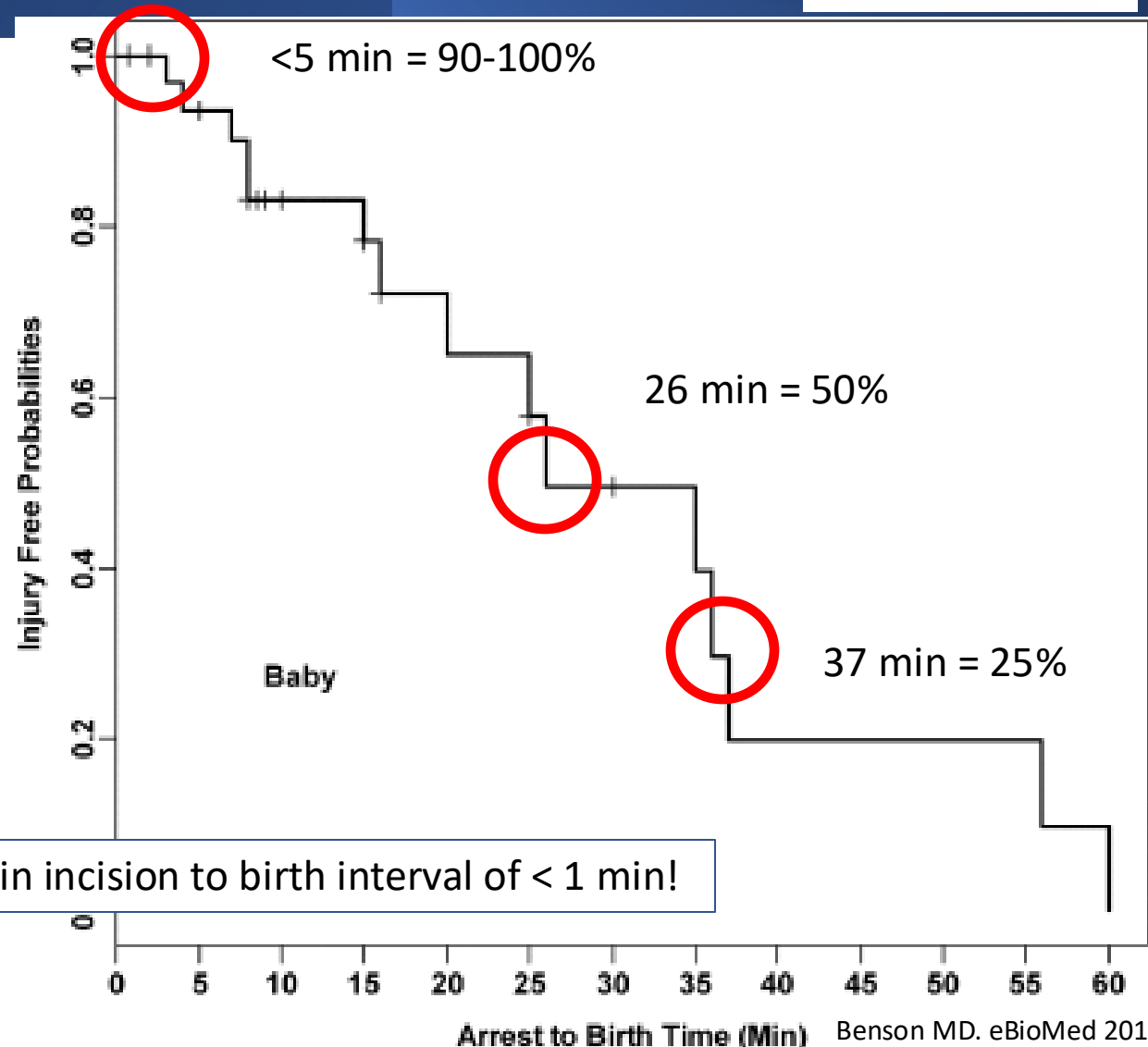
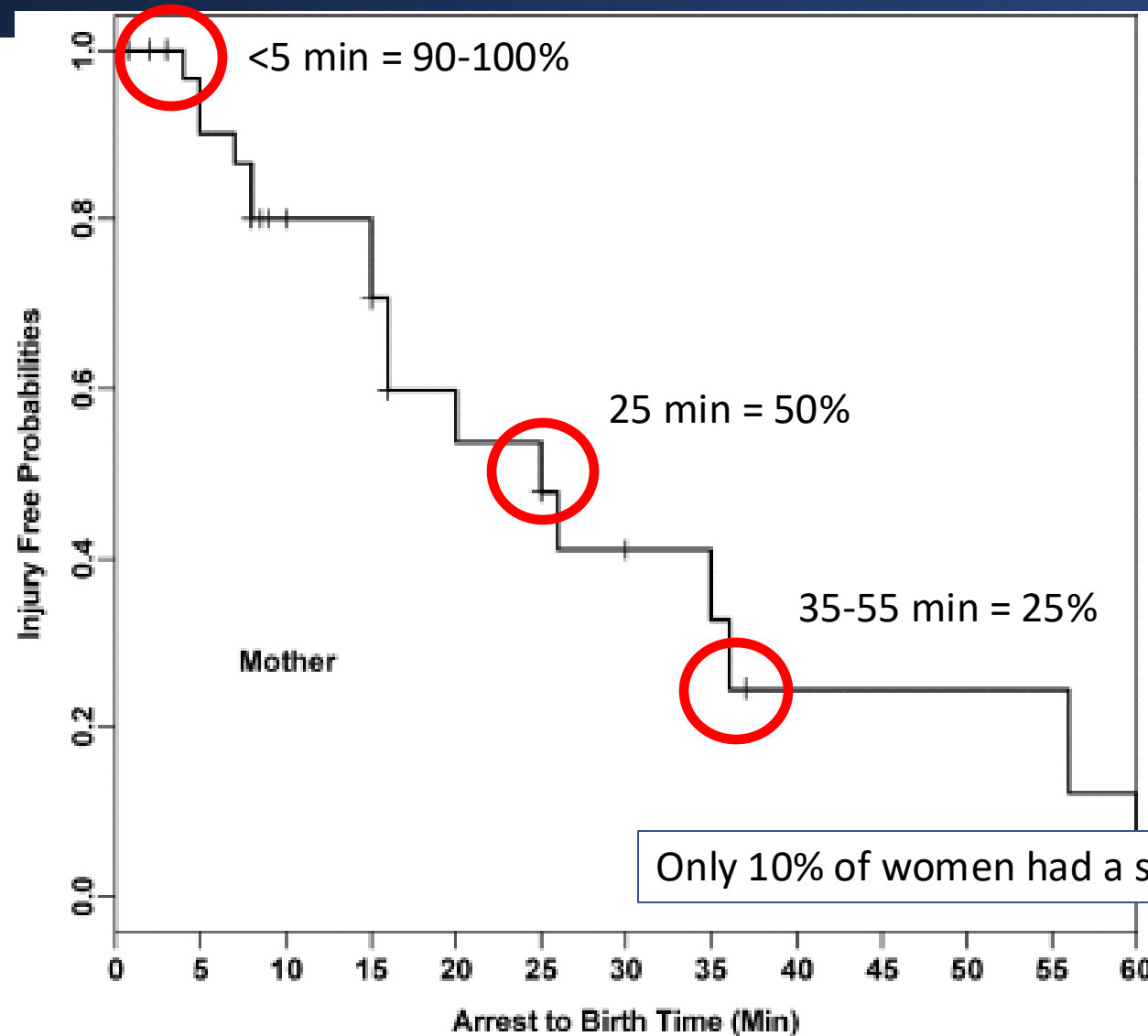
- Unknown
- Reports of maternal survival when RCD performed as long as 40-60 minutes from time of arrest^{Pecher, Kazandi, Benson}
- Late RCD > 25 minutes^{Shields}
- Do not hesitate to perform RCD in refractory CPR during MCA; data on late RCD should be collected and outcomes analyzed^{Shields}

