Pediatric Cardiac Emergencies

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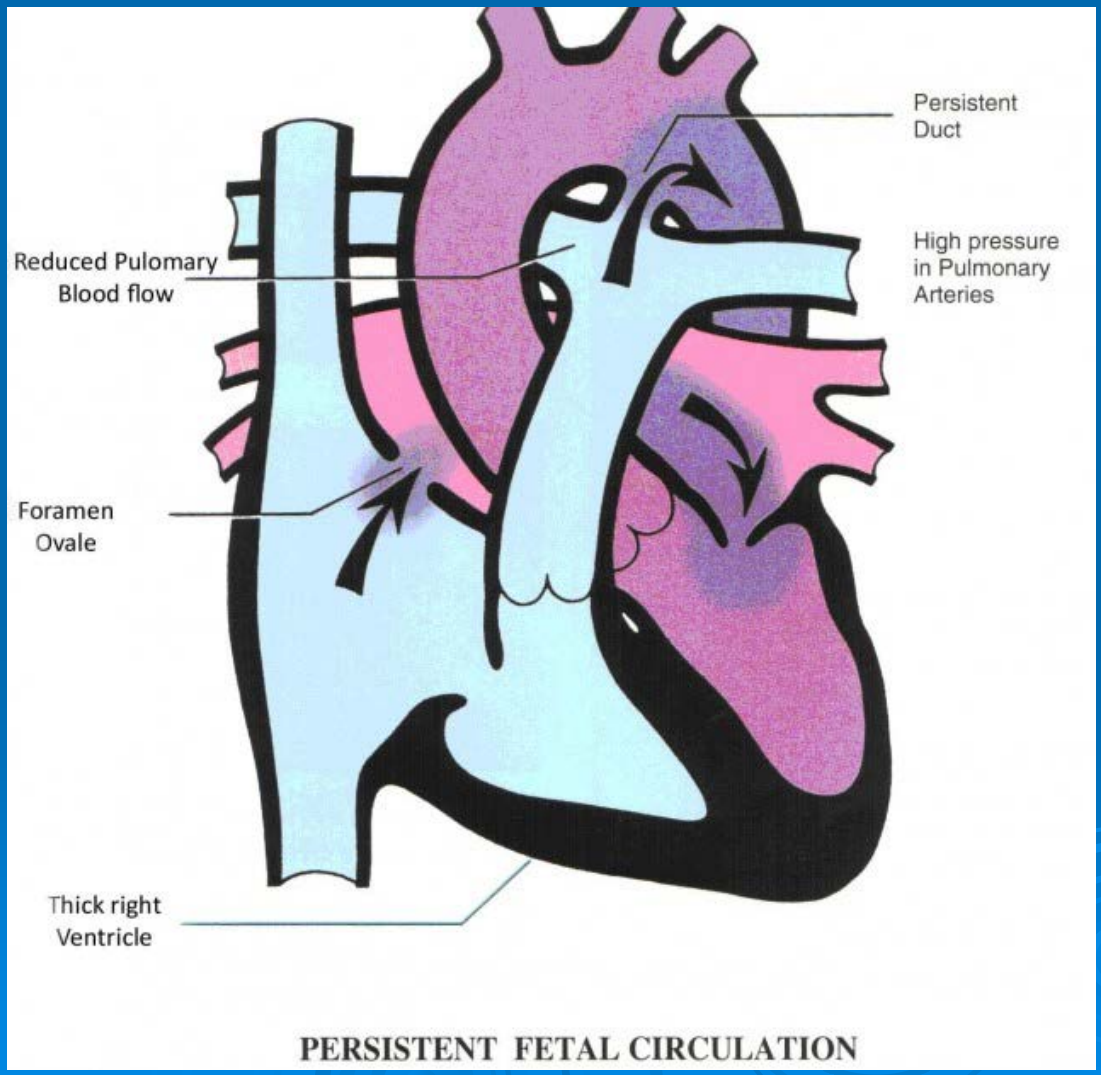
Pediatric Cardiology

- Children Have Hearts
- Things can go wrong with them
  - Anatomic
    - Congenital
  - Electrical
  - Acquired
    - Infectious

Case 1

- Mother brings 4 day old to ED with complaint of lethargy. Mother is accurate. ED evaluation negative. Pulse Ox 50%. No respiratory distress, RR 30.

Fetal Circulation

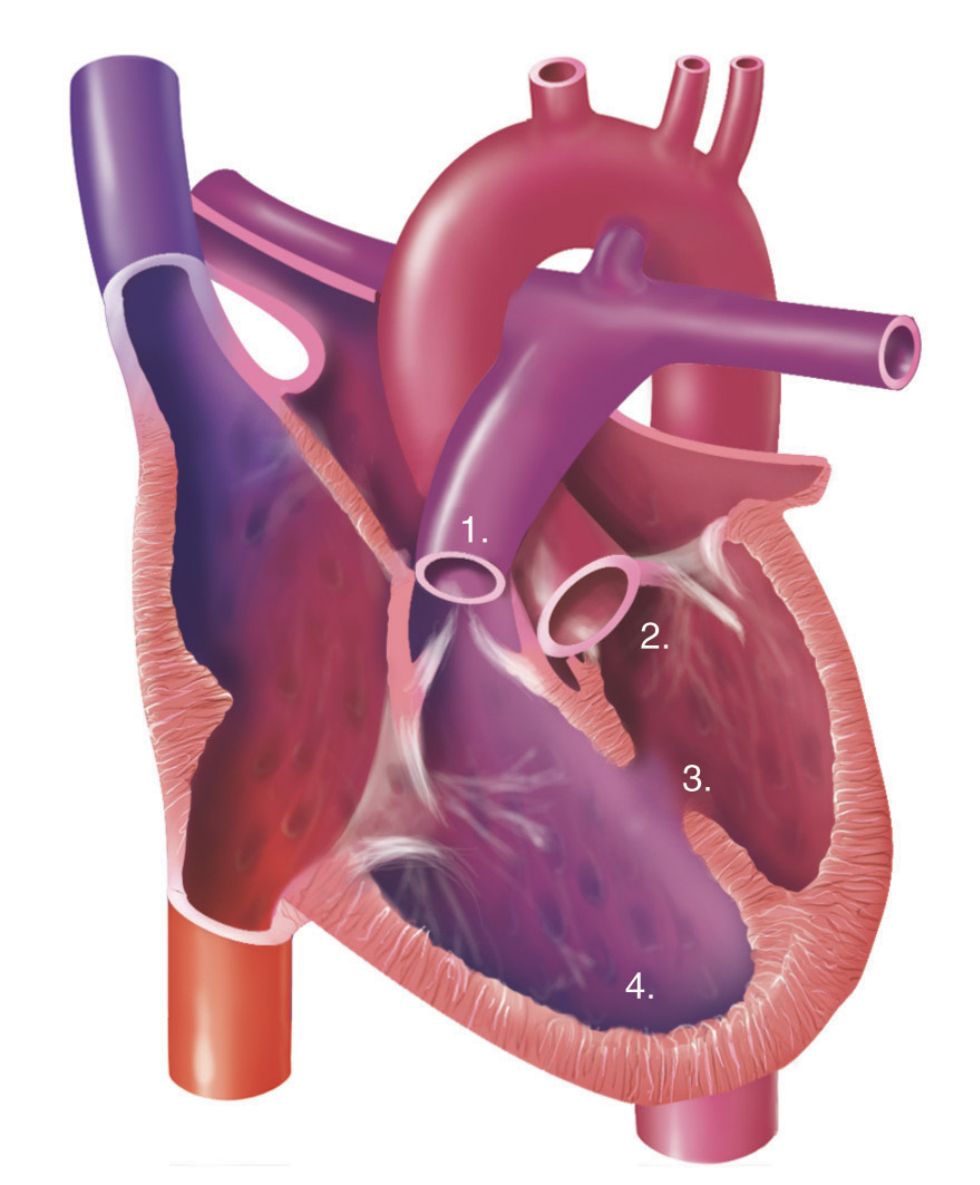


Birth Effects

- Foramen Ovale
  - Pressure related closure
- Ductus Arteriosum
  - Time dependant closure

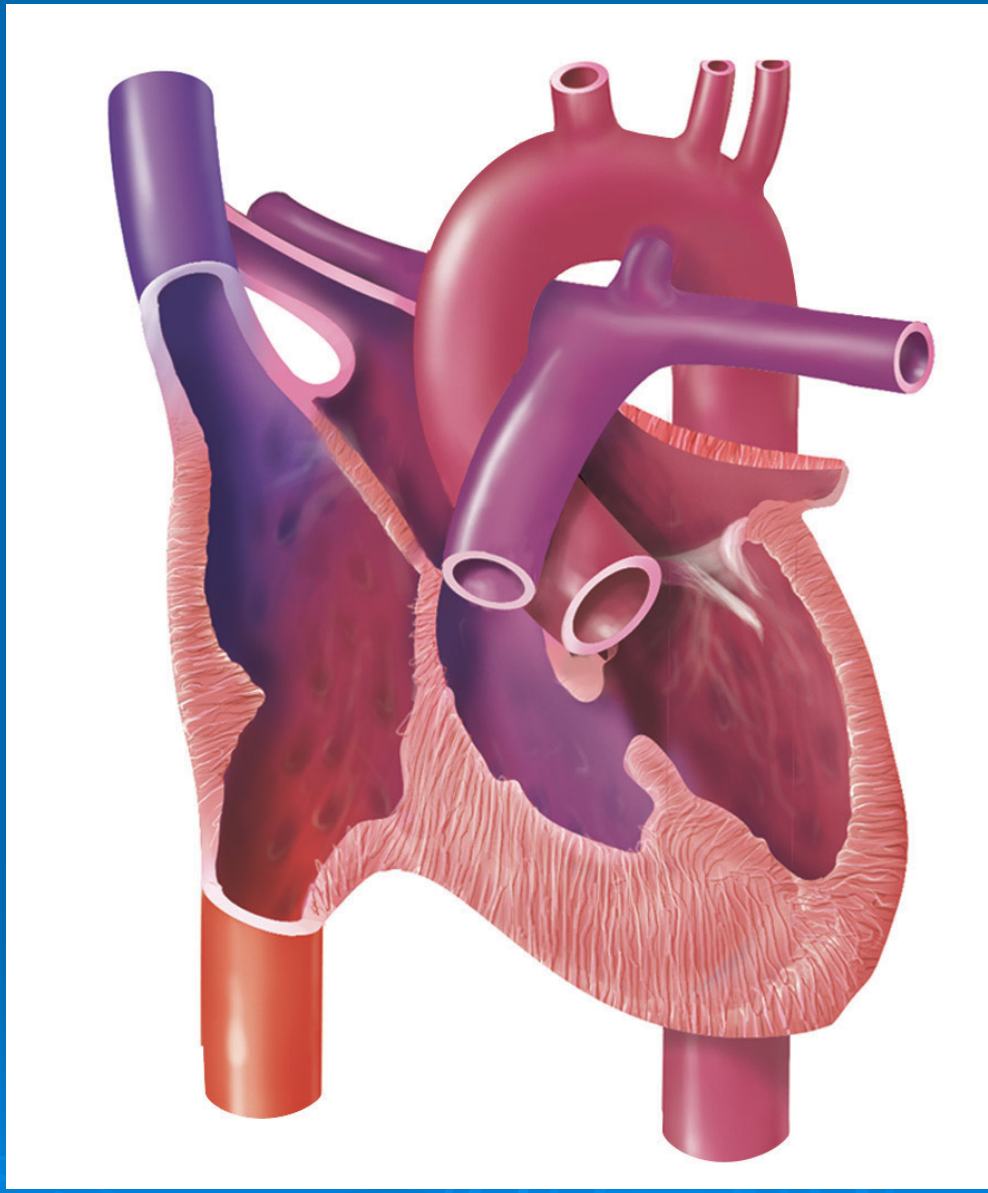
Tetralogy of Fallot (TOF)

- Pulmonic stenosis
- Aortic override
- VSD
- RVH
- Right-to-left shunting through VSD dependent on severity of pulmonic stenosis

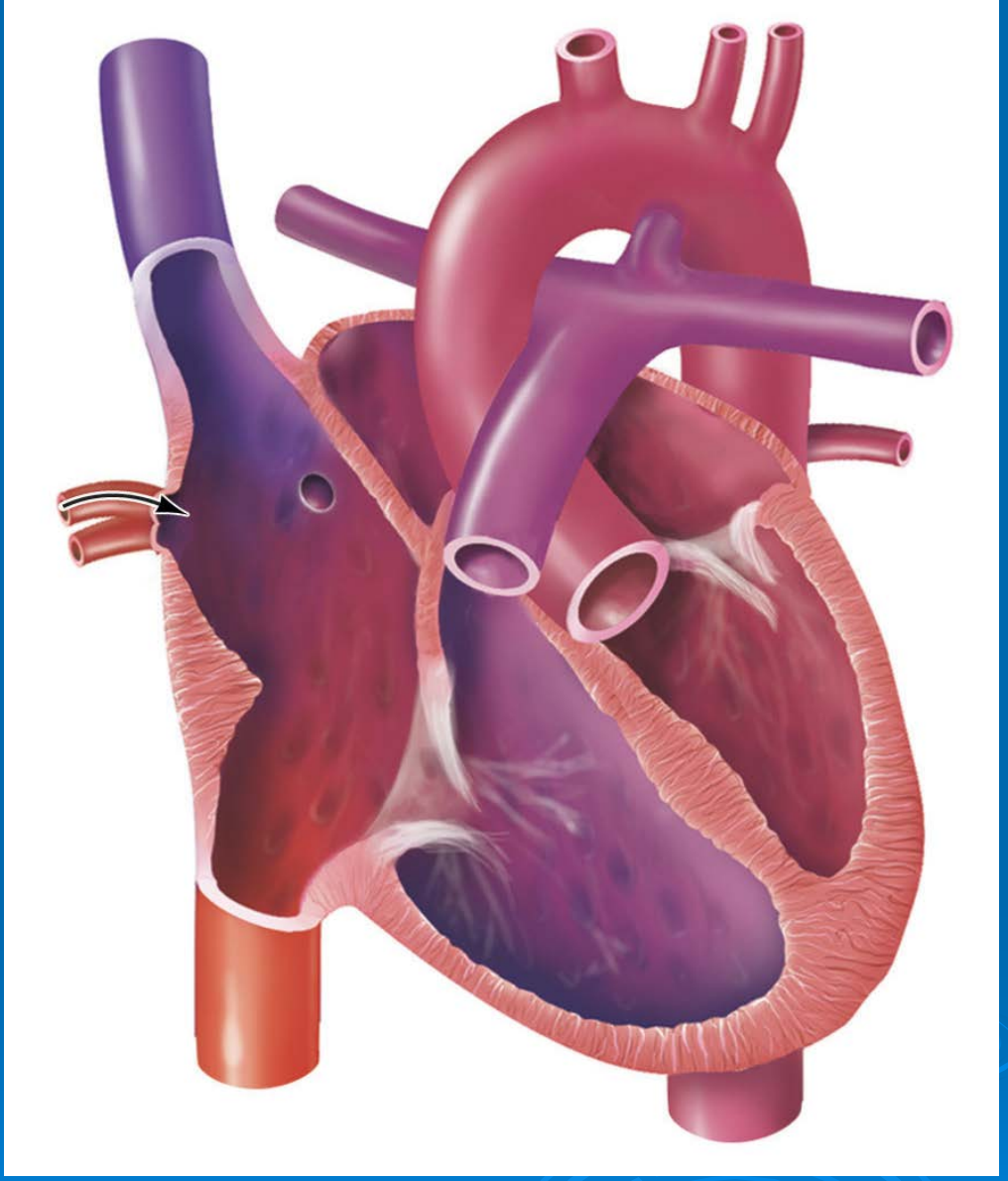


Tricuspid Atresia

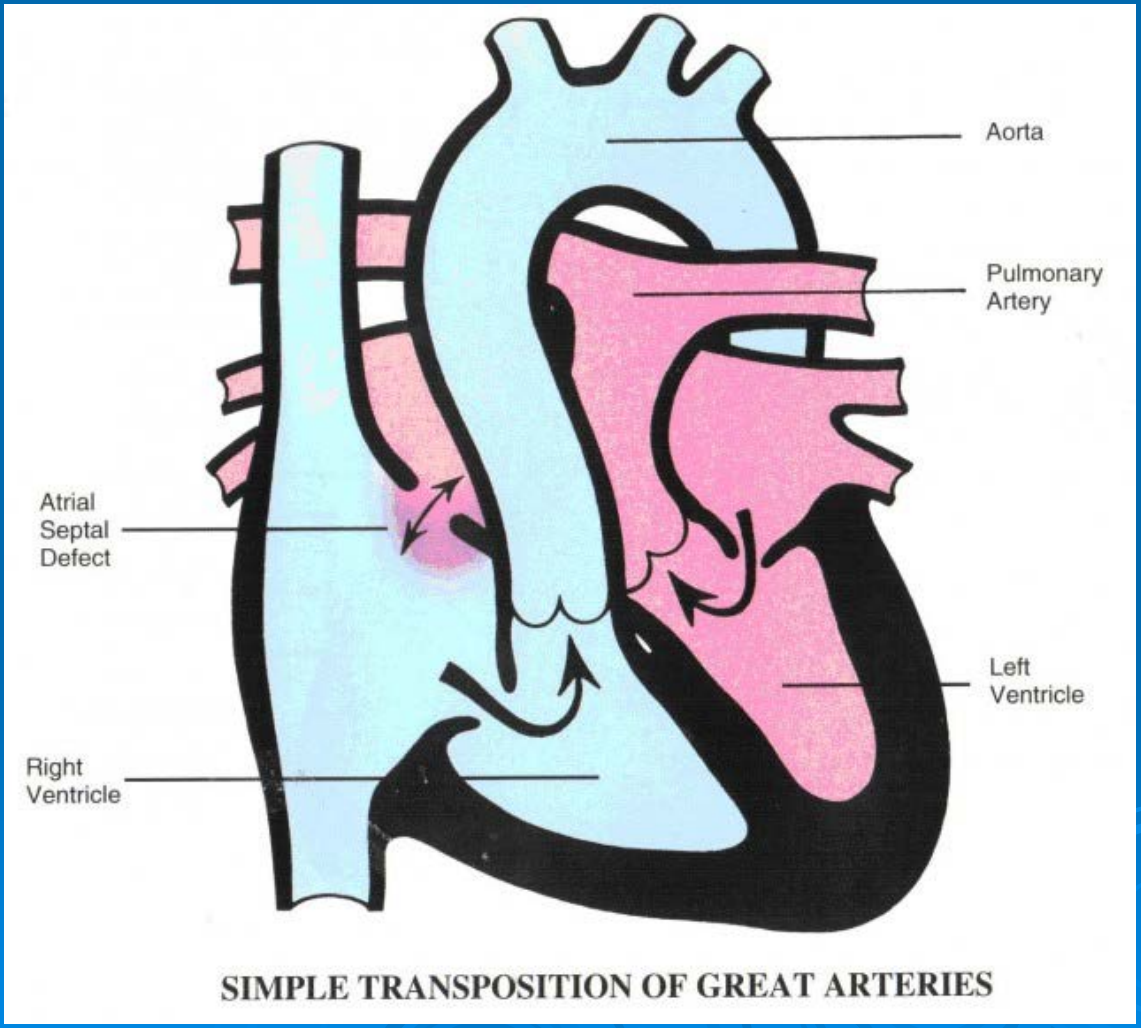
- RV is hypoplastic.
- Right-to-left shunt through VSD



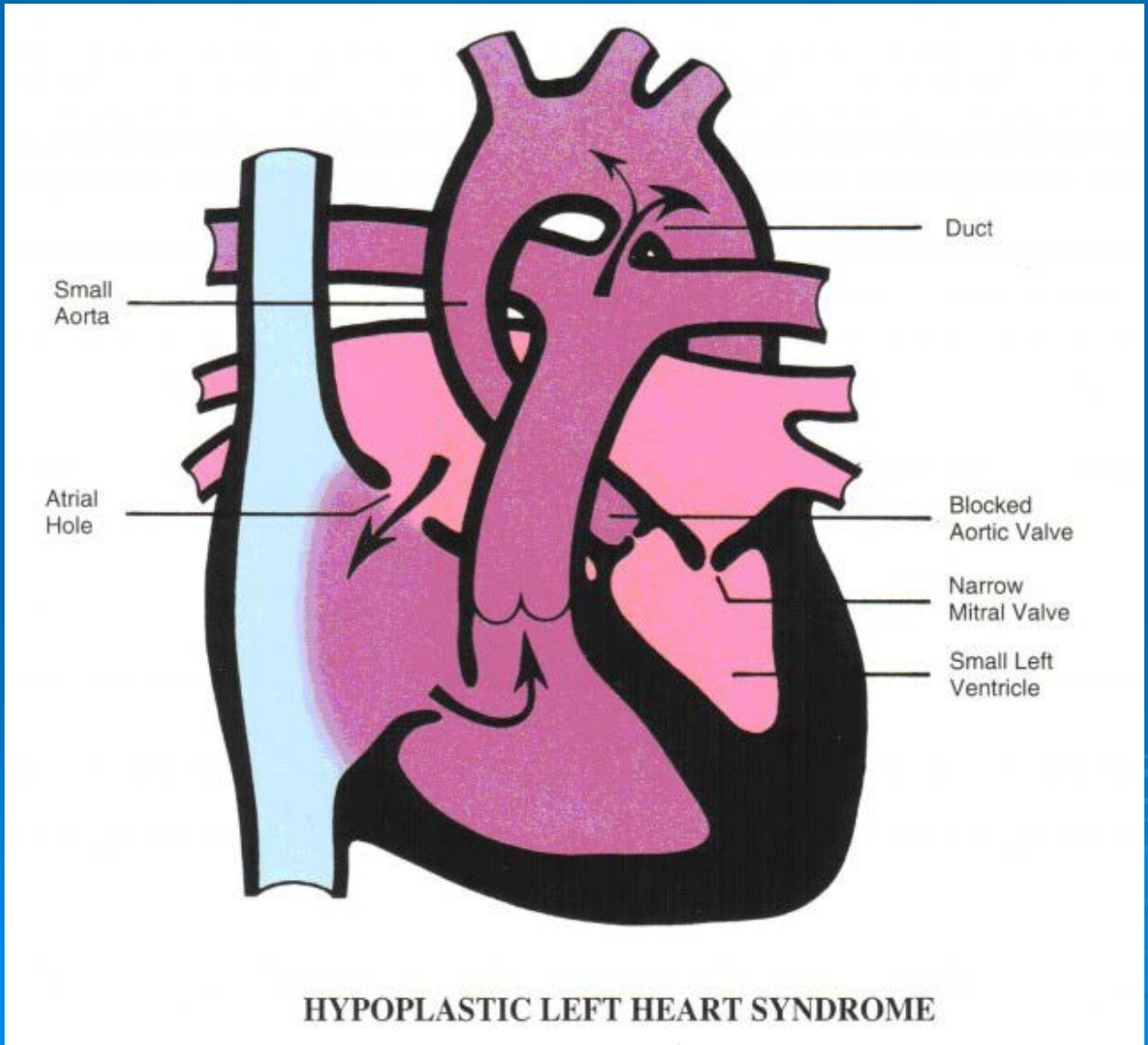
Total Anomalous Pulmonary Venous Return (TAPVR)



Transposition



HPLHS


Duct
Small Aorta
Atrial Hole
Blocked Aortic Valve
Narrow Mitral Valve
Small Left Ventricle
HYPOPLASTIC LEFT HEART SYNDROME

Presentation Patterns

- Cyanotic
  - Decreased Pulmonary Blood Flow
    - TOF (Right to Left Shunt)
  - Normal Pulmonary Blood Flow
    - TAPVR
- CHF
  - Increased Pulmonary Blood Flow
    - AS (Left to Right Shunt)
- Shock
  - HPLHS