Systematic Review of RCD



- Review of outcomes of RCD for MCA
- Analysis of maternal and neonatal **injury free survival rates** as a function of arrest to birth intervals, as well as actual **incision to birth intervals**.
 - **74 pregnant women**
 - **73 newborns delivered**
 - 33 mother died
 - 8 serious injury
 - **33 no sequelae evident at the time of discharge**
 - **73 newborns delivered**
 - 17 babies died
 - 14 injured
 - **42 survived without apparent injury**

DOES RCD REALLY WORK?



Only 10% of women had a skin incision to birth interval of < 1 min!

Does RCD really work?



- The earlier the better^{Einav,Zelop,Benson}
- There was no evidence for any specific survival threshold at 4 min^{Benson}
- Skin incision to birth intervals of < 1 min occurred in only 10% of women^{Benson}

Challenge the 4 minute rule?

Resuscitative Cesarean Delivery



- ✓ Aim to do it as quickly as possible with the understanding that you may not complete the RCD by 5 minutes

Midline Vertical Incision



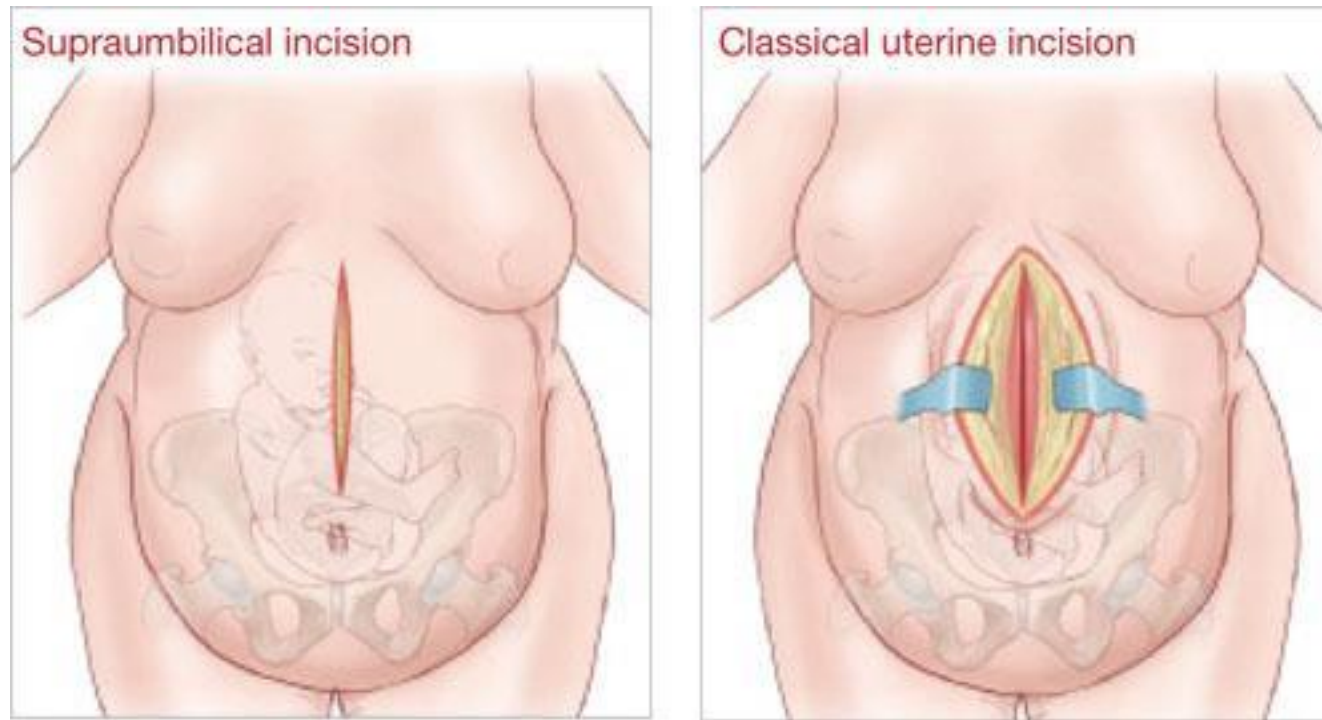
- Less likely to injure abdominal wall vasculature
- Can extend if needed (e.g., exploration for trauma, cross-clamping aorta in hemorrhage, etc.)
- Easier access with less risk of infection in extreme obesity