Cyanosis

Presentation Timing

- Ductal dependent timing

0-6 Days	7-13 Days	14-28 Days
D-TGA (19)	COA (16)	VSD (16)
HPLHS (14)	VSD (14)	COA (12)
TOF (8)	HPLHS (8)	TOF (7)
COA (7)	D-TGA (7)	D-TGA (7)
VSD (3)	TOF (7)	PDA (5)
Others (49%)	Others (48%)	Others (53%)

Emergency Medicine

- It doesn't matter
  - Heart as a black box
- Child suspected cardiac issue
  - Cyanotic
  - Respiratory Distress
  - Shock

ED Evaluation

- Cardiac Specific History
  - Poor feeding
  - Lethargy
- Cardiac Specific Physical
  - Respirations
  - Femoral Pulses
  - Liver
    - Murmur

ED Evaluation

- Diagnostics
  - Pulse Ox
    - Hyperoxygenation Test
  - EKG
    - Right sided leads
  - Echocardiogram

Treatment

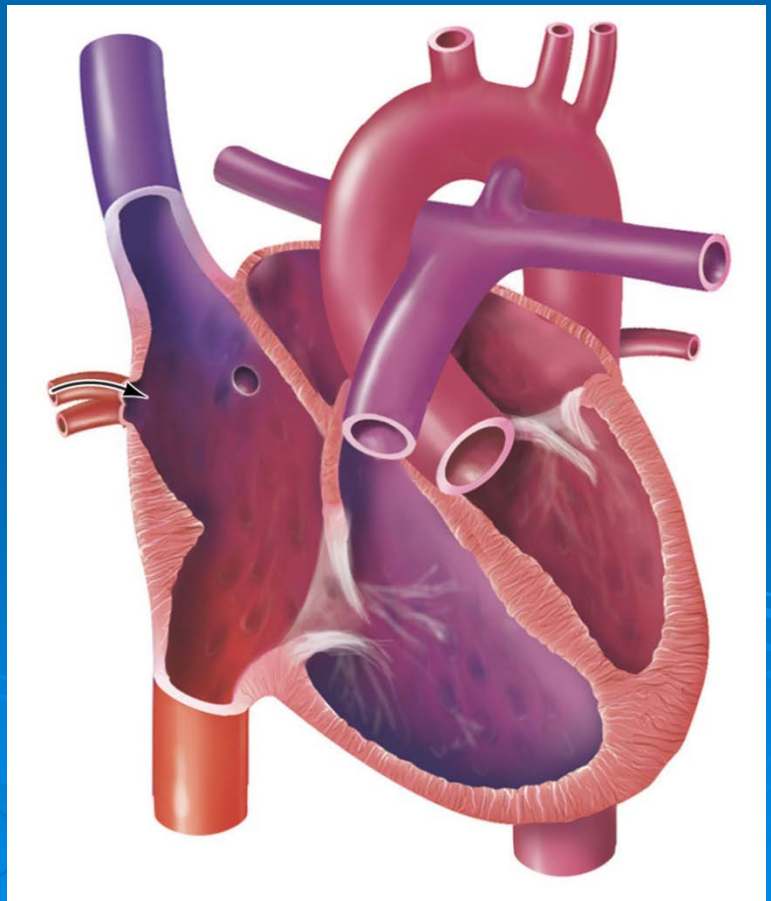
- Hydration
- Oxygen
- Prostaglandin (PGE1)
  - Any neonate in shock
  - ETI
- Inotropic support

PGE1

- 0.05 to 0.1 ug/kg/minute
  - Response within 15 minutes
- Apnea (10%)
- Flushing (10%)
- Bradycardia (7%)

Case 1

- Child fails hyperoxygenation test
- Admitted to PICU
- Begun on PGE1
- Dx TAPVR



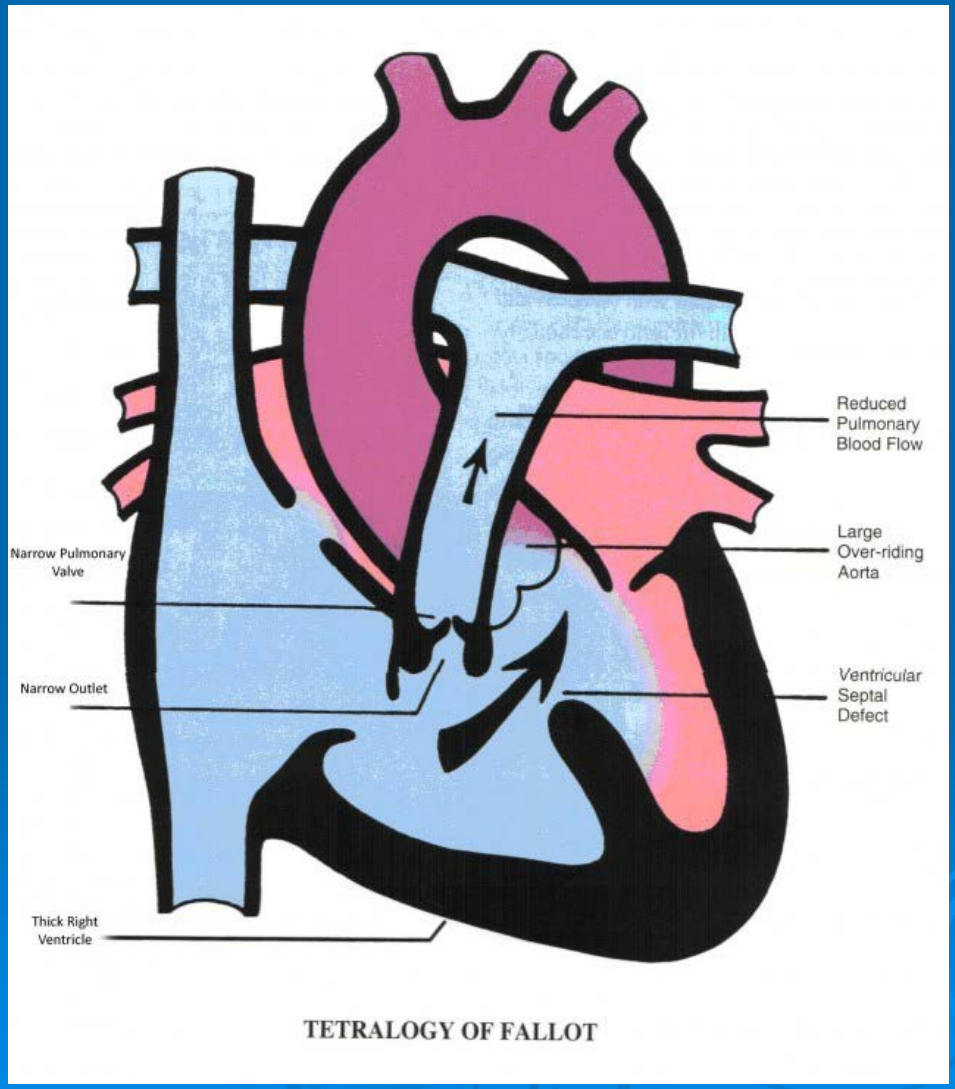
Case 2

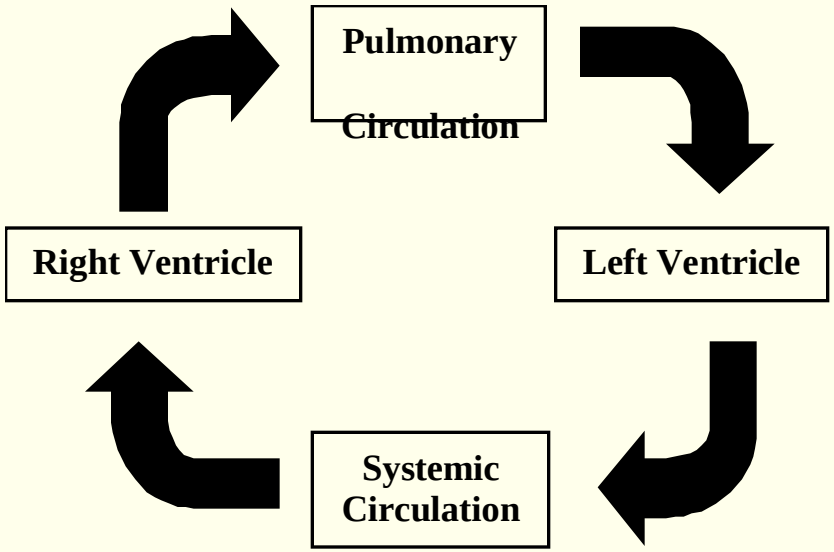
- 5 week old lethargy, tachypnea.
- S/p palliative repair for HPRH, PA with central shunt
- Ashen color, no pulses
- IO line, ETI, 100%
- Kid worsening

Case 2

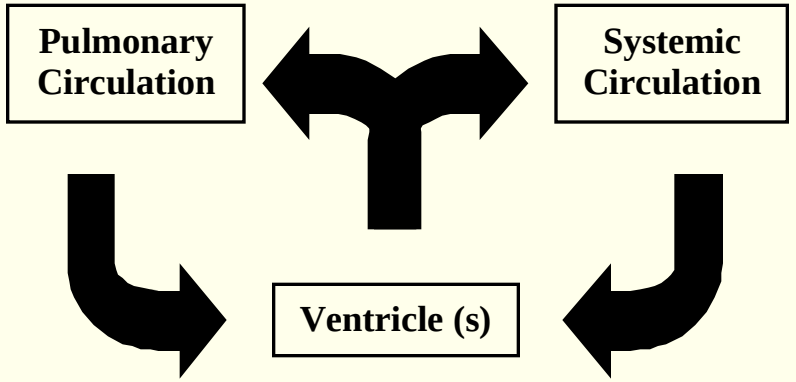
- Pediatric Cardiologist
  - Bedside echo-shunt working
- Second consultant
  - Hypoventilate with room air
- Bright pink infant with bounding pulses
- What the hell just happened here?

Open Circulation





Normal Circulation



Mixing Lesion Circulation

Open Circulation

Hypercyanotic Spell

- Severe right to left shunt
- Increase PVR
  - Knee chest position
  - Oxygen / Morphine
  - IV bolus NSS
  - Esmolol
  - Phenylephrine (0.02mg/kg)

Shock

- Severe left to right shunt
- Increase Pulmonary Pressure
  - Fluids
  - Iatrogenic hypoxia
  - Iatrogenic hypercapnea

Post Surgical Repair

- Palliative procedure
  - Hypoxic: (? Baseline)
  - pH and clinical picture
  - H/H
- Complete repair
  - 2 Ventricles
  - 1 Ventricle

Case #3
Fever and Lethargy

“Got a Whole Lot Of Stuff Goin’ On”

- A 6 day old infant
  - difficulty feeding
  - increased sleeping
  - increased respiratory rate
  - child felt warm
- Past medical history
  - term product of G3P2012
  - vaginal delivery

Physical Exam

- Mottled, cyanotic
- Cried intermittently
- Looked ill
- Pulse 160; rectal temp 38.4°C; BP 55/30; RR: 60-80; weight 3.1 kgs

Physical Exam (continued)

- Skin: peripheral cyanosis
- Cor: tachycardia with gallop, I/VI murmur left side of chest and apex
- Chest: soft rales
- Abdomen: soft , enlarged liver
- Neuro: lethargic, hypotonic

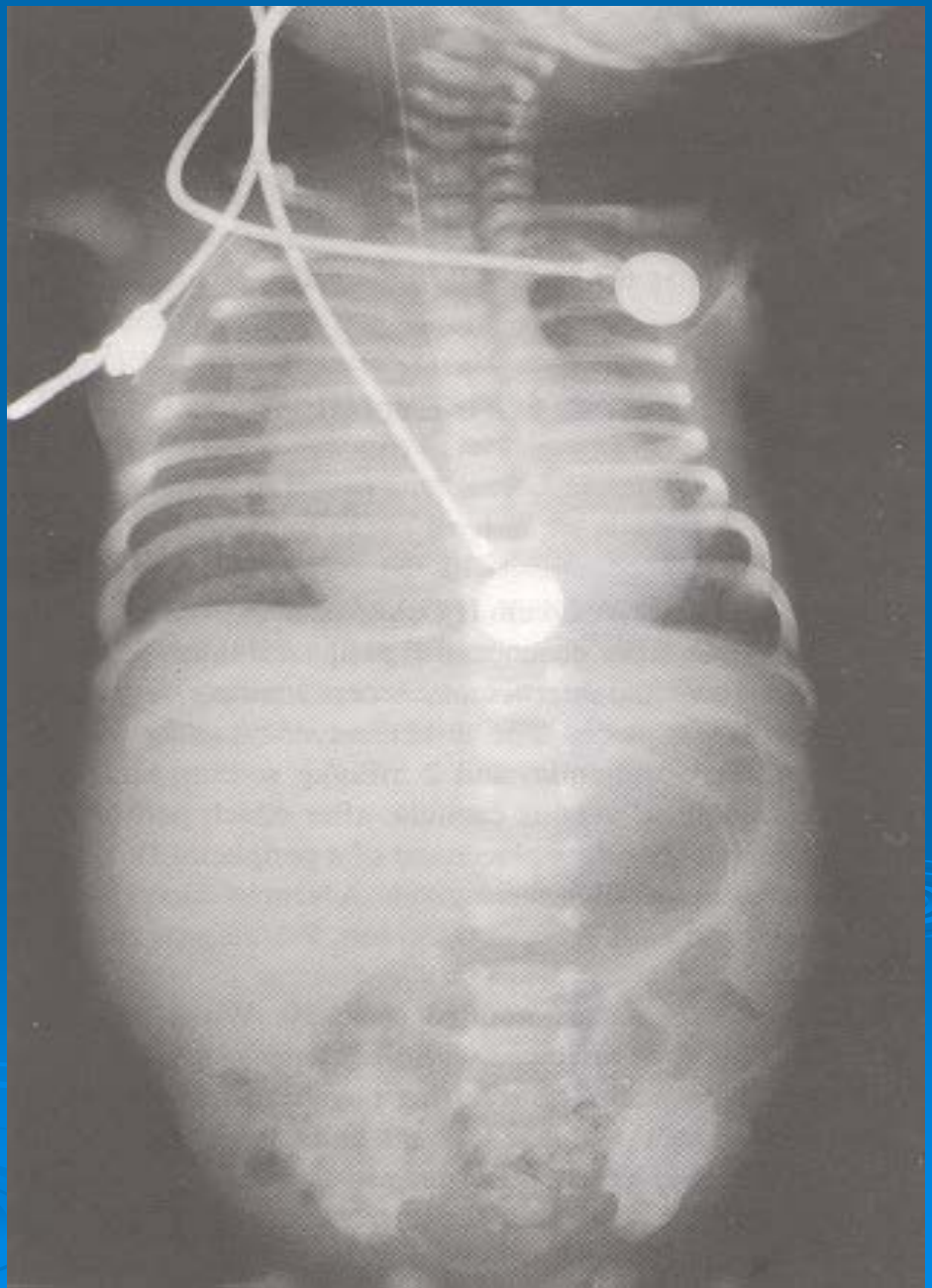
Problem List

- Shock
- Abnormal mental status
- Peripheral cyanosis
- Fever
- Rales
- Tachycardia

Case Progression

- CBC: WBC 22,000
  - 45 PMNs, 12 Bands, 32 Lymphs,
  - Hgb 13 g/dl
- Lytes: Na+ 137, K+ 4.9, Cl 105, CO2 10 mEq/L, Gluc 185
- U/A: 1-3 WBCs, 8-10 RBCs
- ABG (60%O2): pH 7.17, pCO2 30;PO2: 82

Radiograph



Case Progression

- Child intubated, 40 resp / minute
  - PIP 24 cm H2O, PEEP 5 cm H2O
- IV attempt: unsuccessful
- Umbilical cutdown
  - 20 cc/kg bolus of NS x 2
  - 1 meq / kg HCO3

Initial Considerations

- Sepsis
- TORCH infection
- Grp B Strep pneumonia
- NEC
- Meningitis
- Congenital Adrenal Hyperplasia
- Cardiac Disease

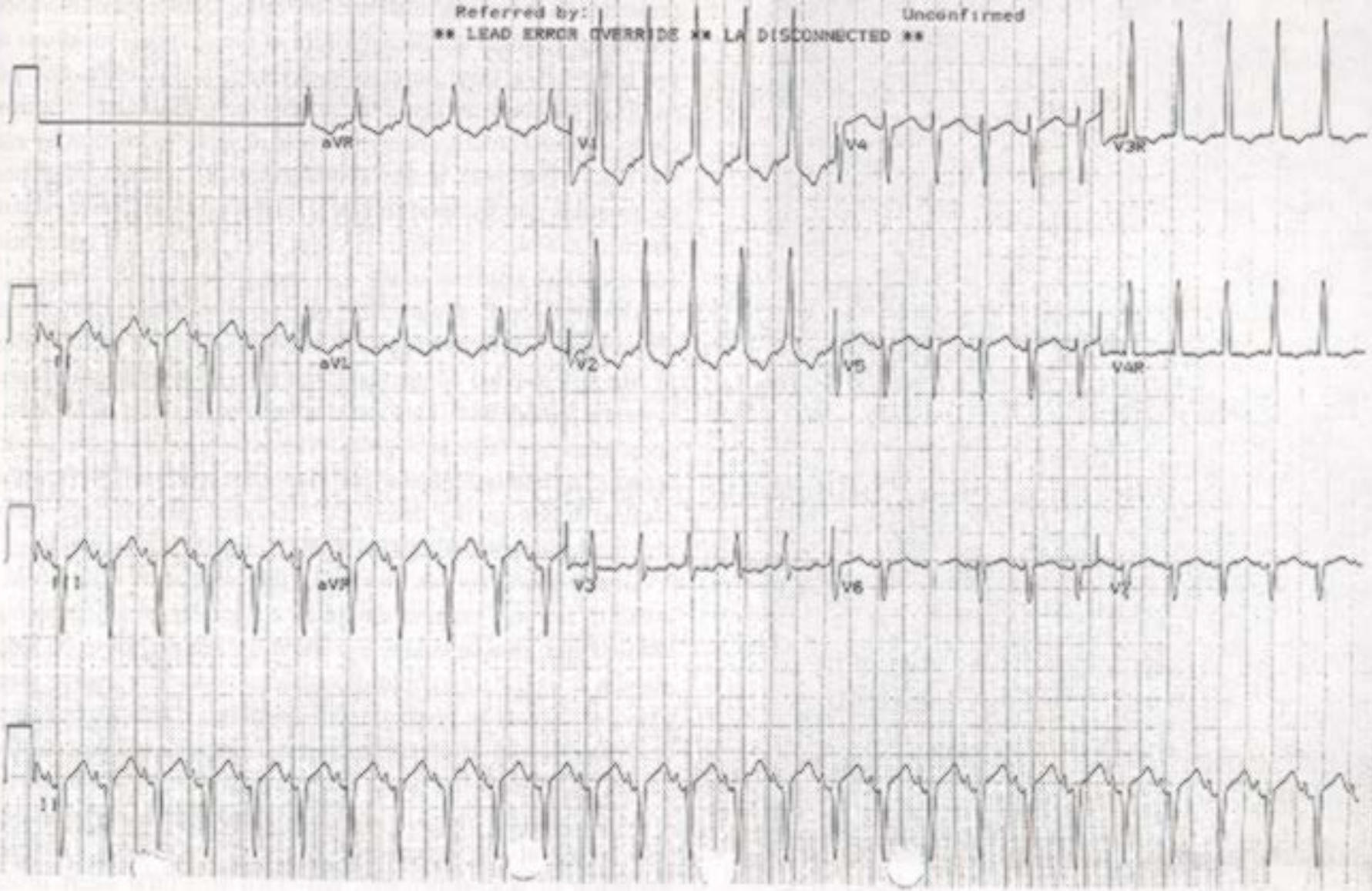
10mm/mV
40Hz
Pgm 1088
12SLtm v74

ZDK 14 Ht: Wt:
Sex: F Race: Casc
Loc: 26 Room:

*** POOR DATA QUALITY. INTERPRETATION MAY BE ADVERSELY AFFECTED
** ** ** ** * PEDIATRIC ECG ANALYSIS * ** ** ** ** **
NORMAL SINUS RHYTHM ~~WITH TOP-SHORT AV BLOCK~~
RIGHT BUNDLE BRANCH BLOCK

Vent. rate	164	BPM
PR interval	90 ~~100~~	ms
QRS duration	84	ms
QT/QTc	288/475	ms
P-R-T axes	90 270	90

Referred by:
Unconfirmed
** LEAD ERROR OVERRIDE ** LA DISCONNECTED **



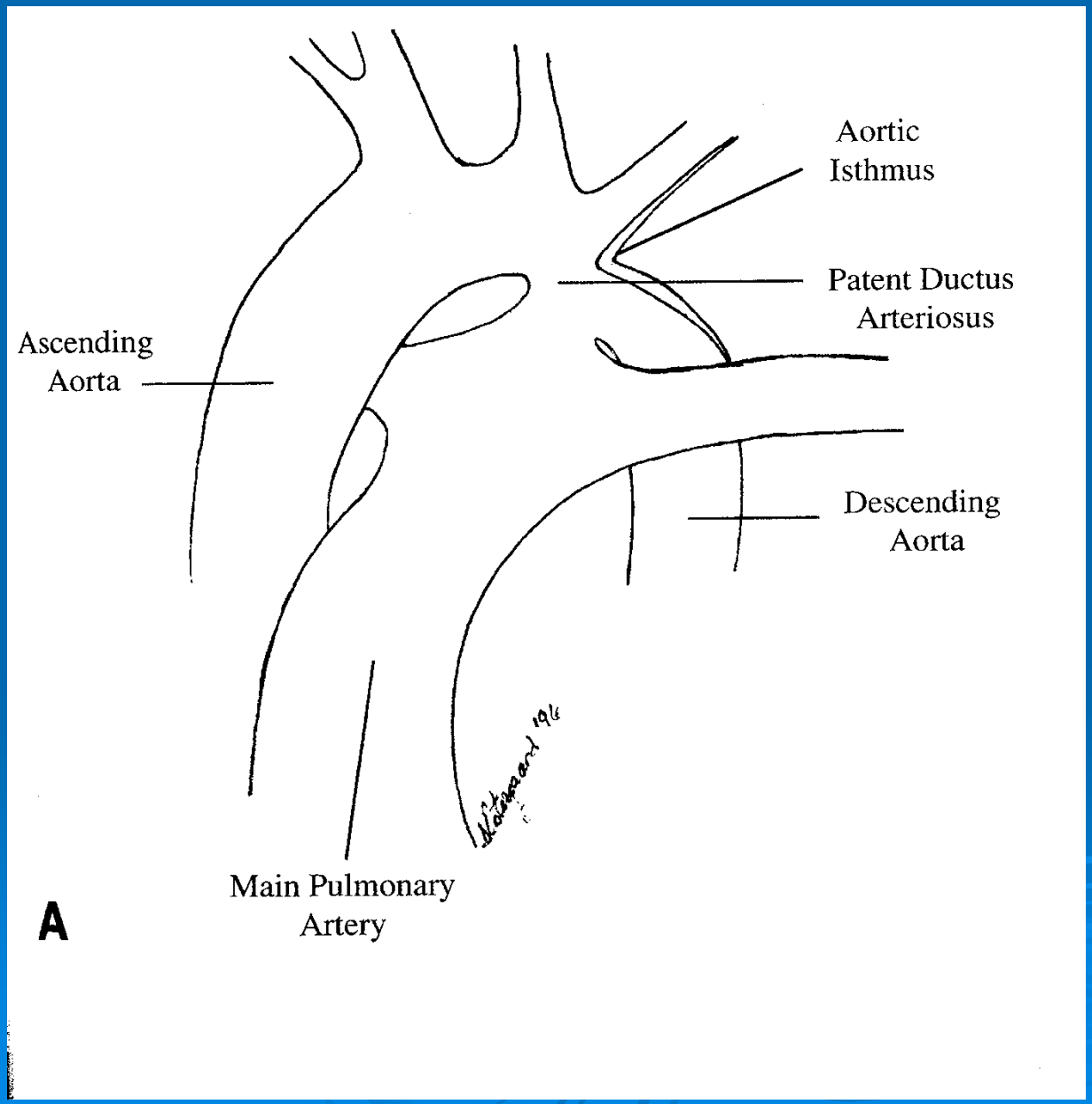
Continuation of Case

- Repeat fluid bolus
  - improved circulation but…
  - diminished pulses
- Claforan 50 mg/kg and ampicillin
- Prostaglandin E_1 @ 0.1 ucg/kg/min
- Improved perfusion

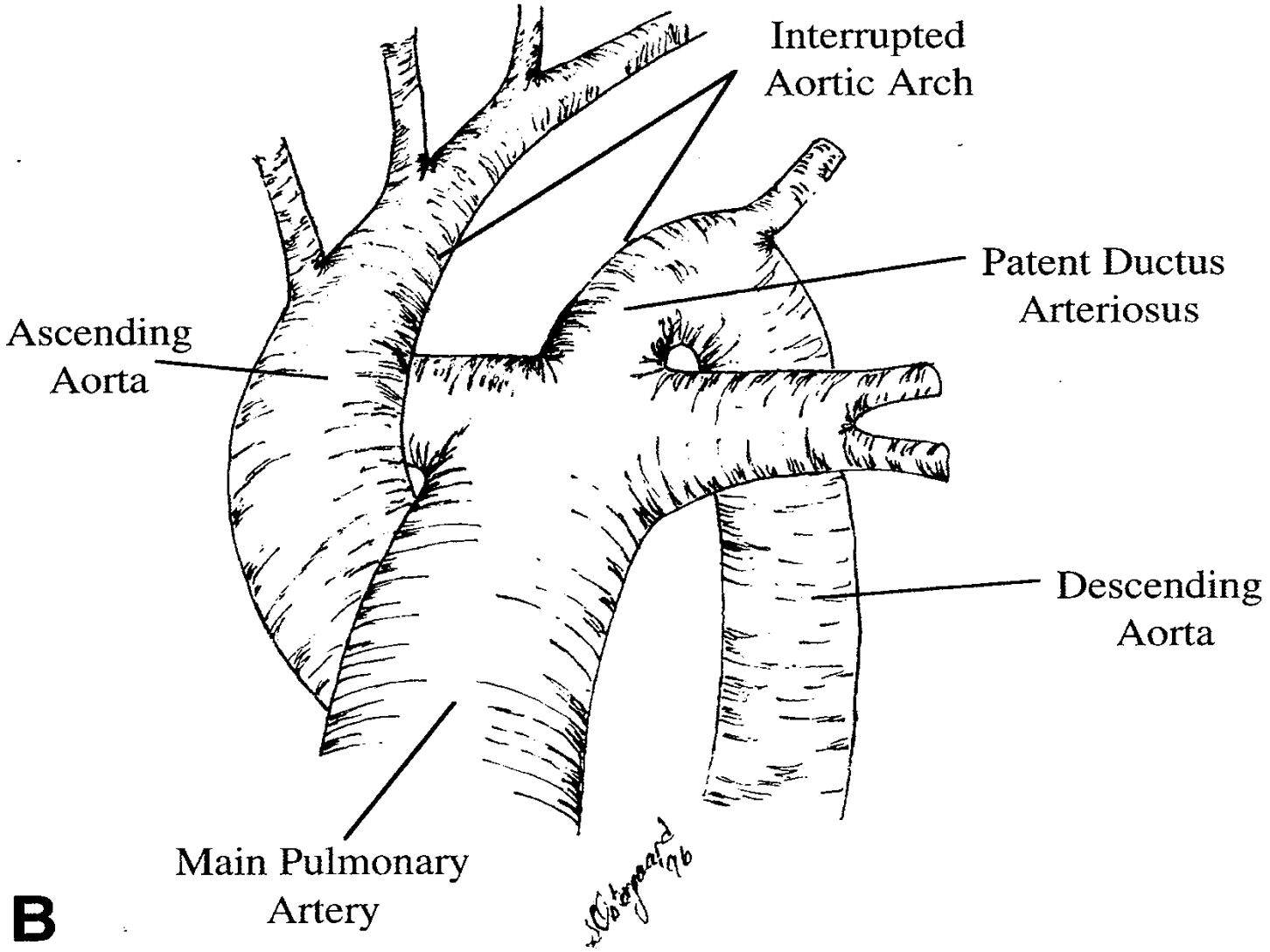
Echocardiogram

- Obstructive cardiac disease
- Markedly hypoplastic transverse aortic arch
- Severe obstruction at the level of the ductus
- Large ventricular septal defect
- Dilated right ventricle
- Large PDA with Right to Left shunt

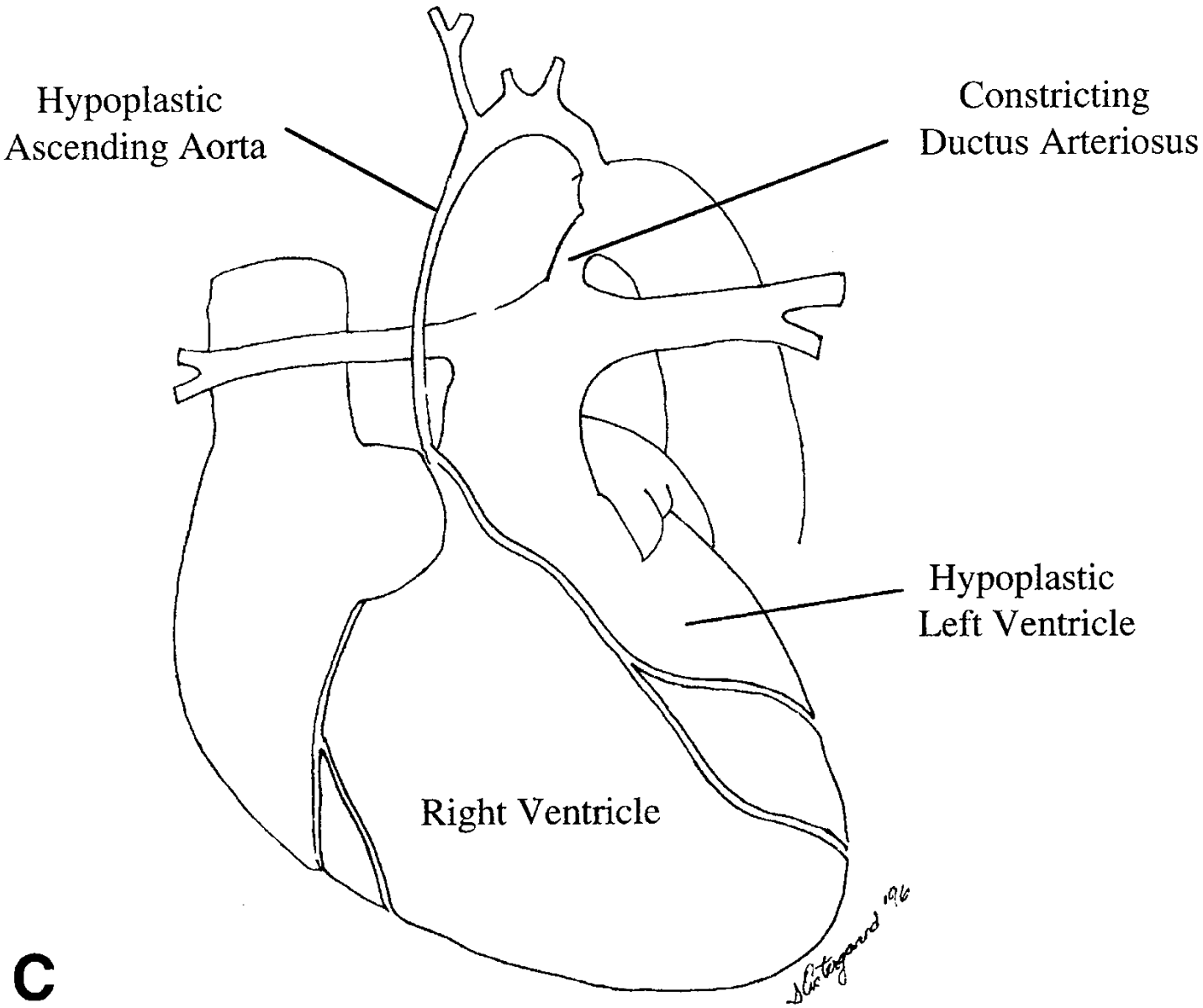
Cardiac Disease



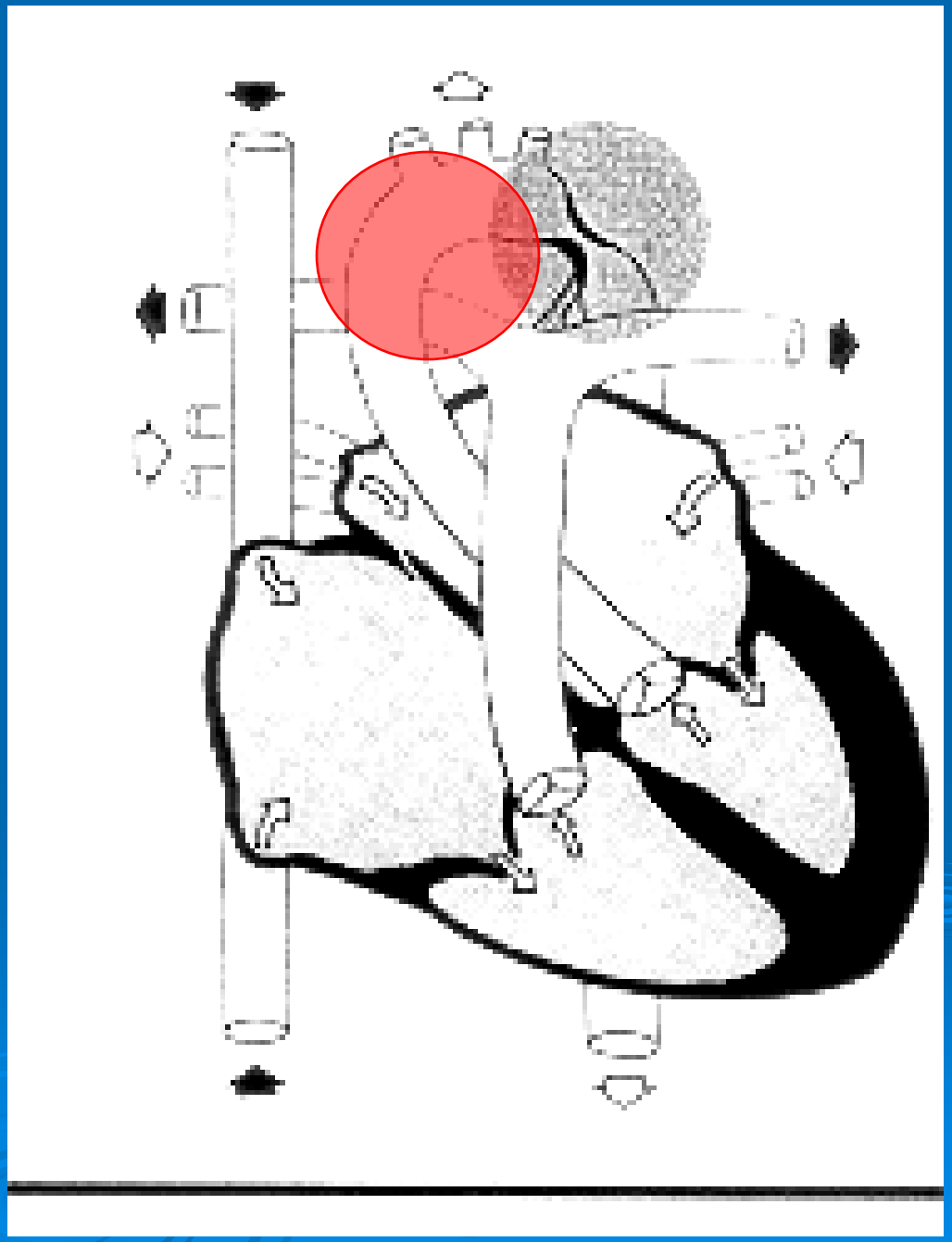
Cardiac Disease



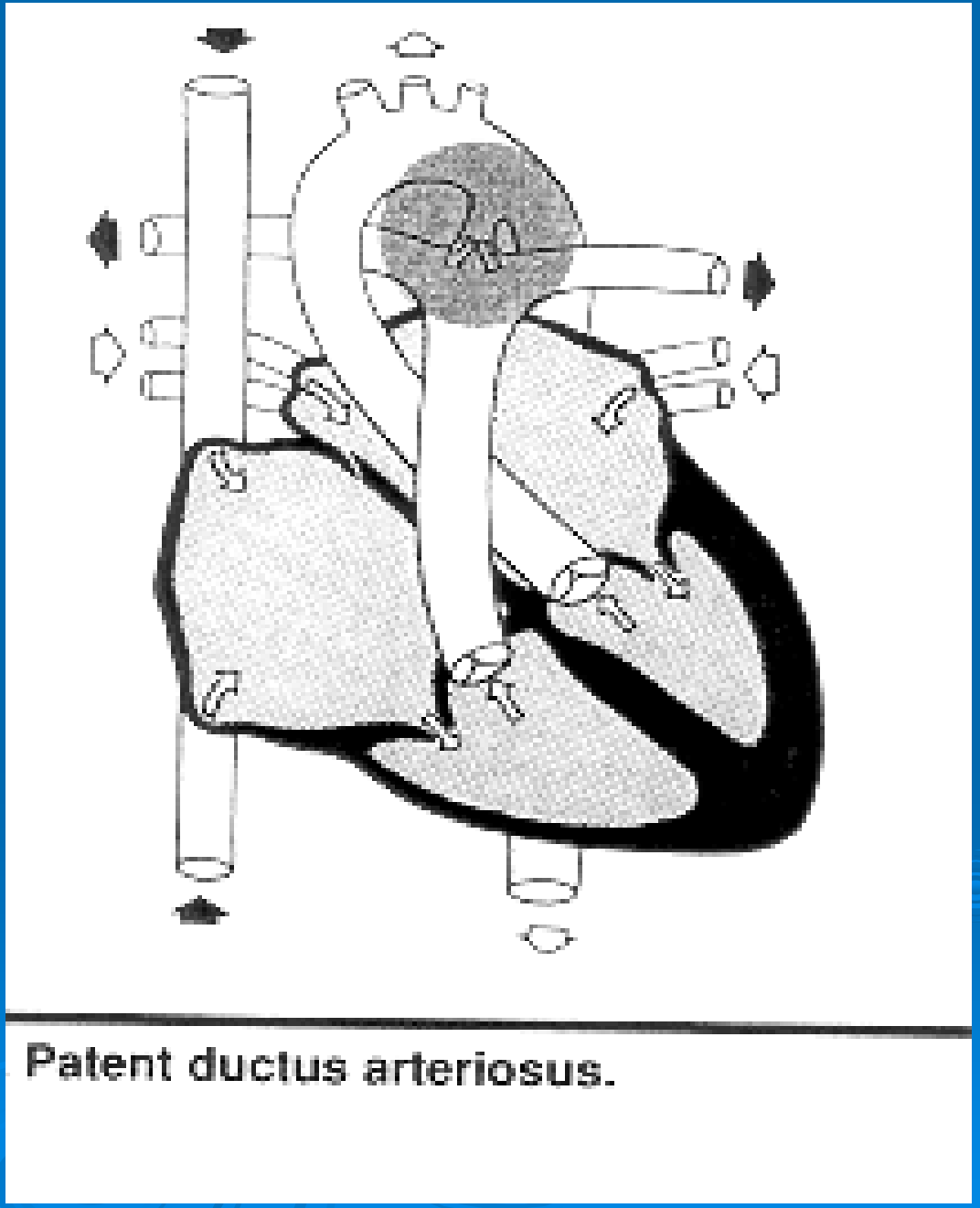
Cardiac Disease



Coarctation



PDA



Patent ductus arteriosus.

Neonatal Emergencies: Sepsis versus Congenital Heart Disease (CHD)

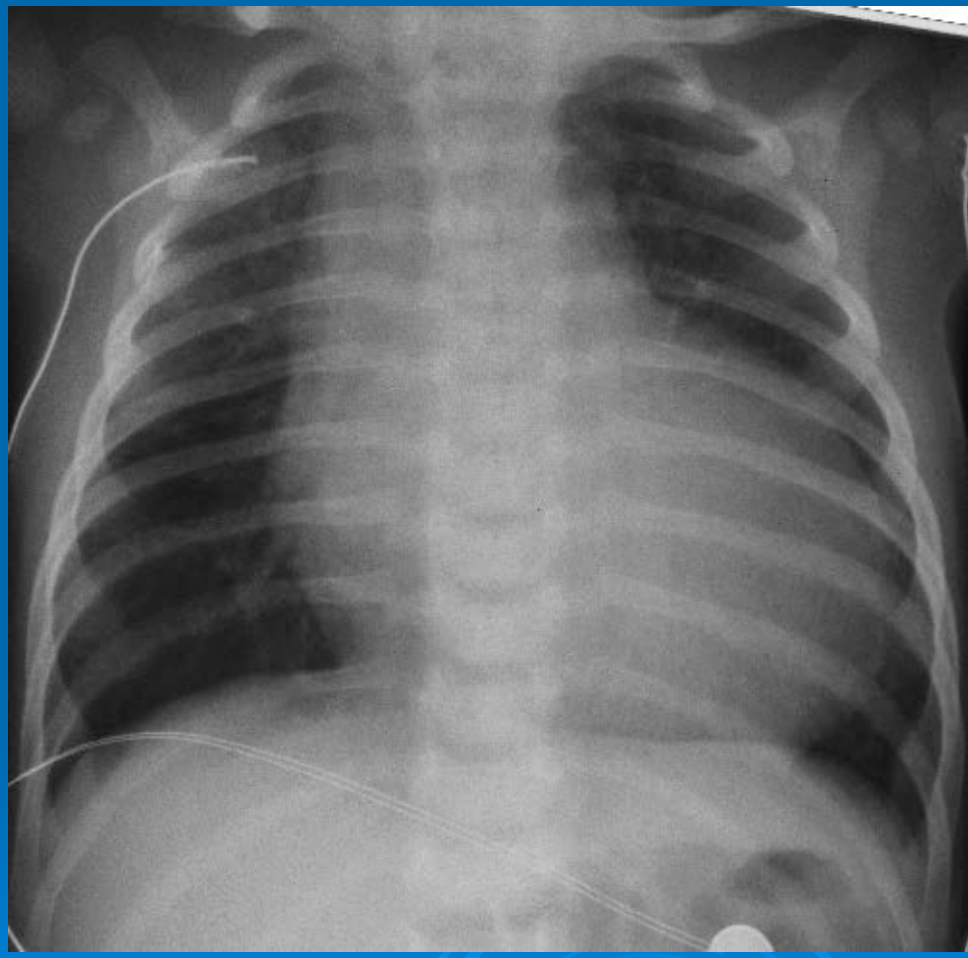
- Dyspnea (CHF?)
- Cyanosis (Cyanotic Heart Disease?)
- Profound respiratory Distress / Shock
  - (Left ventricular outflow obstruction)

Case 4

- 6 month old male, s/p URI
- Tachypnea, wheezing, rhinitis
- Punky, no severe distress
- Saline nose drops, discharge
- 2 days later return visit
  - Moribund

Diagnostic Studies: Myocarditis

- Radiology:
  - CXR will reveal cardiomegaly and prominent vasculature, perhaps even pulmonary edema
  - Laboratory:
    - May not add much
    - Not specific



Myocarditis

- Acquired Disease
- Viral mediated autoimmune
  - Coxsackie-Adeno receptor
- Epidemiology
  - Incidence 0.3% admissions in tertiary centers
  - 15% SIDS

Myocarditis

- History
  - Sounds like every other virus
- Physical
  - Muffled heart sounds
  - Hepatomegaly
  - CHF

Myocarditis

- Diagnostics
- CXR
  - Cardiomegaly
- Echo
- Contrast MRI
- Serum

Management

- ED supportive care
- CHF
- Anticoagulation (?)

Case
More Wheezing!

3-month-old female with wheezing

What history would do you need to know?

Pertinent Information: History

- Rhinorrhea and cough for 2 days
- No fever
- No ill contacts
- PMH: Wheezing heard at 1 month and treated with albuterol
- Family history noncontributory

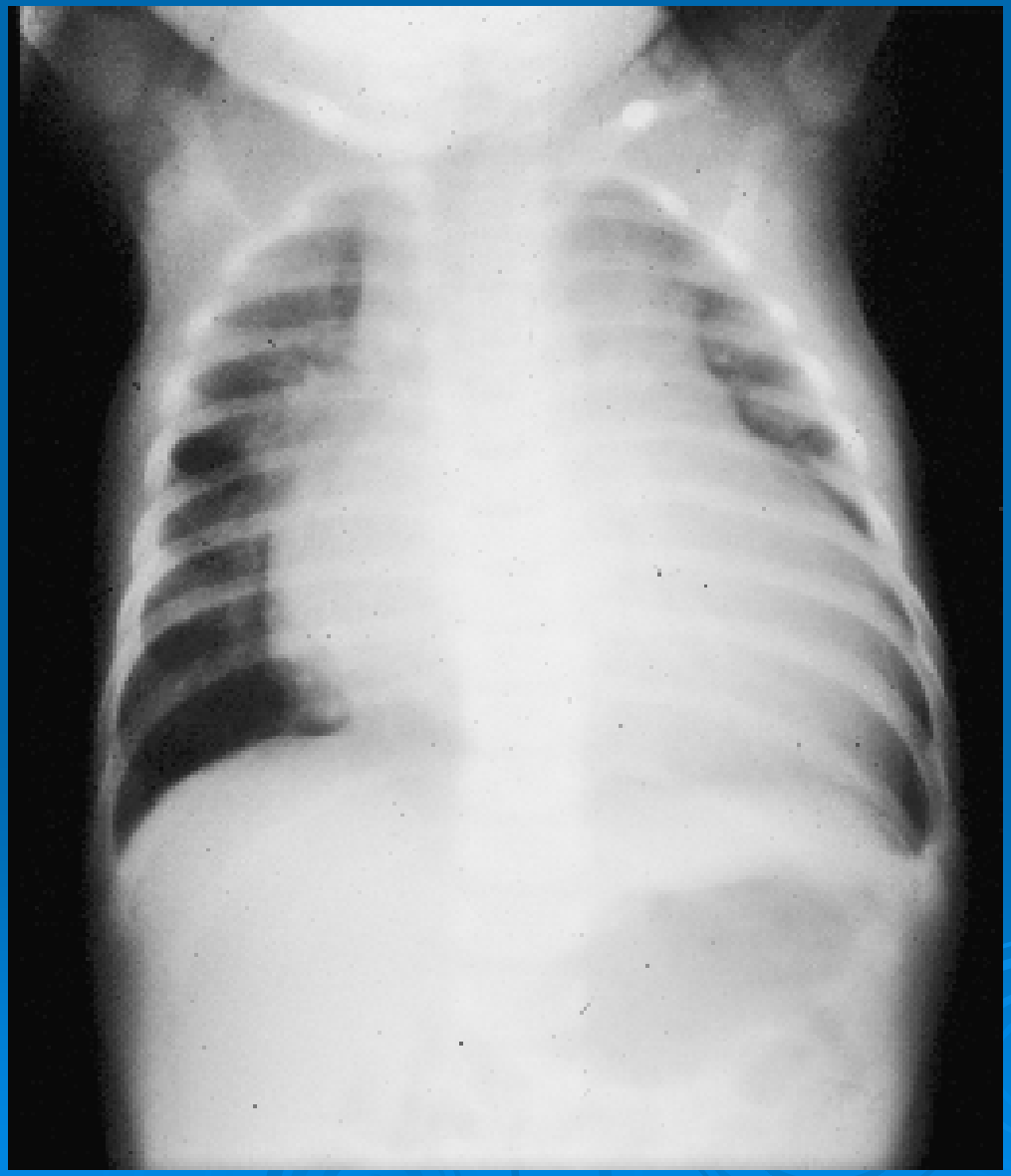
Pertinent Information

- Feeding
  - *Intermittent sweating* episodes associated with crying/feeding for 2 weeks
  - Vigorous at the start of each feed but *tires easily* (frequent feeding breaks; takes 45 min to finish bottle)