RCD with OBESITY



Supraumbilical incision



Anatomy by Design, Inc.



Resuscitative Cesarean Delivery (RCD)



Special Considerations: Thoracentesis

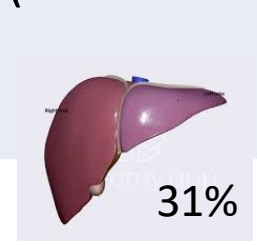
- Reviewed 91 chest x-rays, 56 CT scan throughout pregnancy
- Measured chest wall thickness and distance to vital structures at 2nd MCL, and 4th and 5th AAL

Special Considerations: Thoracentesis



Chest Wall Thickness and Distance To Vital Structures

Measurement	R. 2 nd Intercostal MCL	L. 2 nd Intercostal MCL	R. 4 th Intercostal AAL	L. 4 th Intercostal AAL	R. 5 th Intercostal AAL	L. 5 th Intercostal AAL
Chest Wall Thickness in millimeters*	73.605 (42.9-119.7)	72.695 (44.3-117.2)	50.833 (26.9-91.8)	49.359 (27.8-90.1)	48.416 (26.4-86.8)	45.658 (23.3-86.7)
Distance To Vital Structures in millimeters*	135.1 (109.1-158.1)	122.308 (70.8-156.8)	124.314 (44.9-181.2)	109.669 (44.9-158.3)	109.634 (35.3-162.0)	91.633 (35.2-132.7)