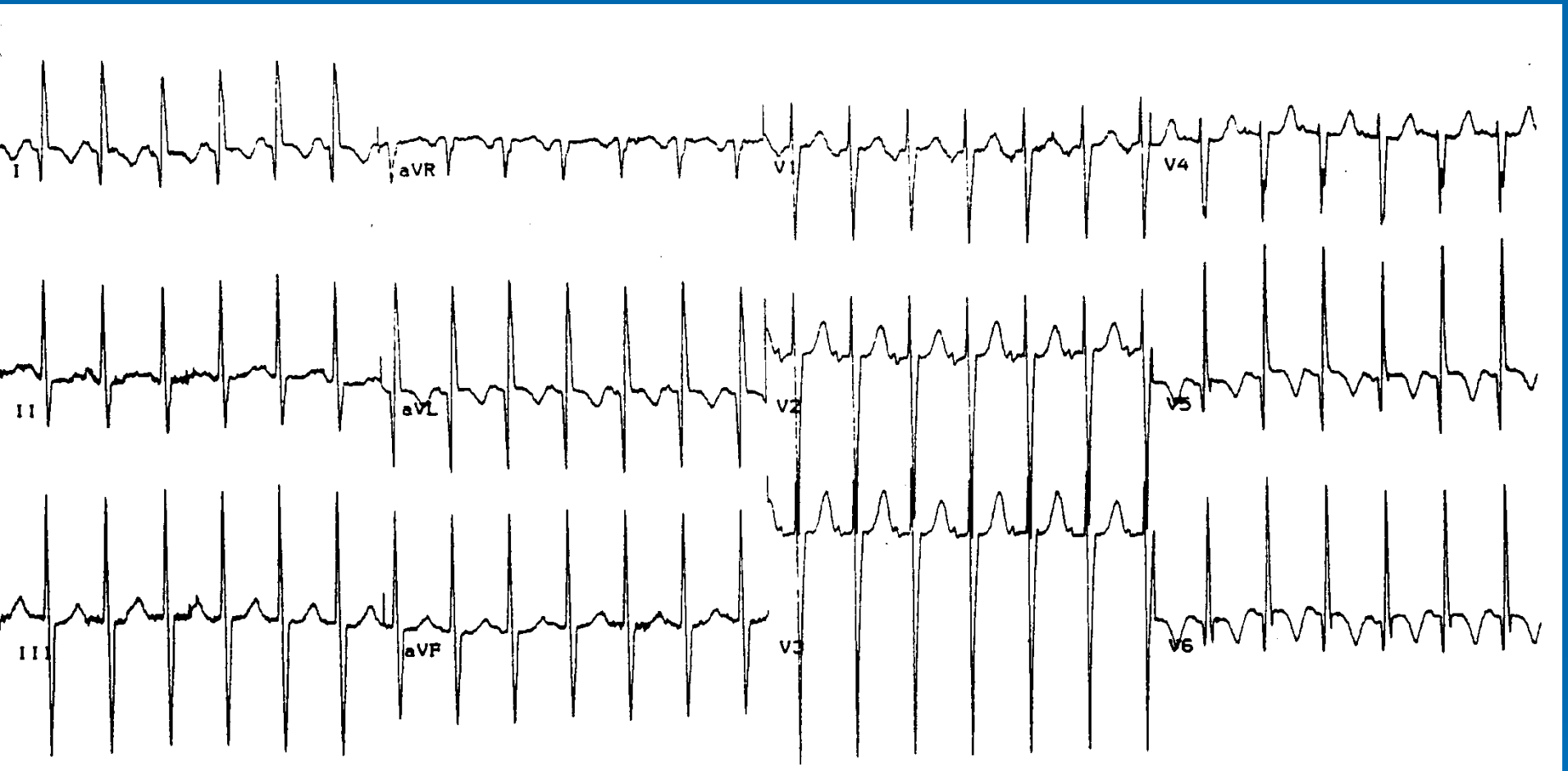
Pertinent Information

37.6° C, HR 176, RR 70, BP 80/P

- SaO_2 100% on room air
- Bilateral end-expiratory wheezes
- Mild suprasternal retractions
- Cardiac: RRR with *questionable* S_3
  - No murmur
  - Good femoral pulses
- Abdomen: soft, questionable spleen tip
- Remainder of physical exam normal

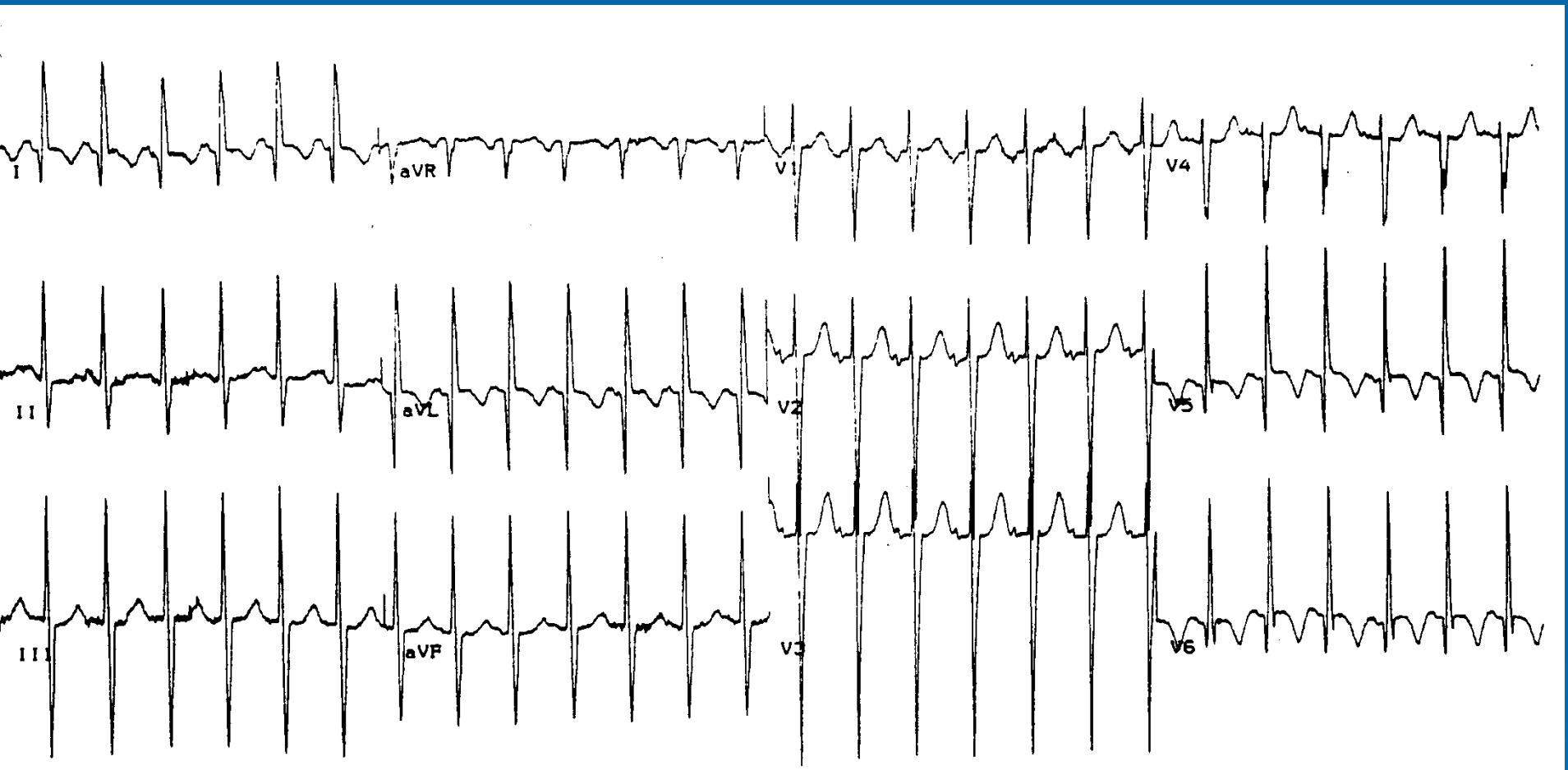


Courtesy of Dr. Bob Hickey



ECG: *Q waves* in leads I, aVL, V_5 and V_6 and flipped T waves

Franklin WH, Dietrich AM, Hickey RW, Brookens MA. Anomalous left coronary artery masquerading as infantile bronchiolitis. Pediatr Emerg Care 1992; 8(6):338-341.


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6

Diagnosis

- Anomalous coronary artery arising from the pulmonary artery
- Coronary arteries fill during diastole. When a coronary artery arises from the pulmonary artery, the diastolic pressure is insufficient to adequately perfuse the heart, causing myocardial ischemia and congestive failure

Critical Concepts

- Feeding and crying are the “infant stress test”
- “All that wheezes is not asthma.”
- Other causes of *cardiac-associated* wheezing in infancy include
  - Cardiomyopathy
  - Myocarditis
  - Left-sided obstructive lesions (eg, aortic stenosis and coarctation of the aorta)
  - Left-to-right shunt lesions

Critical Concepts

- Anomalous coronary artery, myocarditis, and cardiomyopathy can be especially difficult to diagnose on physical examination because wheezing and tachycardia easily obscure the gallop rhythm and soft murmurs associated with these conditions

Critical Concepts

- Consider heart disease in the child with wheezing
  - Remember the ROS questions associated with cardiac disease
  - Listen for soft murmurs and gallop
  - Feel for hepatosplenomegaly
  - Feel the distal pulses—infants with asthma/reactive airways disease are typically well perfused

Non-Cardiac Causes of Wheezing in Infancy Include

- Bronchiolitis
- Asthma
- Gastroesophageal reflux
- Pneumonia
- Foreign body
- CHF
- Cystic fibrosis
- Tracheoesophageal fistula
- Lobar emphysema

Summary

- Wheezing in infancy can be a presentation for cardiac disease
  - Sweating and shortness of breath during feeding is associated with cardiac disease in infancy
  - Perform a thorough cardiac exam in infants with wheezing

The Inconsolable Infant/Child
Causes

- Infection
- Trauma
- Metabolic
- Toxic
- Behavioral
- Other Medical/Surgical problems.

Where to start??

Case
Inconsolable Infant

This 22 month old infant has been to their private physician twice and to two other ED's for evaluation of fever and extreme irritability of five days duration. A lumbar puncture was negative last night, and cultures of the blood, CSF, and urine are negative at 48 hours. The irritability is spreading to the tired and anxious parents.

The Inconsolable Infant/Child
Causes

- Infection
- Trauma
- Metabolic
- Toxic
- Behavioral
- Other Medical/Surgical problems.

Where to start??

Kawasaki Disease Diagnosis

- **Fever > 5 days**
- **Plus 4 of 5:**
  - hand/feet changes
  - “road map” scleral conjunctivitis with sparing of limbus
  - polymorphous rash
  - lip/mouth/tongue changes
  - unilateral cervical lymphadenopathy

Kawasaki Disease Complications

- Cardiac complications
  - coronary aneurysms, thrombosis
  - tachydysrhythmias, block
  - myocarditis
- Extreme Irritability
  - sleep, behavior changes
- Aseptic meningitis
- Gall bladder hydrops
- Pancreatitis
- Thrombocytosis

Kawasaki Disease

- #1 cause of acquired heart disease in U.S.
- Without IVGG, 15-25% develop CAL.
- With IVGG, < 5% develop CAL
- Early Rx improves outcome
- < 6 months of > 8 year children have a higher risk of complications
- 20+% of those with CAL from Kawasaki don't meet clinical criteria. (Incomplete Kawasaki).

Case: Epilogue

The child was admitted, given IVGG, and had an ECHO by cardiology that was negative for aneurysms. He was discharged home for follow-up in one week.

Three days later he returned to ED with a temp of 100.6 F. Exam showed a dull, red left tympanic membrane. PE is otherwise WNL. Treat and street??

Case: Not Good

The patient was sent home on amoxicillin for treatment of otitis media. Three weeks later he was readmitted for acute respiratory distress, was found to have large coronary aneurysms and subsequently died.

Predictors of coronary artery lesions after treatment with IVIG

- Persistent fever beyond 48 hours post IVIG
- Less than one or greater than eight years old
- Fever >ten days before IVIG
- High baseline WBC/band counts.
- Thrombocytopenia post IVIG
- Rising CRP and WBC after IVIG
  - AAP Red Book, 2003

Predictors of Coronary Artery Lesions after Treatment with IVIG

- 193 Children with Kawasaki
  - 24 (12.2%) had CA lesions
- Predictors of CAL 2-3 days post Rx.
  - ↑ WBC and neutrophils
  - ↑ CRP

Mori et al, J. Ped, 2000

Kawasaki Disease

- Epidemiology
  - #1 Acquired heart disease
  - 15/100,000
- Etiology (?)
  - Infectious / autoimmune
  - Staph A. or Group A Step
  - Carpet cleaning / humidifiers vindicated

Kawasaki Disease

- History
  - 3 phase disease
  - Acute (1-2 wks)
  - Subacute (2-8 wks)
  - Convalescent (Months - yrs)

Kawasaki Disease

- Fever ≥ 5 days
- 4 or more criteria
  - Non-exudative conjunctivitis
  - Polymorphous rash
  - Mucosal involvement
  - Extremity edema
  - Cervical adenopathy
    - Need not all be present at once

Kawasaki Disease

- Specific physical findings
  - Mouth: erythema, fissures, crusting, strawberry tongue
  - Extremities: Palmar and plantar erythema, desquamation, transverse groves across finger nails (Beau lines)

Kawasaki Disease

- Cardiac involvement
  - Pancarditis
  - Cardiomyopathy
  - CHF
  - Coronary artery aneurysms
    - Sub acute phase

Kawasaki Disease

- IV Immunoglobulin (2 g.kg)
- ASA 80-100 mg/kg/day
- ? Value

Rheumatic Fever

- Post infectious autoimmune inflammatory disease
  - GABHS rheumatogenic strain
- 0.05/100,000 industrial countries
  - 500/100,000 tropical countries

Rheumatic Fever

- Modified Jones Criteria
  - 2 major or 1 major, 2 minor

Major	Minor
Polyarthritis	Fever
Carditis	Arthralgia
Sydenham chorea	Elevated ESR/CRP
Eryth. Marginatum	Prolonged PR
Sub Q Nodules	

Rheumatic Fever

- Physical Exam
  - Murmur
  - Musculoskeletal
    - Painful ROM
  - Neurologic
    - Movement disorders
  - Dermatologic
    - Nodules / Rash

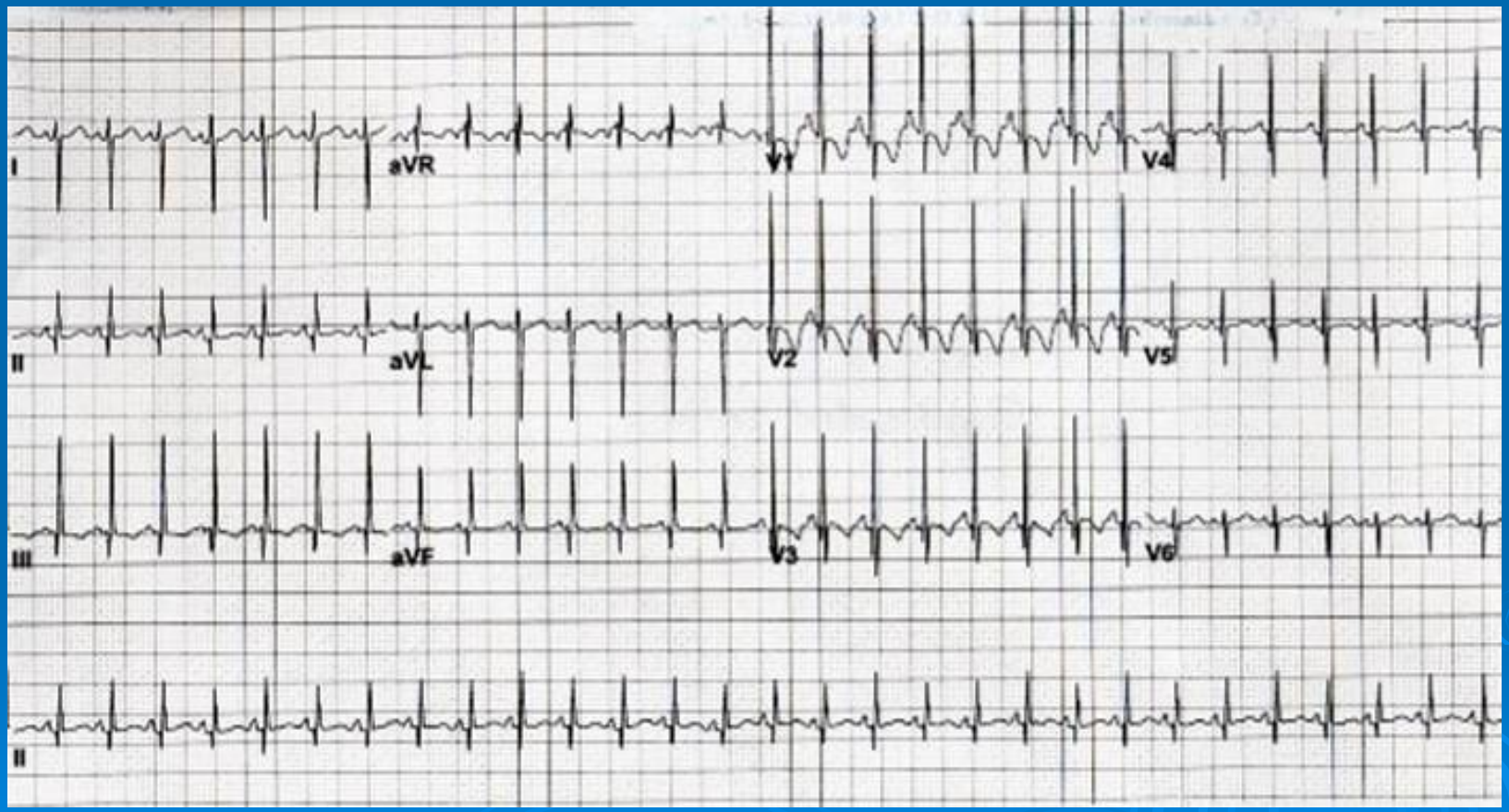
Case 3

- 10 year old female
  - Fluttering in chest
  - Occurs 2-3 times / year
- VS HR 180, BP 110/70
- Child notes she can fix it.
  - Walks to corner of room stands on head and returns to NSR

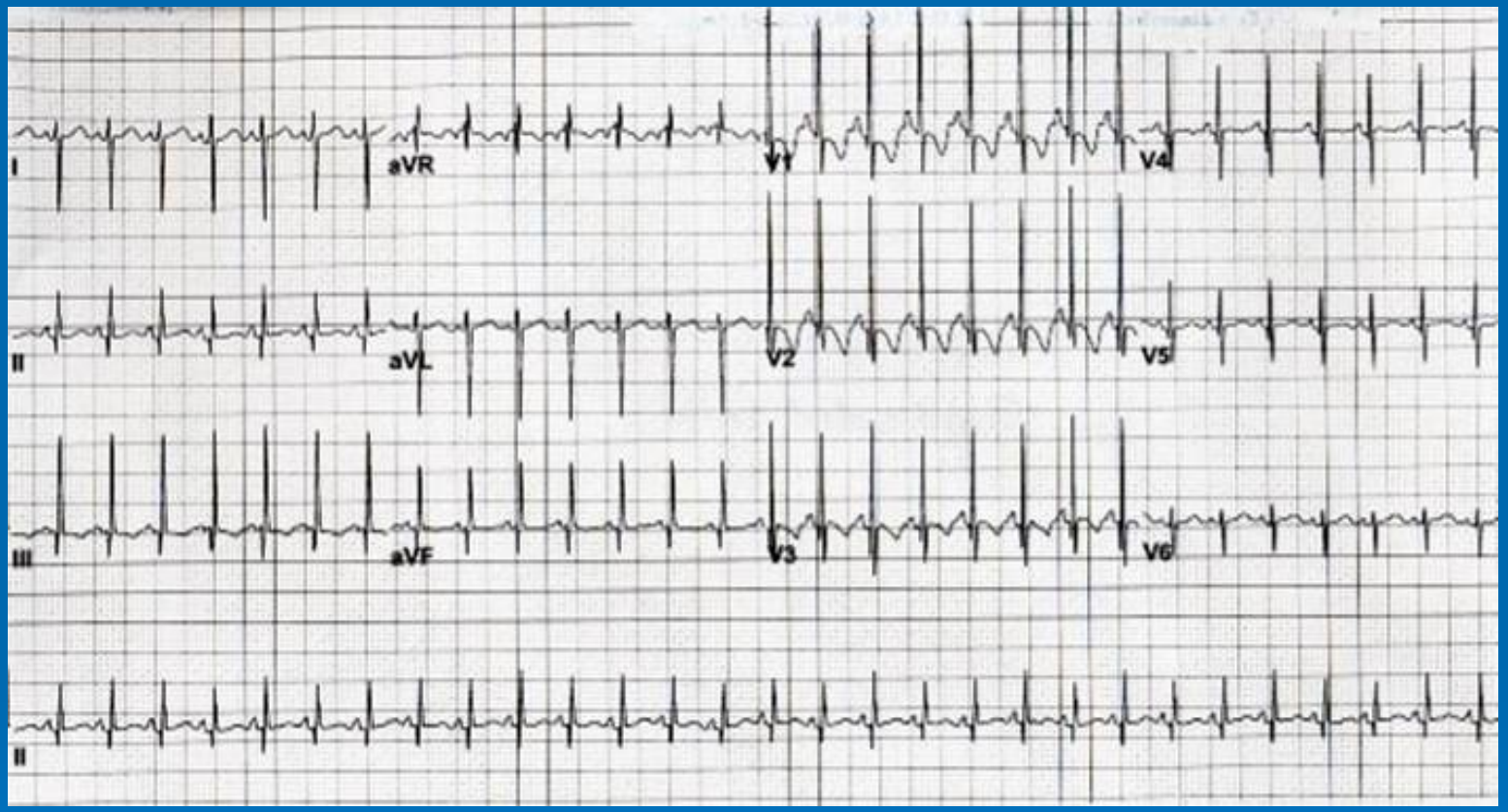
Electrocardiology

- Same as adults
  - P wave: QRS : T wave
  - Axis
  - Intervals
  - Incredibly subtle stuff that even the pediatric cardiologists don't remember.

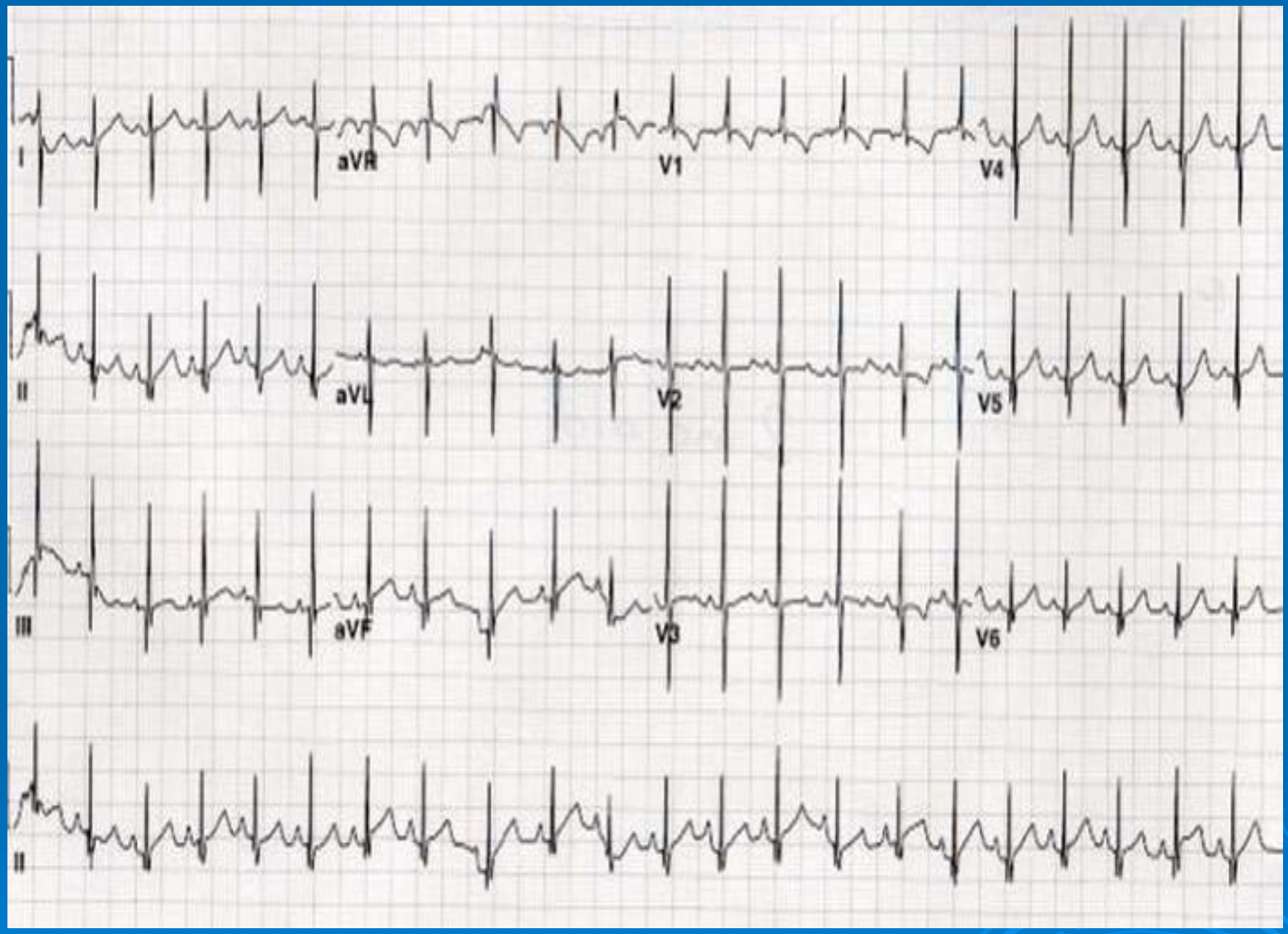
Pediatric EKG



Newborn EKG

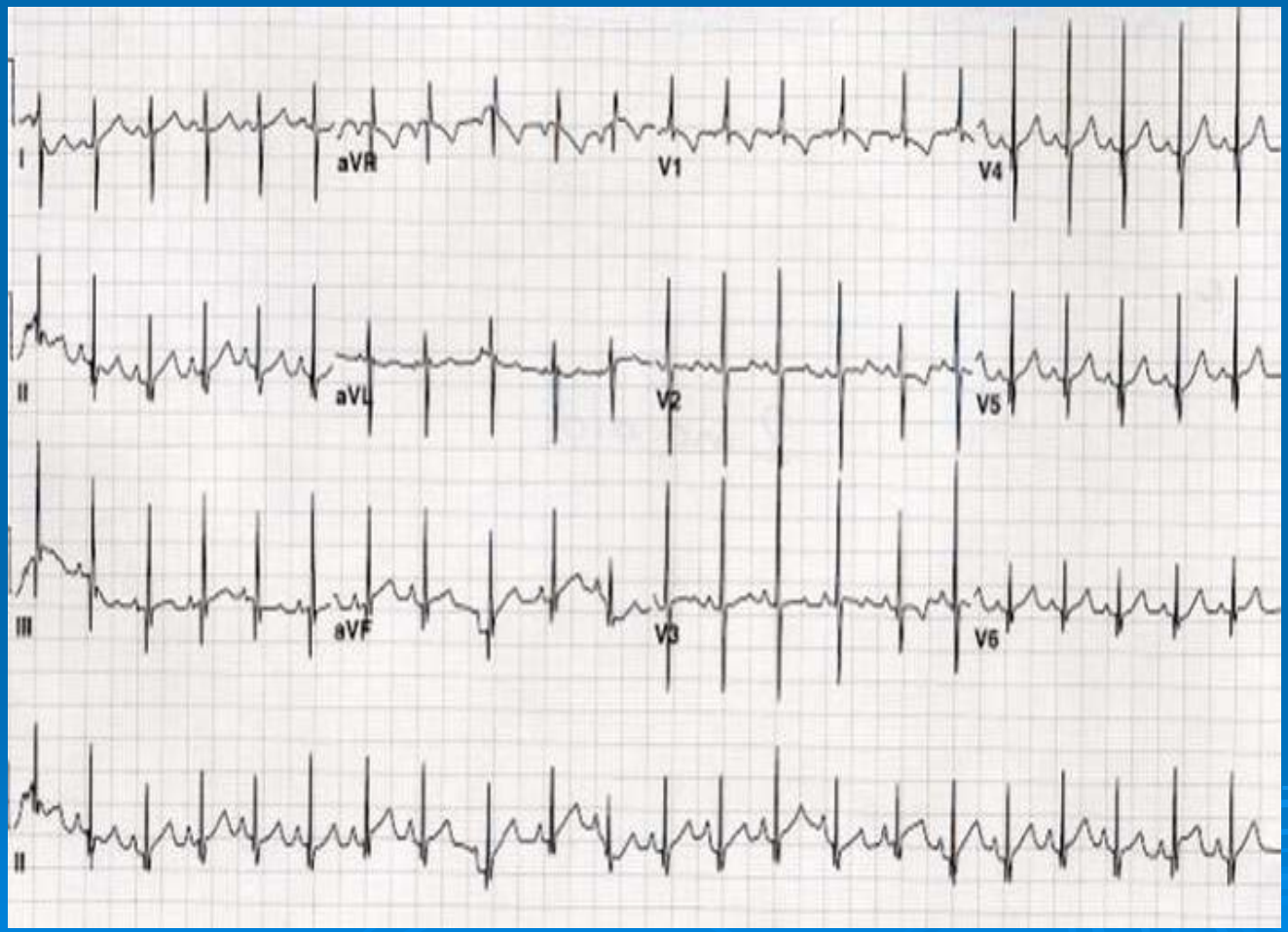


Newborn ECG – Rightsided forces

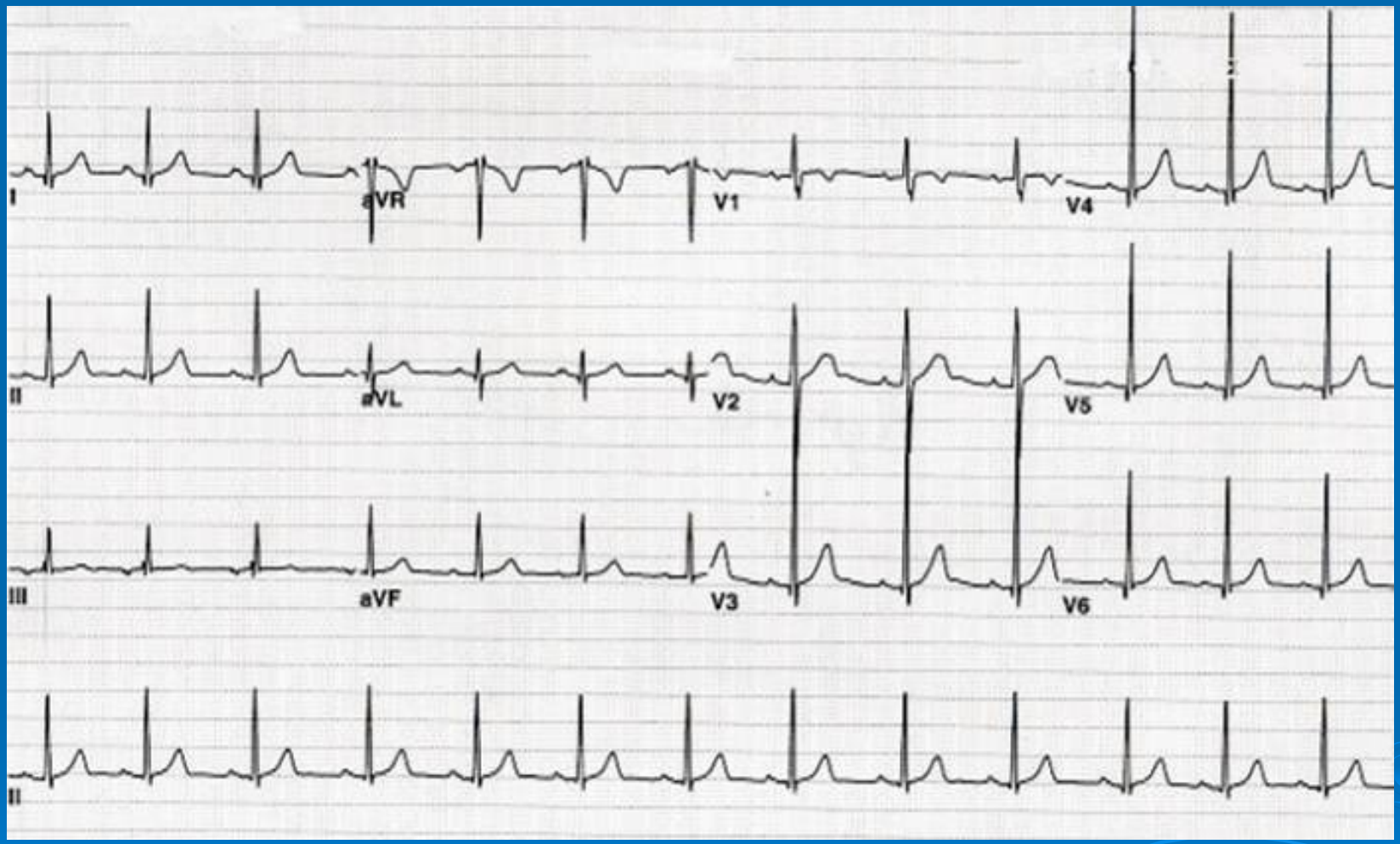


2-month-old

Pediatric EKG



Toddler EKG

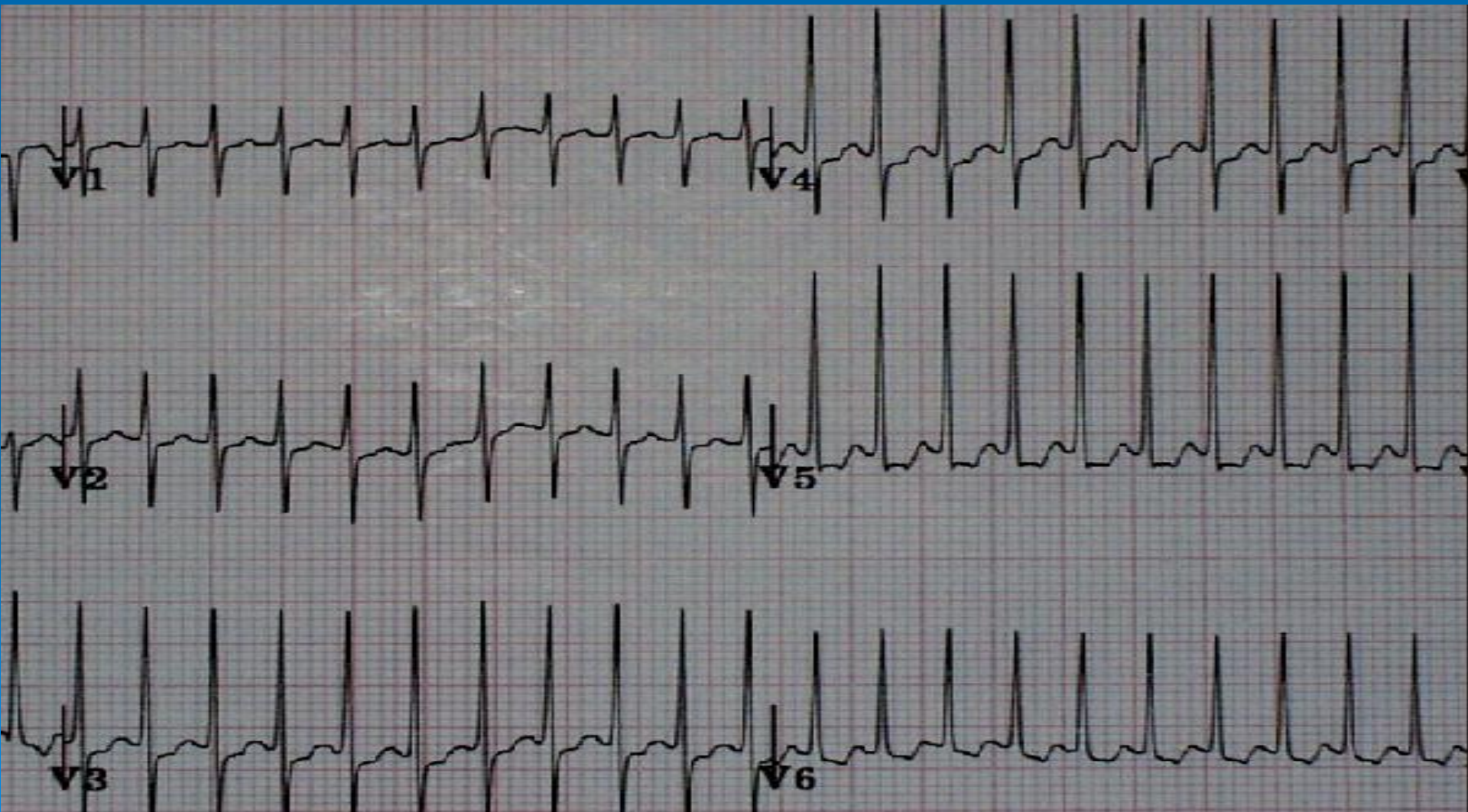


11-year-old

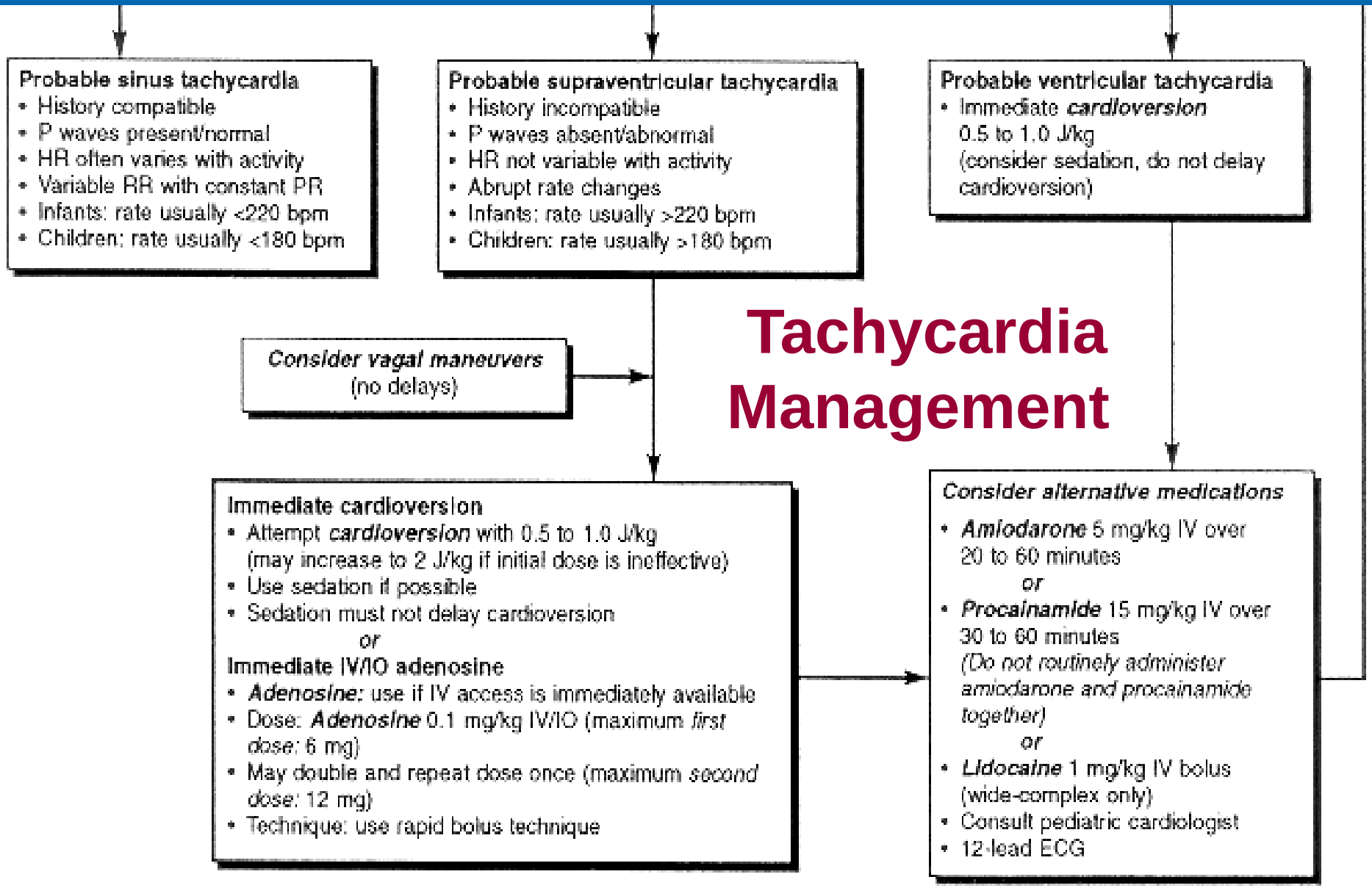
Arrhythmias

- Tachyarrhythmias
  - Fast, very very fast
    1:1 AV conduction
- Narrow complex
  - Atrial origin
  - Variety
  - Management same

Supraventricular Tachycardia



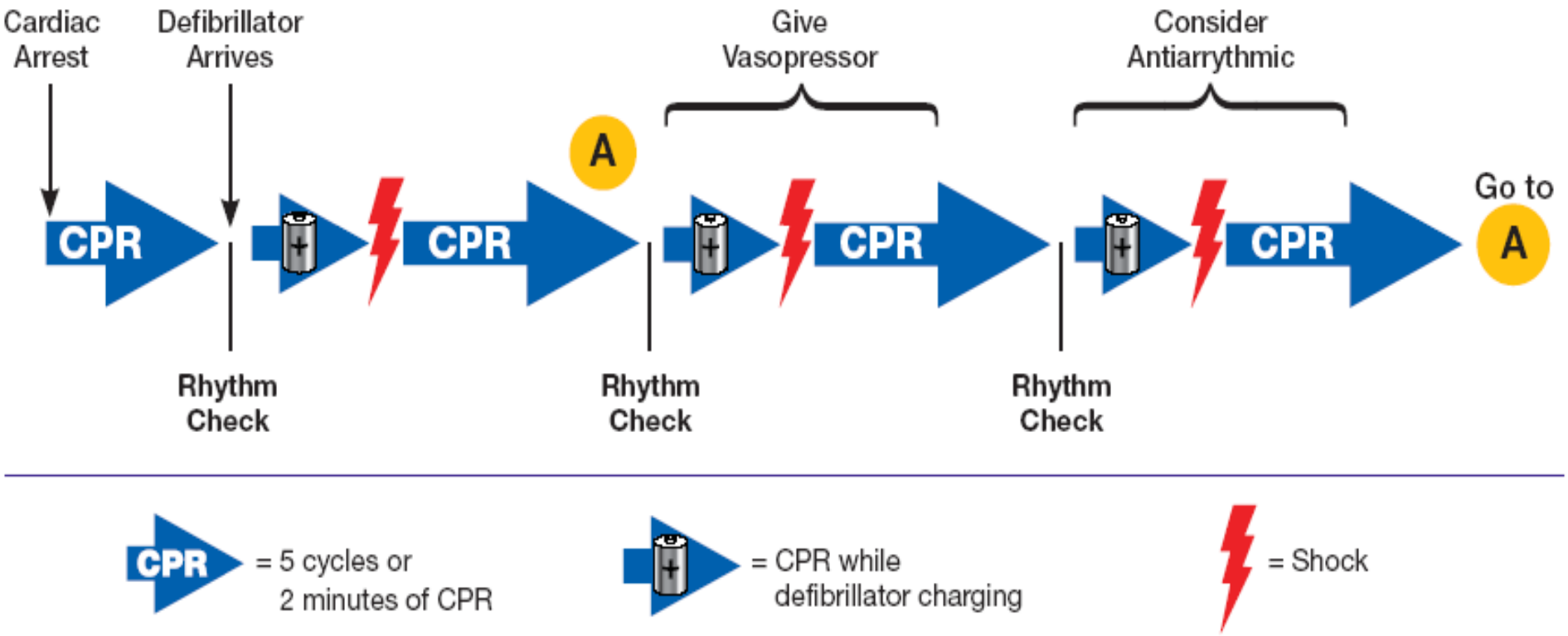
Tachycardia Management



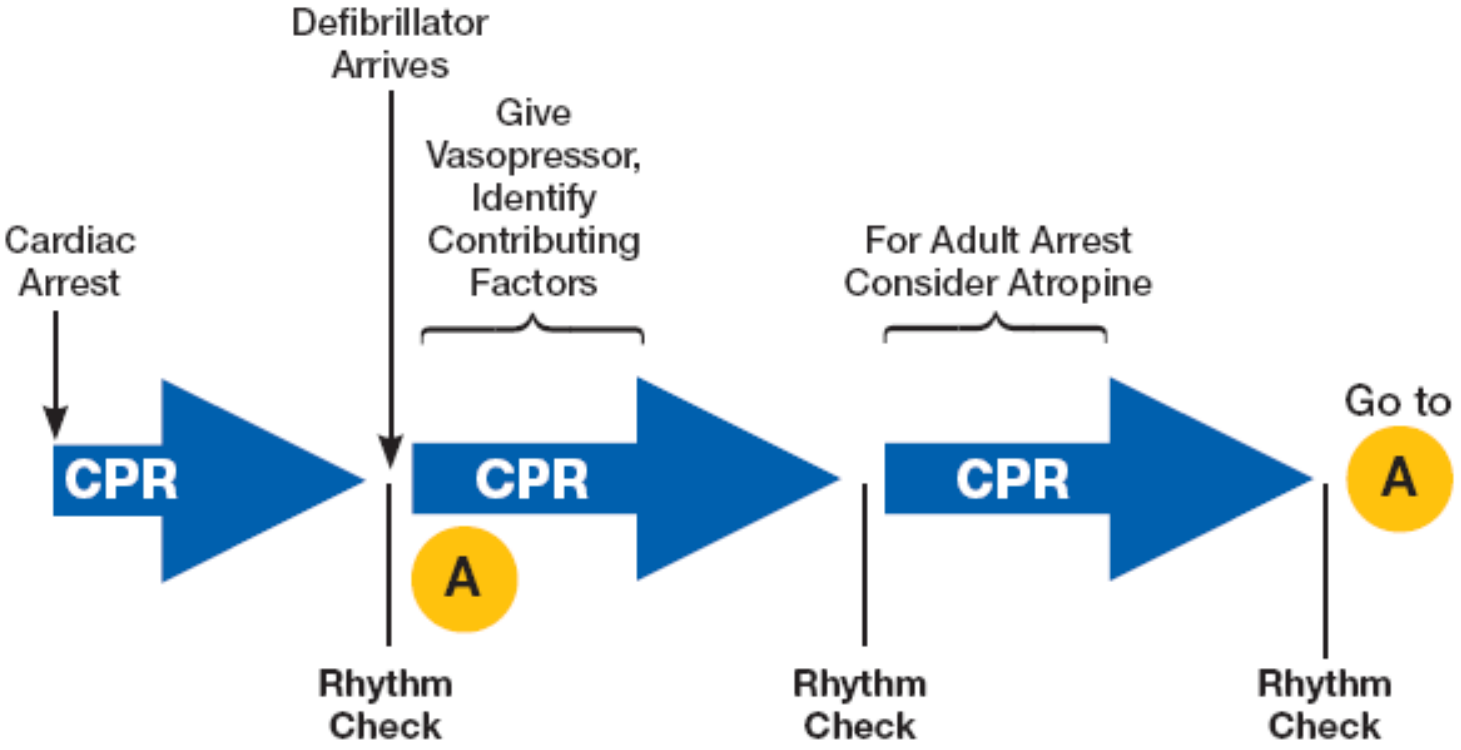
Ventricular Arrhythmias

- Wide complex
- V-tach or Torsades
- Management same as adult

Ventricular Fibrillation/Pulseless VT



Asystole and Pulseless Electrical Activity



CPR = 5 cycles or 2 minutes of CPR

Attempted Defibrillation: 1 Shock, Then Immediate CPR ***2005 (New):***

- When attempting defibrillation, all rescuers should deliver 1 shock followed by immediate CPR, beginning with chest compressions.
- All rescuers should check the victim's rhythm after giving about 5 cycles (about 2 minutes) of CPR.
  - Once AEDs are reprogrammed by the manufacturers, they should prompt rescuers to allow a rhythm check every 2 minutes.