*Mean and range

MCL = midclavicular line, AAL = anterior axillary line

Tse 2026



Special Considerations: Thoracentesis

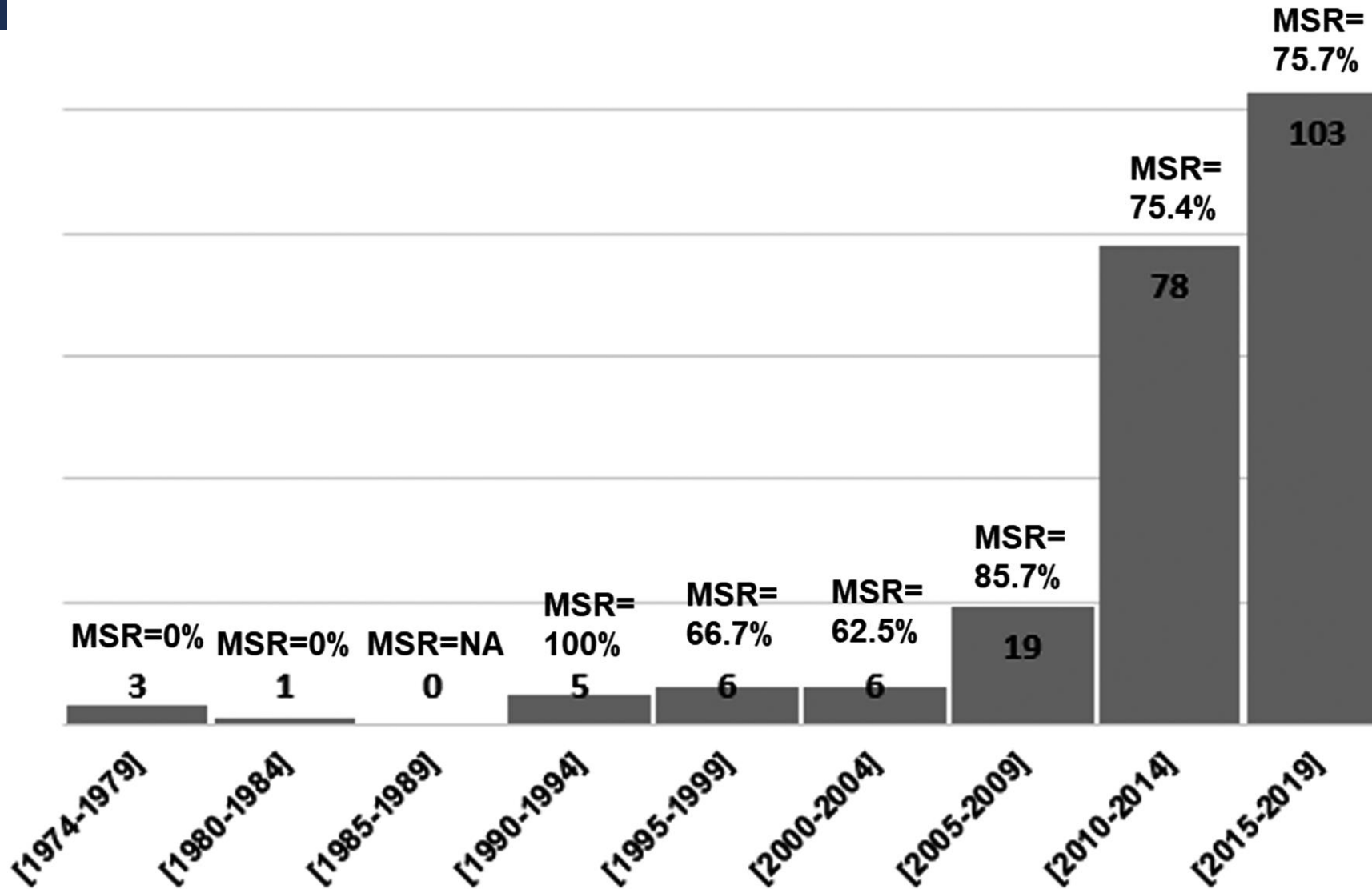
- OBLS recommends performing chest decompression at the **4th ICS at the anterior axillary line** based on the newest evidence, rather than the 2nd or 4th-5th ICS in the midclavicular line recommended by ATLS.

ECPR



- ECPR can be used to restore circulation in trauma patients with cardiac arrest. ECPR may result in higher-than-expected survival rates, even when applied in patients with traumatic cardiac arrest.
- Etiologies:
 - Penetrating trauma 50%
 - Hemorrhagic shock 33.3 %
 - Respiratory failure 29.2 %
 - Pericardial tamponade 25.0 %
 - Other pathologies 12.5 %
- Hospital survival **29.2%**

ECLS in Pregnancy and Postpartum



ECLS in Pregnancy and Postpartum



- 2020 systematic review → associated with relatively high maternal survival and acceptable complication rates.^{Nauom E JAHA 2020}
- 2016 review → maternal survival of approximately 78% and fetal survival of approximately 65% among published cases.^{Moore S Surg 2016}
- 2020 systematic review: 150 cases support ECMO as a salvage therapy in refractory maternal cardiopulmonary failure.^{Webster C AJOG 2020}
- 2022 Delphi consensus paper on maternal cardiac arrest discussed ECPR in maternal cardiac arrest and noted reported survival-to-discharge rates as high as 77% for mothers and 67% for fetuses in selected cases.^{Shields BMC Emerg Med 2022}

Thank you!

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210-632-0017



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