Why?: The rationale for this new protocol is based on 3 findings:

1. The rhythm analysis by current AEDs after each shock typically results in delays of **37** seconds or even longer before the delivery of the first post-shock compression. Such long interruptions in compressions can be harmful (see Figure 1).

2. With most defibrillators now available, the first shock eliminates VF more than 85% of the time. In cases where the first shock fails, resumption of CPR is likely to confer a greater value than another shock.

4. Why?: The rationale for this new protocol is based on 3 findings:

3. Even when a shock eliminates VF, it takes several minutes for a normal heart rhythm to return and more time for the heart to create blood flow.

A brief period of chest compressions can deliver oxygen and sources of energy to the heart, increasing the likelihood that the heart will be able to effectively pump blood after the shock.

There is no evidence that chest compressions immediately after defibrillation will provoke recurrent VF.

AHA anticipates that AED manufacturers will reprogram AEDs to support this recommendation.

The AHA encourages AED manufacturers to develop devices that can analyze the victim's heart rhythm without interrupting chest compressions.

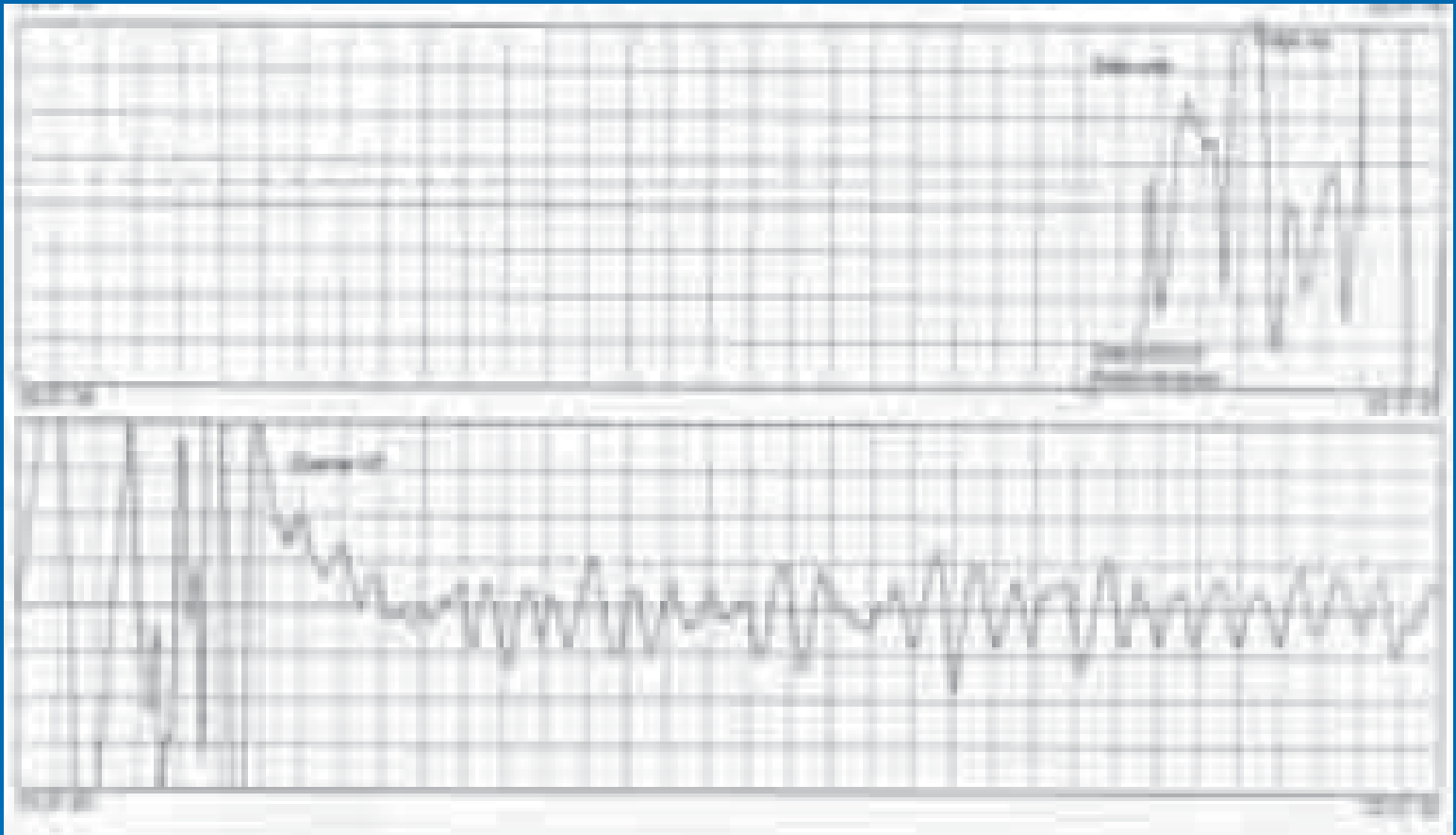


Figure 1-A

The first segments were recorded when the AED was turned on and attached (time is 22:37:22). The rhythm is labeled as "coarse VF.

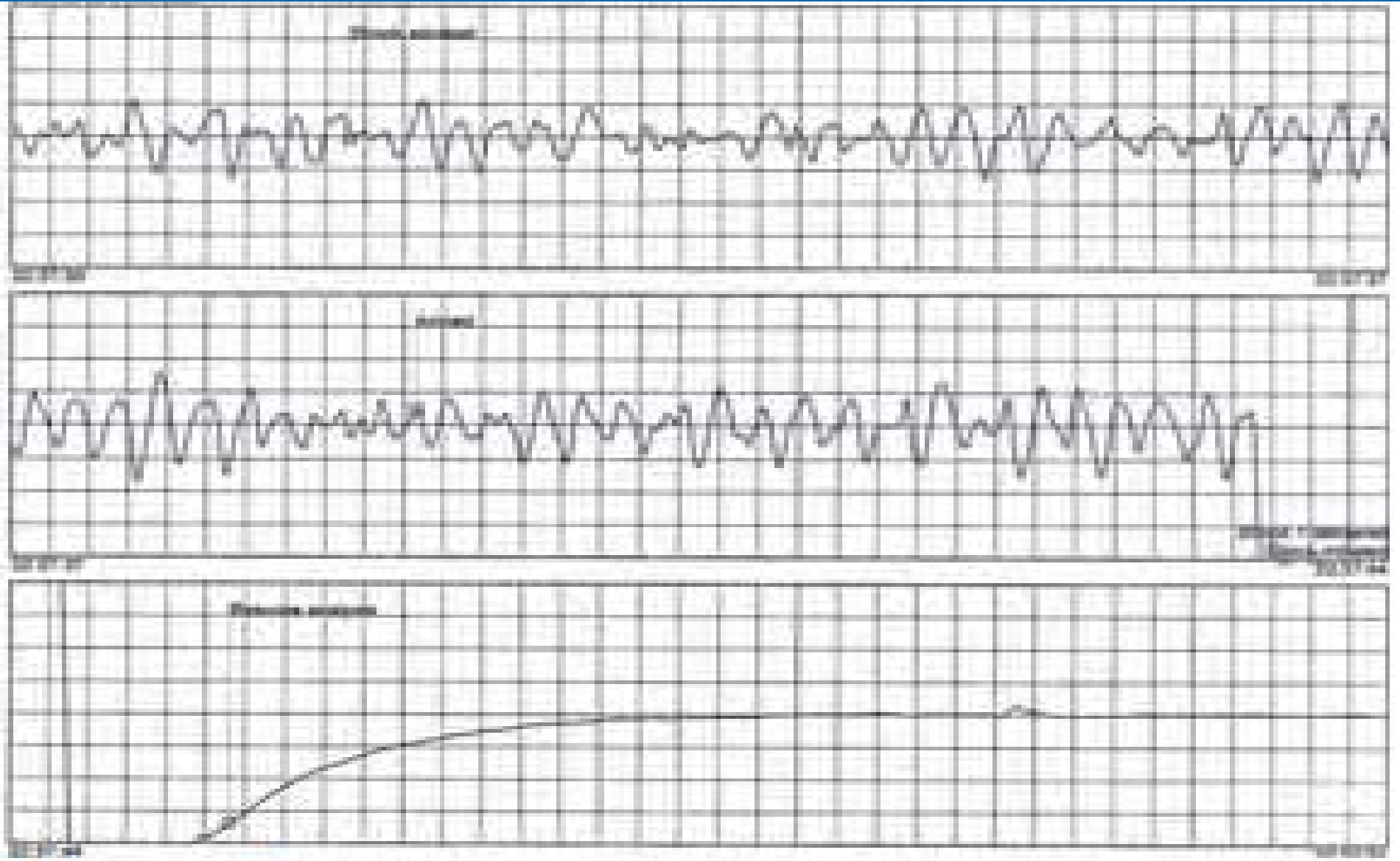


Figure 1-B

In this second series, a shock is advised and is delivered (at 22:37:44), 22 seconds after the pads were attached. The shock eliminates the VF; the initial post-shock rhythm is asystole. The AED then analyzes the rhythm after the first shock.

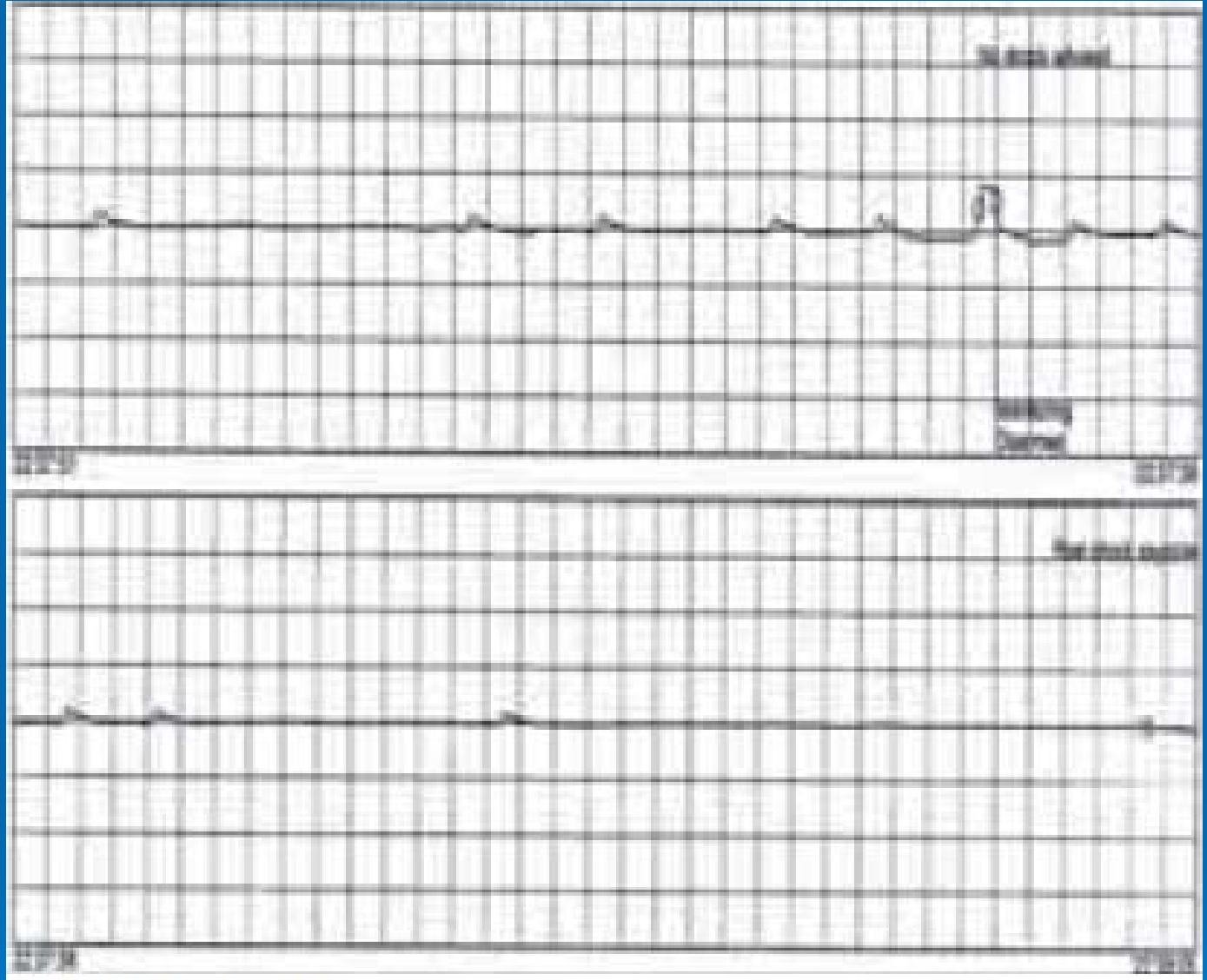


Figure 1-C

This third ECG segment depicts the post-shock rhythm through the next 21 seconds. Asystole is present, and the AED is analyzing the rhythm so no CPR is provided and there is no blood flow.

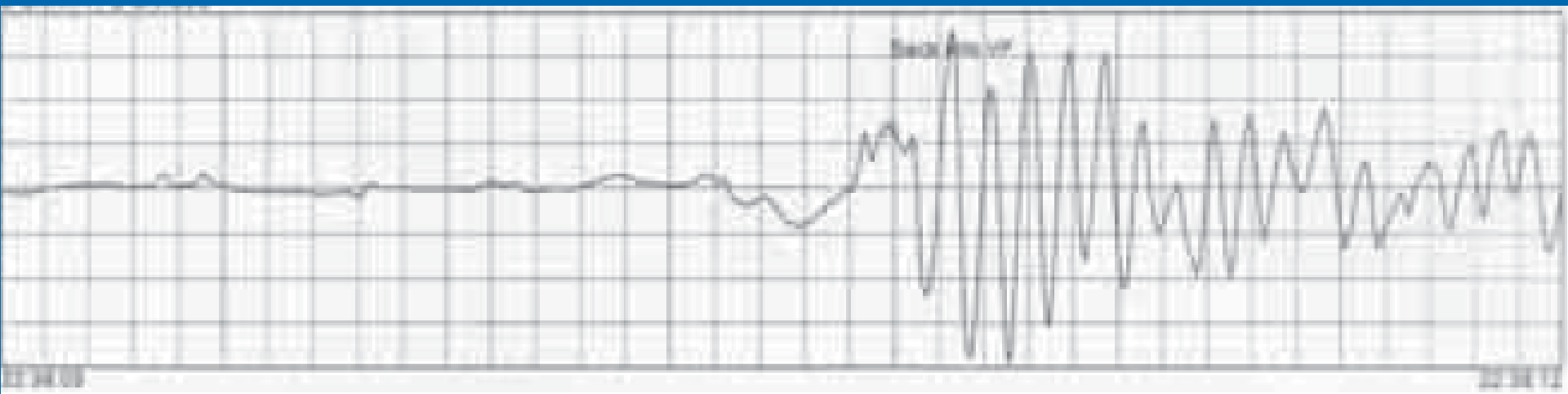


Figure 1-D

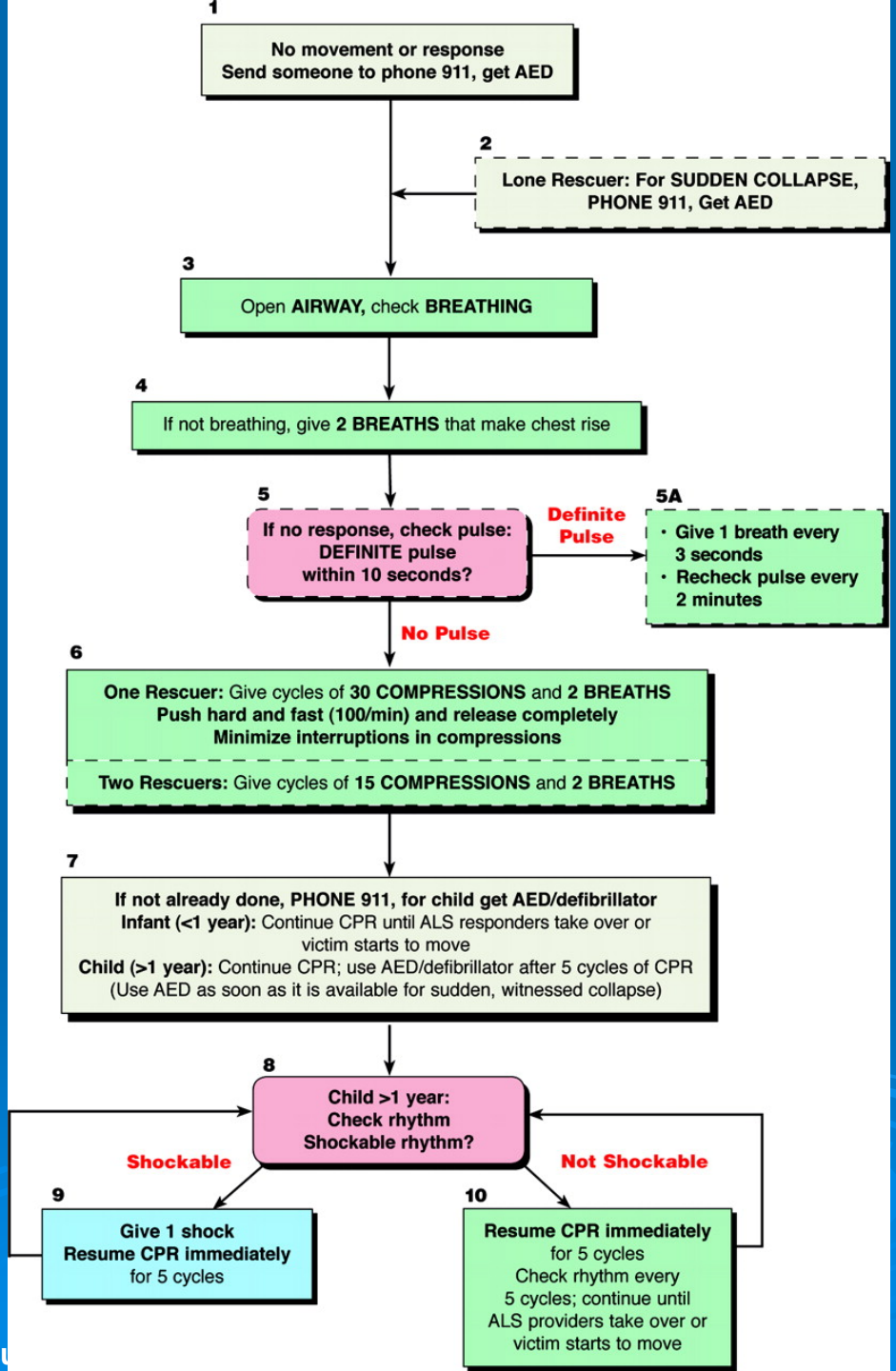
This fourth segment depicts refibrillation (at 22:38:09), 25 seconds after the first shock successfully eliminated VF. Note that no CPR was performed during the 25 seconds. The AED then analyzes the rhythm and recommends a shock. A shock is delivered (at 22:38:43), asystole follows, and the AED then analyzes those rhythms. CPR is finally recommended and begins at 22:39:01, a total of 1 minute, 17 seconds after the first shock. The victim survived.

Reaffirmation of 2003 ILCOR Statement: AEDs Recommended for Children Aged 1 Year and Older: ***2005 (New):***

AEDs are recommended for use in children 1 year of age and older.

The evidence is insufficient to recommend for or against the use of AEDs in infants under 1 year of age (Class Indeterminate).

Pediatric Healthcare Provider BLS Algorithm



Circulation

Circu

American Heart Association®
Learn and Live℠

Over-reliance on experience leads you to making the same mistakes with increasing confidence

You have just pulled a 5 yo child from the bottom of a pool. The child is lifeless. You send a bystander to call 911. You and another rescuer must now begin CPR. Your ratio of chest compressions to ventilations should be:

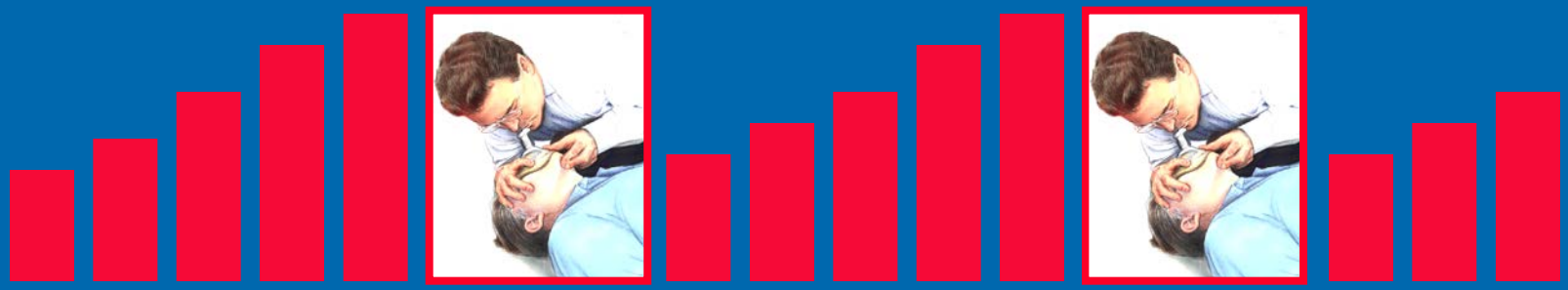
a. 15 CC:2 ventilations

b. 5 CC:1 ventilation

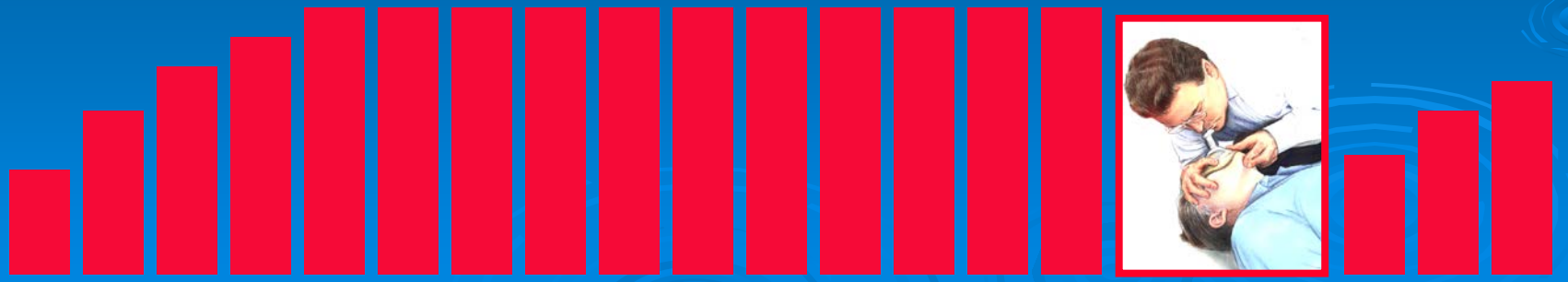
c. All CC, no ventilations

Coronary Perfusion Pressure Improves With Sequential Compressions

CPP at 5:1 ratio



CPP at 15:2 ratio



The patient is now intubated.

What rate and ratio do you want to provide?

a. 15 CC:2 ventilations

b. 5 CC:1 ventilation

c. Asynchronous with HR 100/min & RR10-12/min

Hyperventilation-Induced Hypotension During Cardiopulmonary Resuscitation

Tom P. Aufderheide, MD; Gardar Sigurdsson, MD; Ronald G. Pirrallo, MD, MHSA; Demetris Yannopoulos, MD; Scott McKnite, BA; Chris von Briesen, BA, EMT; Christopher W. Sparks, EMT; Craig J. Conrad, RN; Terry A. Provo, BA, EMT-P; Keith G. Lurie, MD

- Measured observations of EMS providing OOH CPR
- 13 resuscitation attempts
- Intubated adults
- Avg RR=30; Range 15-49 (none survived)
- Positive airway pressure ~ 50% of time

Bedside to Bench:

- Pig model of VF with RR=12 or 20 or 30
- Increased RR associated with increased intrathoracic pressure, lower CPP and lower survival

Circulation 2004;109:1960-65

Hyperventilation-Induced Hypotension During Cardiopulmonary Resuscitation

Tom P. Aufderheide, MD; Gardar Sigurdsson, MD; Ronald G. Pirrallo, MD, MHSA; Demetris Yannopoulos, MD; Scott McKnite, BA; Chris von Briesen, BA, EMT; Christopher W. Sparks, EMT; Craig J. Conrad, RN; Terry A. Provo, BA, EMT-P; Keith G. Lurie, MD

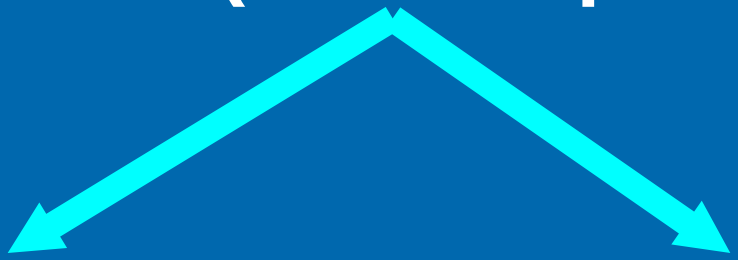
"Unrecognized and inadvertent hyperventilation may be contributing to the currently dismal survival rates from cardiac arrest."

Circulation 2004;109:1960-65

Is Mouth to Mouth Necessary?

Is Mouth to Mouth Necessary?

Telephone Dispatchers Giving CPR Instructions (for collapsed adults)



No Ventilation N=241

Survival 15%*

Included Ventilation N=279

Survival 10%

***P = 0.18**

Hallstrom et al NEJM 2000;342:1546-53

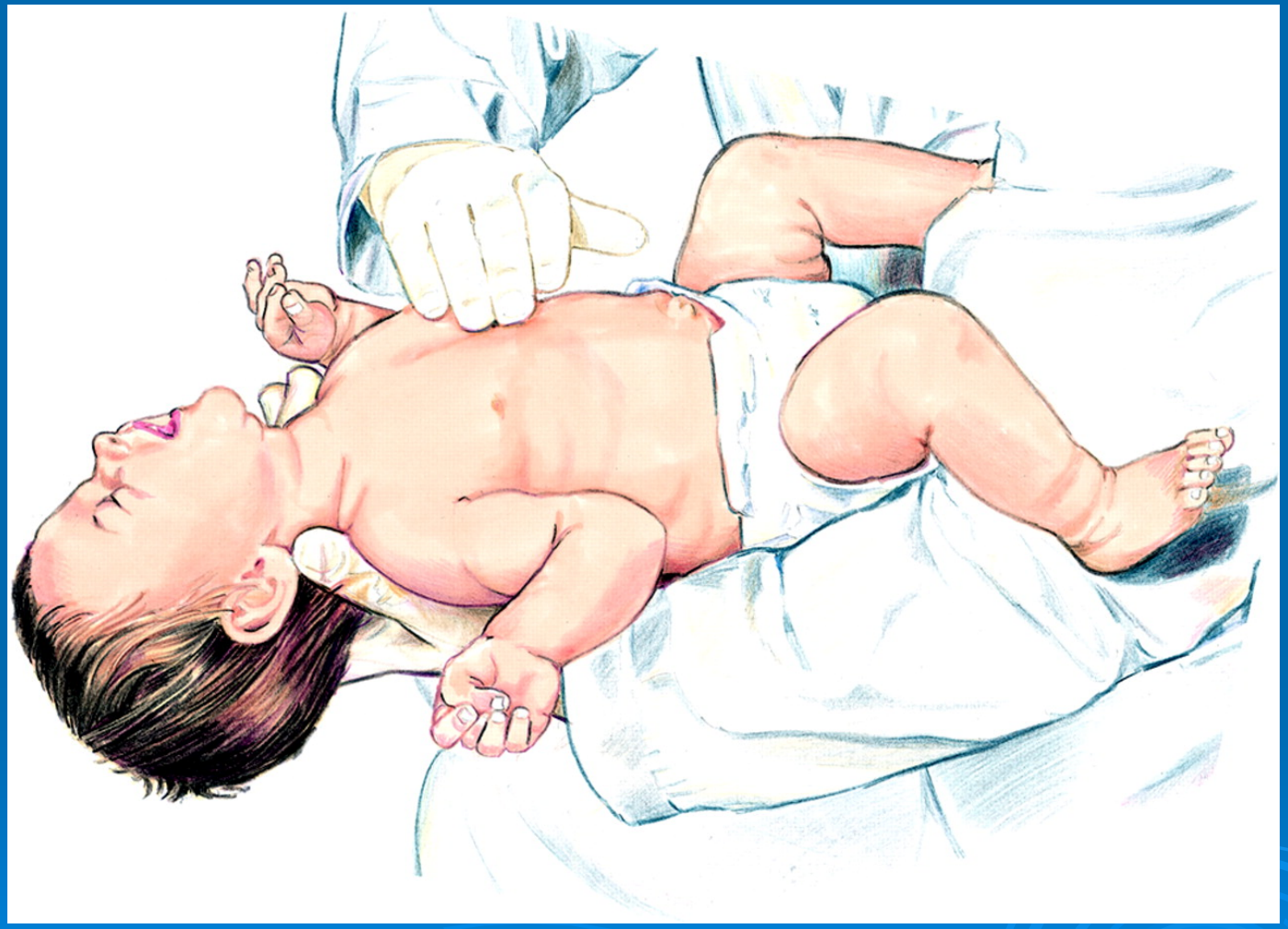
Is Mouth to Mouth Necessary?

CPR: Real world vs Class room (it is NASTY)

- Drop the mouth to mouth?
  - Spontaneous gasp or mechanical vent may be adequate
  - Less fear of infx dis

Is there a better way to do C-CPR?

Two-finger chest compression technique in infant (1 rescuer)



Circulation 2005;112:IV-156-166IV-

Effect of Out-of-Hospital Pediatric Endotracheal Intubation on Survival and Neurologic Outcome

≤ 12 yo 3/94-1/97
LA and Orange Counties

Bag Valve Mask
N=404

Intubation
N=416

Gausche et al *JAMA* 2000;283:783-790

Gausche et al cont.

	BVM	ETI
survival	30%	26%
good neuro	23%	20%

Gausche et al *JAMA* 2000;283:783-790

Complications of Prehospital Tracheal Intubation

- Intubation attempts increased time at the scene by 2 to 3 minutes
- Unrecognized tube displacement or misplacement: 8%
  - Esophageal intubation: 2%
  - Unrecognized extubation: 6%
  - Esophageal intubation or unrecognized extubation fatal (for 14 of 15 patients)

Gausche et al *JAMA* 2000;283:783-790

Incidence of Transient Hypoxia and Pulse Rate During Paramedic Rapid Sequence Intubation

- San Diego Paramedic RSI Trial
  - Stopped when RSI was assoc w/ inc mortality and morbidity (vs matched historical controls)
- Midway through study one agency obtained recording pulse oximetry devices

Dumford JV et al. *Ann Emerg Med* 2003;42:721-8

Incidence of Transient Hypoxia and Pulse Rate During Paramedic Rapid Sequence Intubation

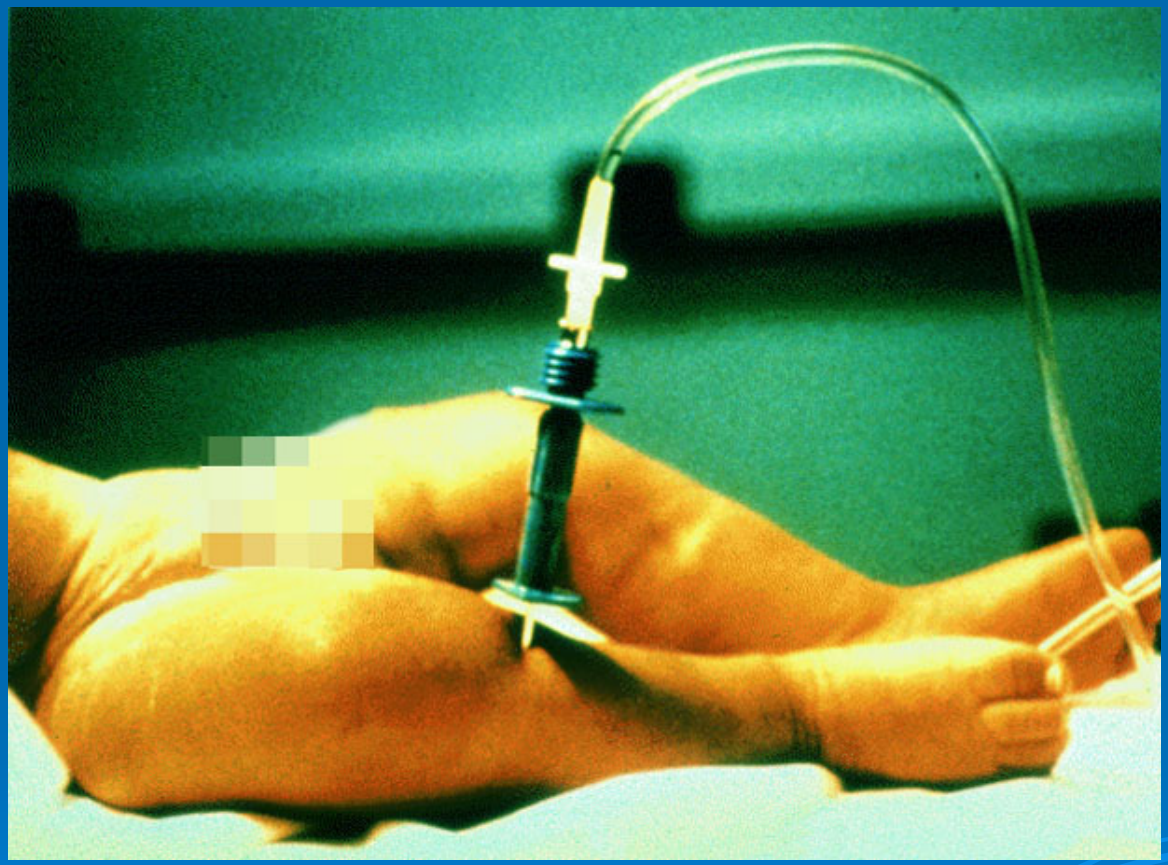
- 54 evaluable pts
  - 57% had desaturations (<90%)
    - 84% of these had nl initial sats
    - Median duration 2 min 40 sec
    - Median decrease 22%
    - 20% had associated bradycardia
    - 84% perceived as “easy” intubations

Dumford JV et al. *Ann Emerg Med* 2003;42:721-8

Incidence of Transient Hypoxia and Pulse Rate During Paramedic Rapid Sequence Intubation

- Hypoxia superimposed on TBI in animals worsens neurologic injury
- 5 pts had “uncorrectable” hypoxia prior to intubation
- Solutions?
  - More training?
    - 7 h of “instruction” in study
  - Better pre-oxygenation?
  - Alternative airways?
  - Heightened awareness of oxygenation

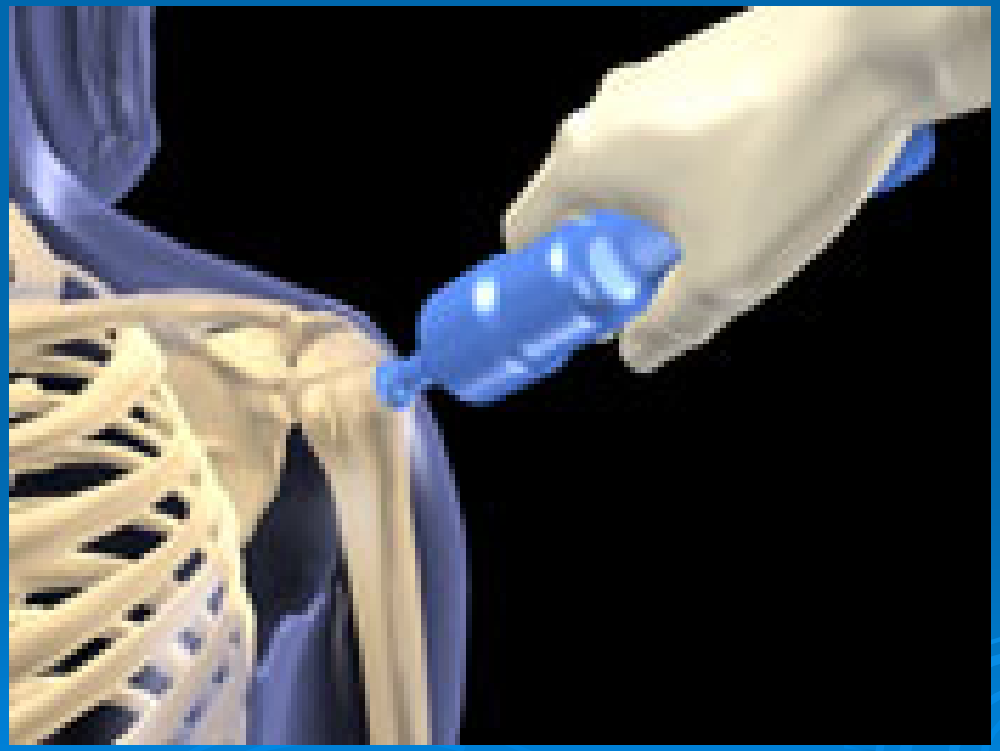
Dumford JV et al. *Ann Emerg Med* 2003;42:721-8



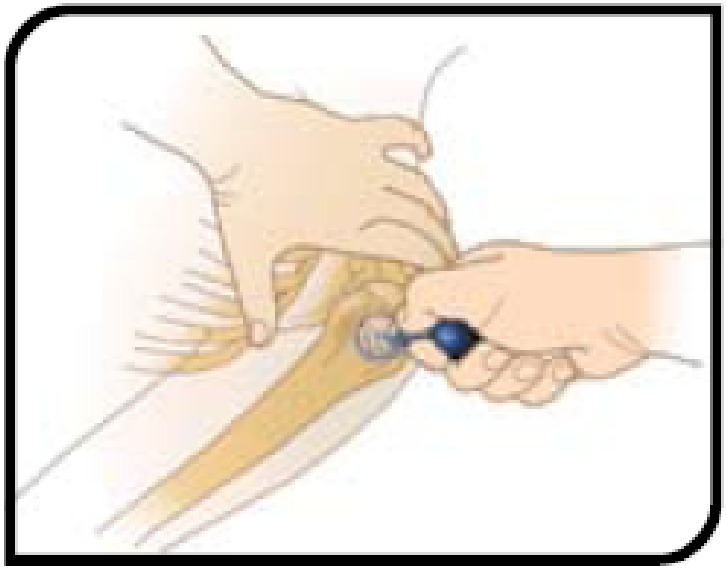
JB Holcomb. Fluid resuscitation in modern combat casualty care: lessons learned from Somalia.
J Trauma. 2003;54:S46-51.

- Combat Fluid Resuscitation Conference at the Uniformed Services University of the Health Science 2001
- …if the soldier is coherent and has a palpable radial pulse, blood loss has likely stopped. Start a saline lock; hold fluids; reevaluate as frequently as situation allows.
- Head injuries impose special regulations…hypotensive resuscitation cannot be recommended

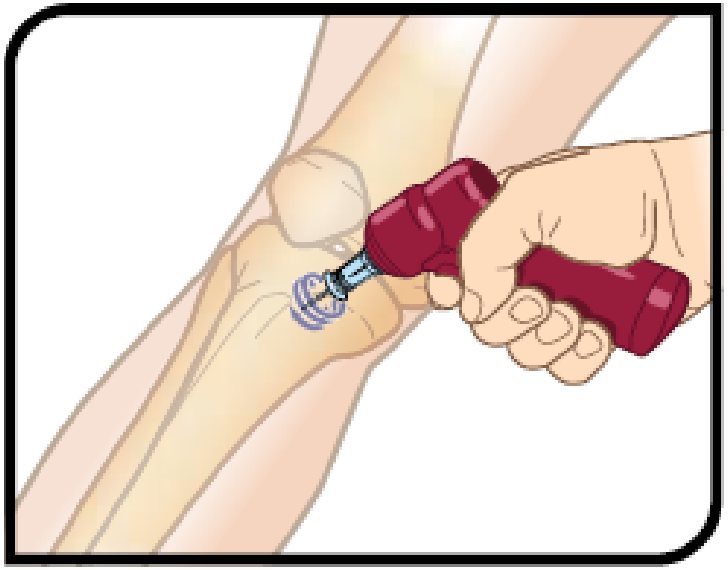
EZ-IO® Power Driver



PROXIMAL HUMERUS



PROXIMAL TIBIA



A drowning victim is resuscitated in your ED. The patient is now hemodynamically stable but remains comatose. The rectal temperature is 33° C. You should:

a. Turn on the overhead heaters and apply warm blankets

b. Allow the patient to remain cool

A drowning victim is resuscitated in your ED. The patient is now hemodynamically stable but remains comatose. The rectal temperature is 37° C. You should:

a. Turn on the overhead heaters and apply warm blankets
b. Allow the patient to remain normothermic
c. Cool the patient to 32-34 deg C for 12-24 h

Post-resuscitative care

- Children after cardiac arrest: hypothermia followed by hyperthermia*
- Hyperthermia possibly facilitated by active warming

*** Hickey et al Pediatrics 2000;106:118**

Hypothermia

2005 (New): Unconscious adult patients with ROSC after out-of-hospital cardiac arrest should be cooled to 32°C to 34°C for 12 to 24 hours when the initial rhythm was VF (Class IIa). Similar therapy may be beneficial for patients with non-VF arrest out of hospital or for in-hospital arrest (Class IIb). Further research is needed.

PALS: Postresuscitation Care *2005 (New):*

- The 2005 guidelines emphasize the importance of avoiding hyperthermia and the possible benefits of induced hypothermia (32˚C to 34˚C) for 12 to 24 hours for patients who remain comatose after resuscitation from cardiac arrest (Class IIb).
- Providers should monitor temperature and treat fever aggressively (Class IIb).

ELSEVIER

Resuscitation 57 (2003) 231–235

RESUSCITATION

www.elsevier.com/locate/resuscitation

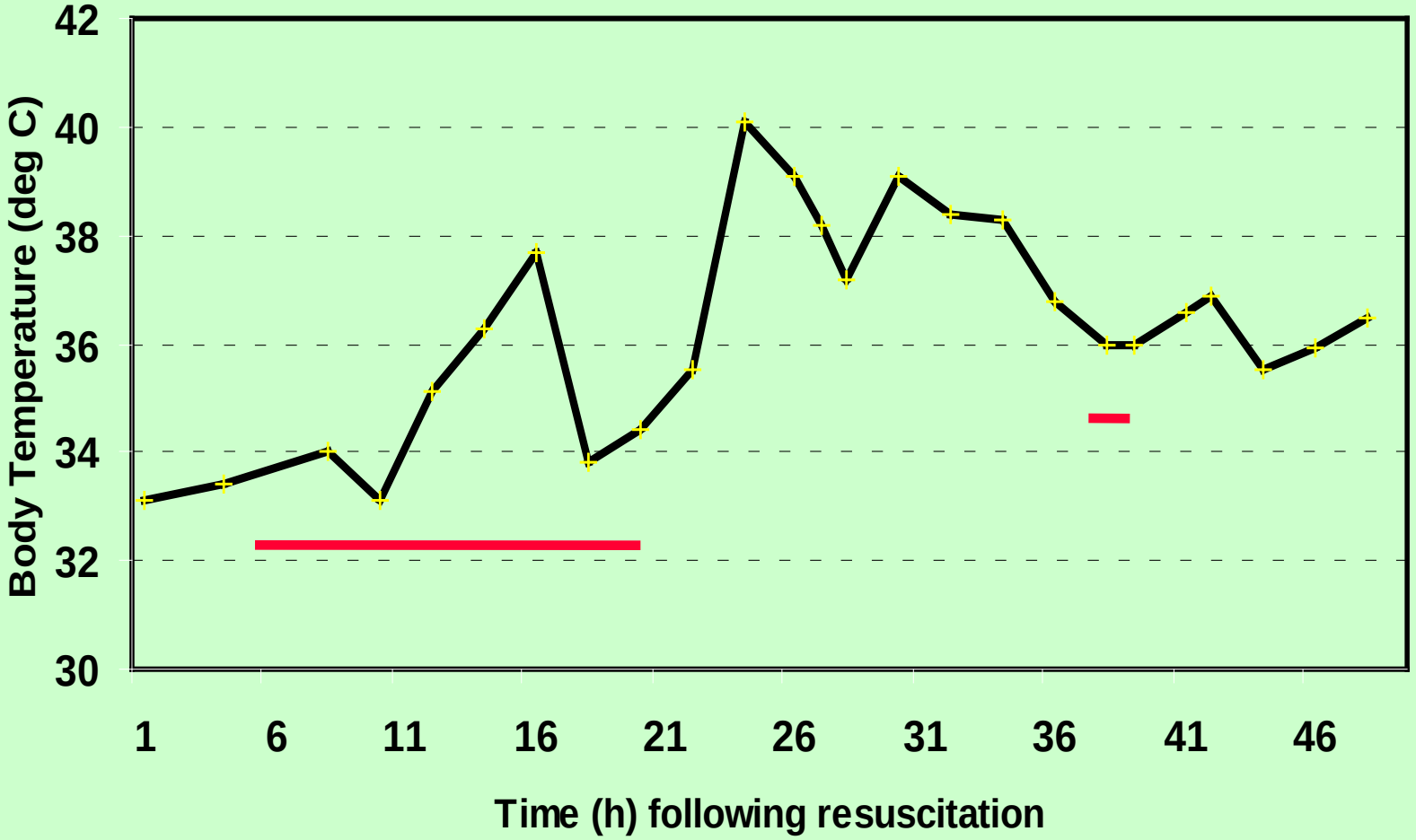
Therapeutic hypothermia after cardiac arrest. An advisory statement by the Advanced Life Support Task Force of the International Liaison Committee on Resuscitation☆

Jerry P. Nolan [a,*], Peter T. Morley [b], Terry L. Vanden Hoek [c], Robert W. Hickey [d,1], ALS Task Force [2]

[a] *Cochair ILCOR, Department of Anaesthesia and Intensive Care Medicine, Royal United Hospital, Bath BA1 3NG, UK*
[b] *Chairman, Advanced Life Support Committee, Australian Resuscitation Council, Intensive Care Unit, Royal Melbourne Hospital, Melbourne, Vic. 3050, Australia*
[c] *Member, ACLS Subcommittee, American Heart Association, Assistant Professor of Emergency Medicine, University of Chicago, 5841 South Maryland Ave, MC5068, Chicago, IL 60637, USA*
[d] *Chair, Subcomittee on Pediatric Resuscitation, American Heart Association, Associate Professor of Pediatrics, Children's Hospital of Pittsburgh, Division of Pediatric Emergency Medicine, 3705 Fifth Avenue, Pittsburgh, PA 15213, USA*

- Unconscious adult patients with spontaneous circulation after out-of-hospital cardiac arrest should be cooled to 32-34 °C for 12-24 h when the initial rhythm was ventricular fibrillation (VF).
- Such cooling may also be beneficial for other rhythms or in-hospital cardiac arrest.

Resuscitation 2003;57:231-35
Circulation 2003;108:118-21.



= Warming Lights

The New England Journal of Medicine

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Volume 346(8) 21 February 2002 pp 549-556

Mild Therapeutic Hypothermia to Improve the Neurologic Outcome after Cardiac Arrest

[Original Articles]

The Hypothermia after Cardiac Arrest Study Group*

Volume 346(8) 21 February 2002 pp 557-563

Treatment of Comatose Survivors of Out-of-Hospital Cardiac Arrest with Induced Hypothermia

[Original Articles]

Bernard, Stephen A.; Gray, Timothy W.; Buist, Michael D.; Jones, Bruce M.; Silvester, William; Gutteridge, Geoff; Smith, Karen.

Volume 346(8) 21 February 2002 pp 612-613

Therapeutic Hypothermia after Cardiac Arrest

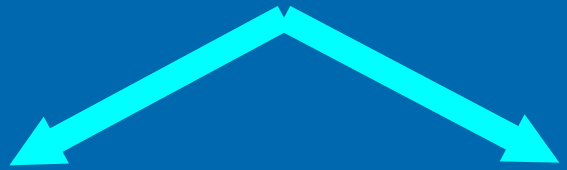
[Editorial]

Safar, Peter J.; Kochanek, Patrick M.

University of Pittsburgh Medical Center; Pittsburgh, PA 15260

European Trial

Multicenter trial
Adults resuscitated from VF
N = 3551



32-34° X 24 h	Normothermia
N = 137	N = 138
55% Good Neuro Outcome*	39% Good Neuro Outcome
41% Died**	55% Died

*6 month CPC 1-2; RR=1.4; 95% CI, 1.08-1.81
**P=.02

NEJM 2002;346:549-556

European Trial

- 6 Pts needed to tx to prevent 1 unfavorable neuro outcome
- 7 Pts needed to treat to prevent 1 death

- Limitations
  - Cooling delayed (median 8 h till 32º)
  - Trend toward inc sepsis and pneumonia

***NEJM* 2002;346:549-556**

The New England Journal of Medicine

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Resuscitation 57 (2003) 231–235

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www.elsevier.com/locate/resuscitation

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- Such cooling may also be beneficial for other rhythms or in-hospital cardiac arrest.

Resuscitation 2003;57:231-35
Circulation 2003;108:118-21.

And then….

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Hypothermia Therapy after Traumatic Brain Injury in Children

James S. Hutchison, M.D., Roxanne E. Ward, B.A., Jacques Lacroix, M.D., Paul C. Hébert, M.D., M.H.Sc., Marcia A. Barnes, Ph.D., Desmond J. Bohn, M.B., Peter B. Dirks, M.D., Steve Doucette, M.Sc., Dean Fergusson, Ph.D.,

NEJM June 5, 2008

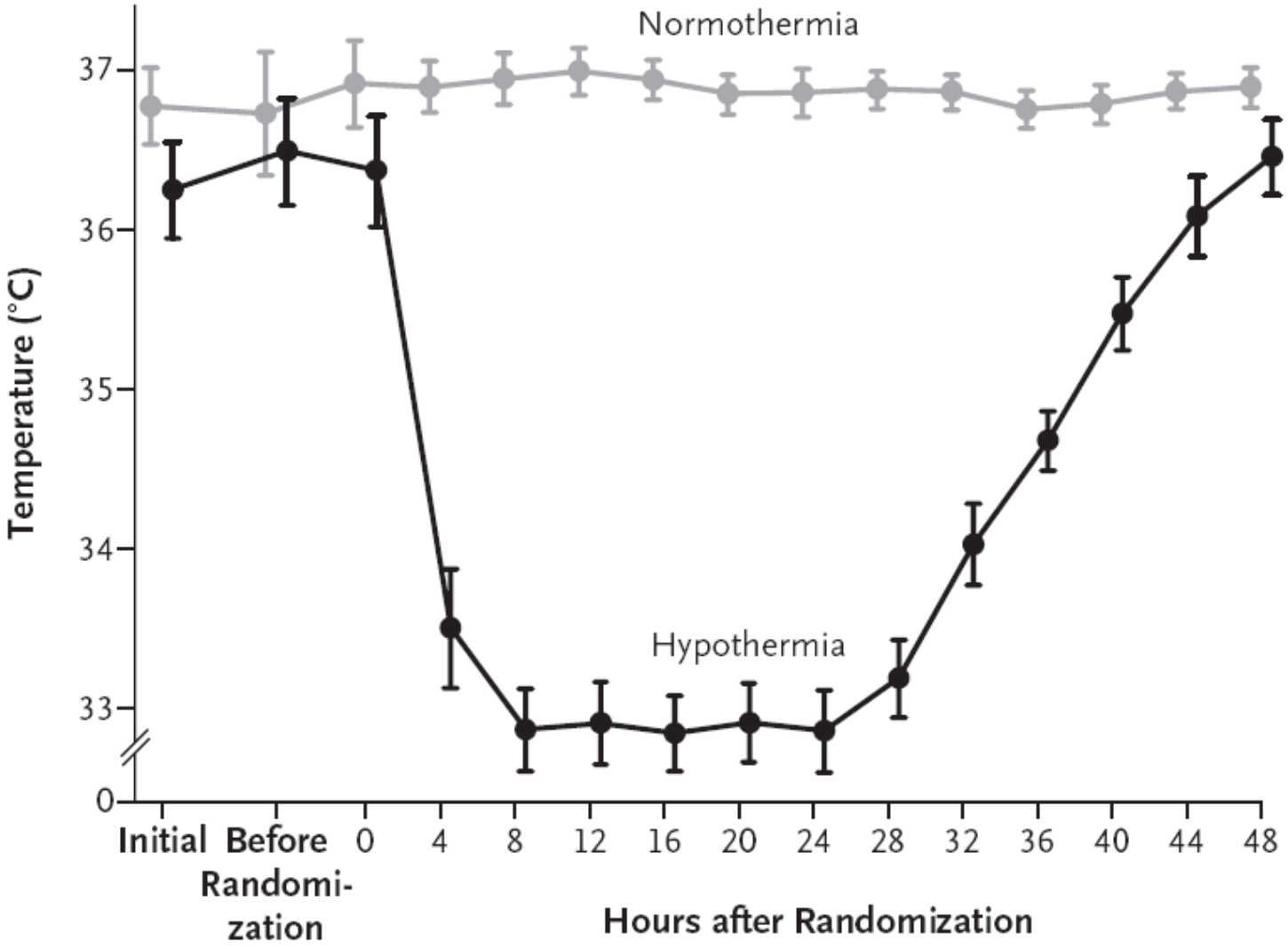


Figure 1. Temperature of Patients in the Hypothermia and Normothermia Groups.

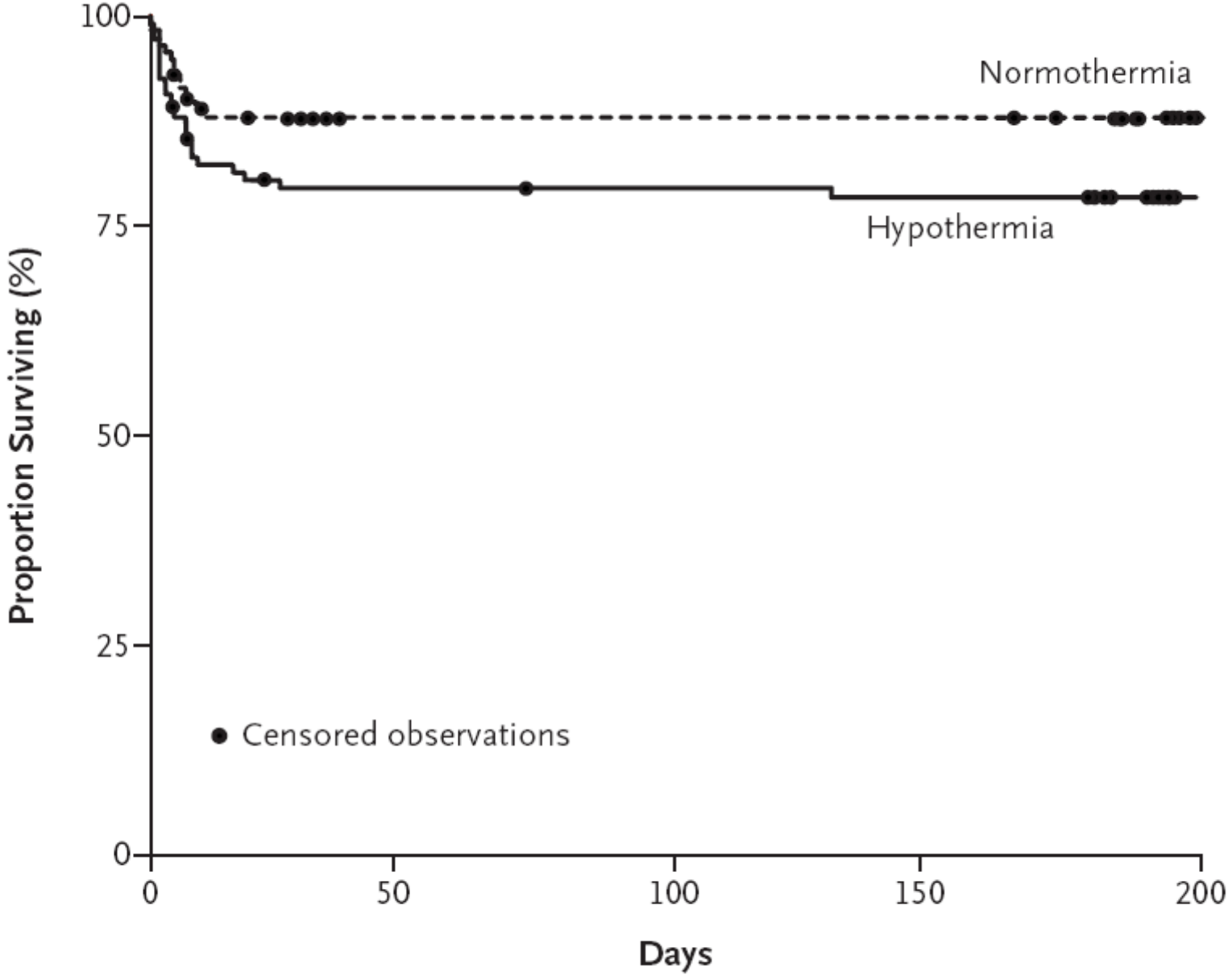


Figure 2. Kaplan–Meier Estimates of Survival.

The preferred gas for resuscitating a newborn is:

a. 100% oxygen
b. Room air
c. A stupid question

The preferred gas for resuscitating a child is:

a. 100% oxygen
b. Room air
c. A stupid question

Oxygen and Resuscitation: Beyond the Myth

Lefkowitz,W. in Pediatrics 2002;109:517-19

"At this point in time, there is no evidence of a role for oxygen concentration above 21% during resuscitation of the newborn, or for those older children and adults with lungs that were functioning adequately on room air before an arrest. In fact, there may be significant harm, based on the concept of reperfusion injury."

Oxygen therapy in acute medical care

Thomson AJ, et al. BMJ 2002;324:1406-07

The potential dangers of hyperoxia need to be recognised

Oxygen is cheap, widely available, and used in a range of settings and conditions to relieve or prevent tissue hypoxia. Since its discovery by Scheele and Priestley in the 1770s, it has remained one of the most effective therapeutic agents available. However, as a result of poor prescribing and monitoring, inappropriate doses are often given.[1]

Oxygen is most commonly delivered by devices

tensions produce little increase in the oxygen carrying capacity of blood, but they promote reflex vasoconstriction via local regulatory mechanisms in arteriolar smooth muscle.[7] In one of the few randomised double blind controlled trials of oxygen therapy, patients with uncomplicated myocardial infarction randomised to receive oxygen tended to have a higher mortality and more ventricular tachycardia than those randomised to

$$2O_2 \xrightarrow{2e^-} 2 \cdot O_2^- \xrightarrow{2e^- + 2H^+}$$

$$H_2O_2 \xrightarrow{e^- + H^+} \cdot OH \xrightarrow{e^- + H^+} H_2O \quad (1)$$

H_2O

$\cdot O_2^-$ = superoxide anion

H_2O_2 = hydrogen peroxide

$\cdot OH$ = hydroxyl radical

Oxygen and Resuscitation: Beyond the Myth

Lefkowitz,W. in Pediatrics 2002;109:517-19

- Chronic oxygen→ROP
- Reperfusion injury:
  - Oxygen following ischemia→ROS
- Animal studies of 100% O2 vs room air for resuscitation:
  - Either no outcome advantage or 100% O_2 worse
- Human newborn studies
  - Delayed onset of spontaneous respiration
  - Prolonged oxidative stress (at 1 month)
    - Decreased ratio of reduced to oxidized glutathione
    - Increased activity of SOD and catalase in RBCs

Neonatal: Use of Oxygen During Resuscitation *2005 (New):*

- Supplementary oxygen is recommended whenever positive-pressure ventilation is indicated for resuscitation;
- Free-flow oxygen should be administered to babies who are breathing but have central cyanosis (Class Indeterminate)

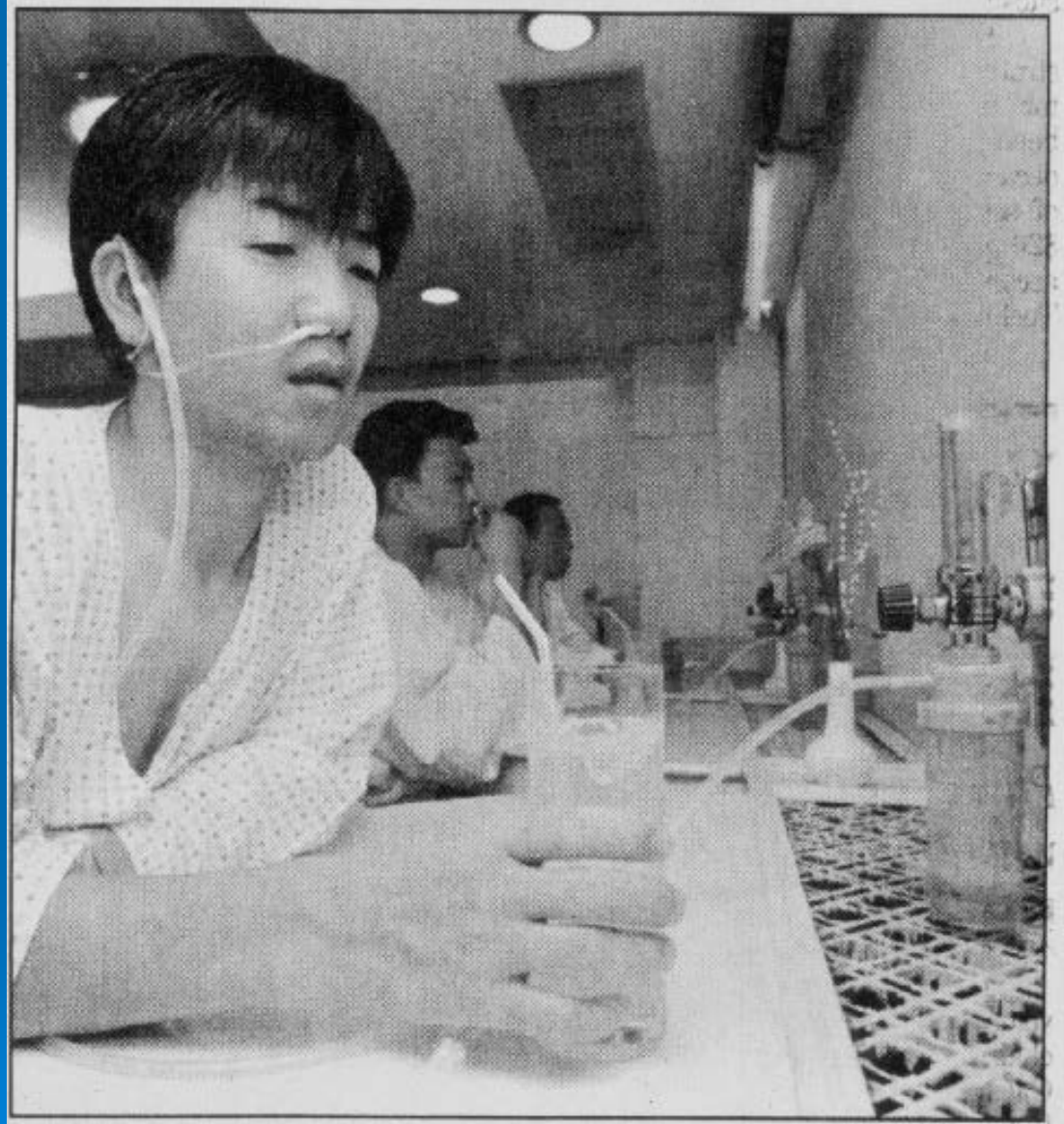
On the other hand…

- **Who cares about APGARs or time to first cry (within reason)**
- **Children with airway causes of cardiac arrest often have parenchymal lung disease**

Still…

- **We can do a better job weaning the oxygen**

TAKING A BREATHER IN BEIJING



Associated Press

A customer breathes pure oxygen at the Dreamland Oxygen Bar in Beijing, one of four such establishments in China's capital city that cater to people seeking relief from increasing air pollution. The bars offer drinks and, for the equivalent of $6 to $9, 30 minutes of oxygen or oxygen mixed with herbal essences. The oxygen bars are dimly lit and offer quiet relaxation.

Case Study: "Unresponsive Episodes"

- 2-year-old girl passed out eating cereal; awoke after 5 min.
- She was stiff with eyes rolled back ~ approx. 5 min.
- Minimal period of sleepiness, now awake and alert; no retractions; skin color is normal

Initial Assessment and Focused History

PAT:

- Normal appearance, normal breathing, normal circulation

ABCDEs:

- Normal
- Vital signs: HR 120; RR 24; BP 80/60; T 37.7° C Wt 12 kg; O_2 sat 99%

Focused History:

- *Three similar episodes;* two associated with “temper tantrums.”
- PMH and FH: Negative

Question

What is your general impression of this patient?

General Impression

- Stable
  - Patient with syncope
  - In no distress; normal exam
  - Concerning/ominous history

What are your initial management priorities?

Case Discussion

- Syncope in young children is a serious symptom.
- Must attempt to exclude life-threatening causes
- Differential diagnosis is critical:
  - Seizure
  - Cardiac
  - Breath-holding spell

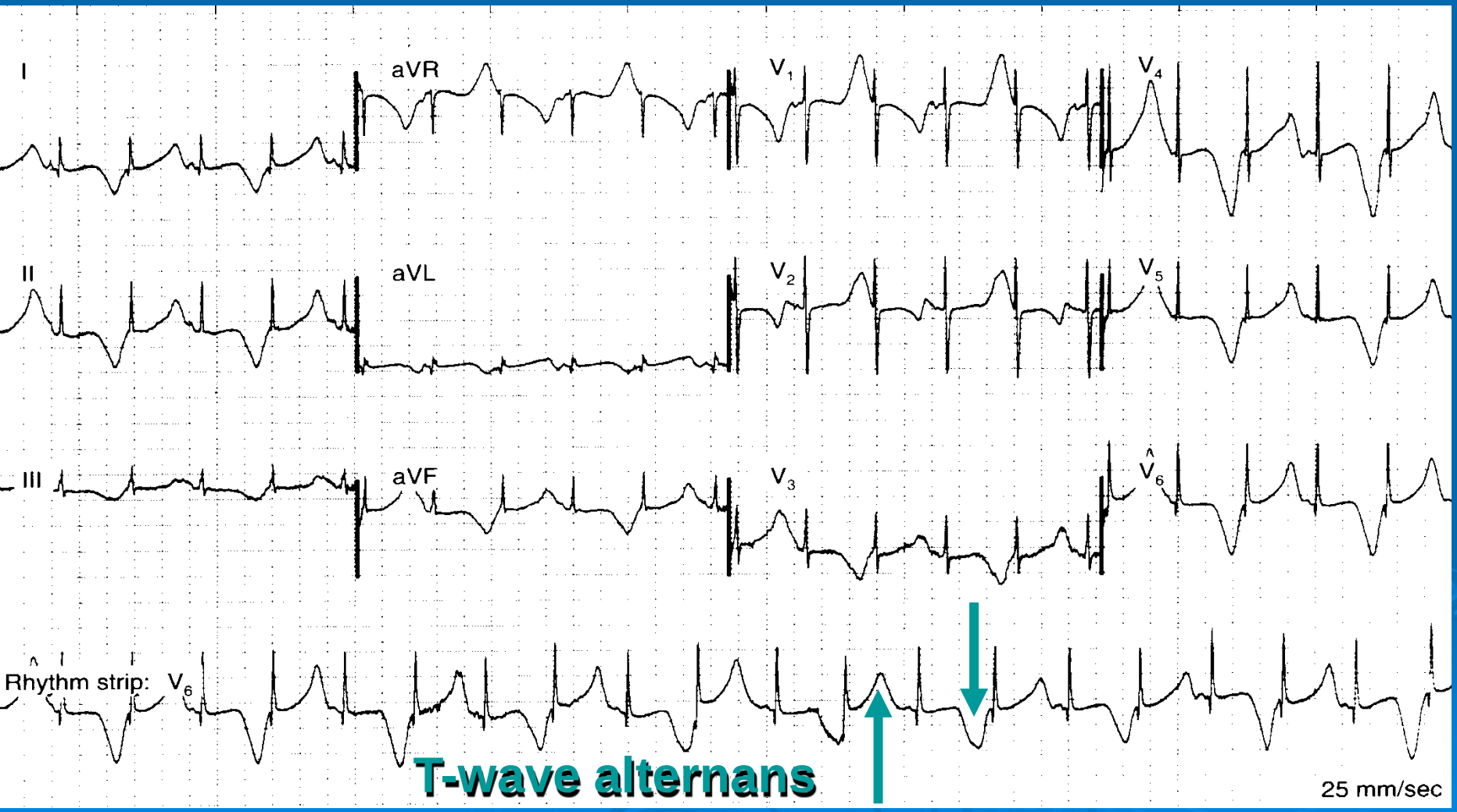
Clinical Features: Your First Clue

- Loss of consciousness
- Lasted only a few minutes
- Minimal or no postictal state
- No stigmata of seizure: Urinary incontinence, bitten tongue, witnessed tonic-clonic activity

Diagnostic Studies

- Radiology:
  - CXR offers little.
  - CT or MRI may be indicated if considering seizures.
- Laboratory is often normal but may include:
  - Electrolytes
  - CBC with differential
  - Ca^{++}, Mg^{++}, PO_4

Markedly Prolonged QT Interval



Prolonged QT

- 10% present with seizures.
- 15% of patients with prolonged QTc die during their first episode of arrhythmia.
  - 30% of these deaths occur during the first year of life.

What Else?
Cardiac Causes of Syncope

- Hypertrophic cardiomyopathy
  - Syncope with exercise
  - At risk for sudden death; positive family history
  - Non-specific murmur; ECG can show non-specific findings.
  - CXR is non-diagnostic
  - Echocardiogram is diagnostic.
- Chronic cardiomyopathy
  - Chronic CHF
- Dysrhythmias

Case 24

- 14 y.o. female
- Syncope at home
  - Bathroom
- 3rd Event
- PE: Normal

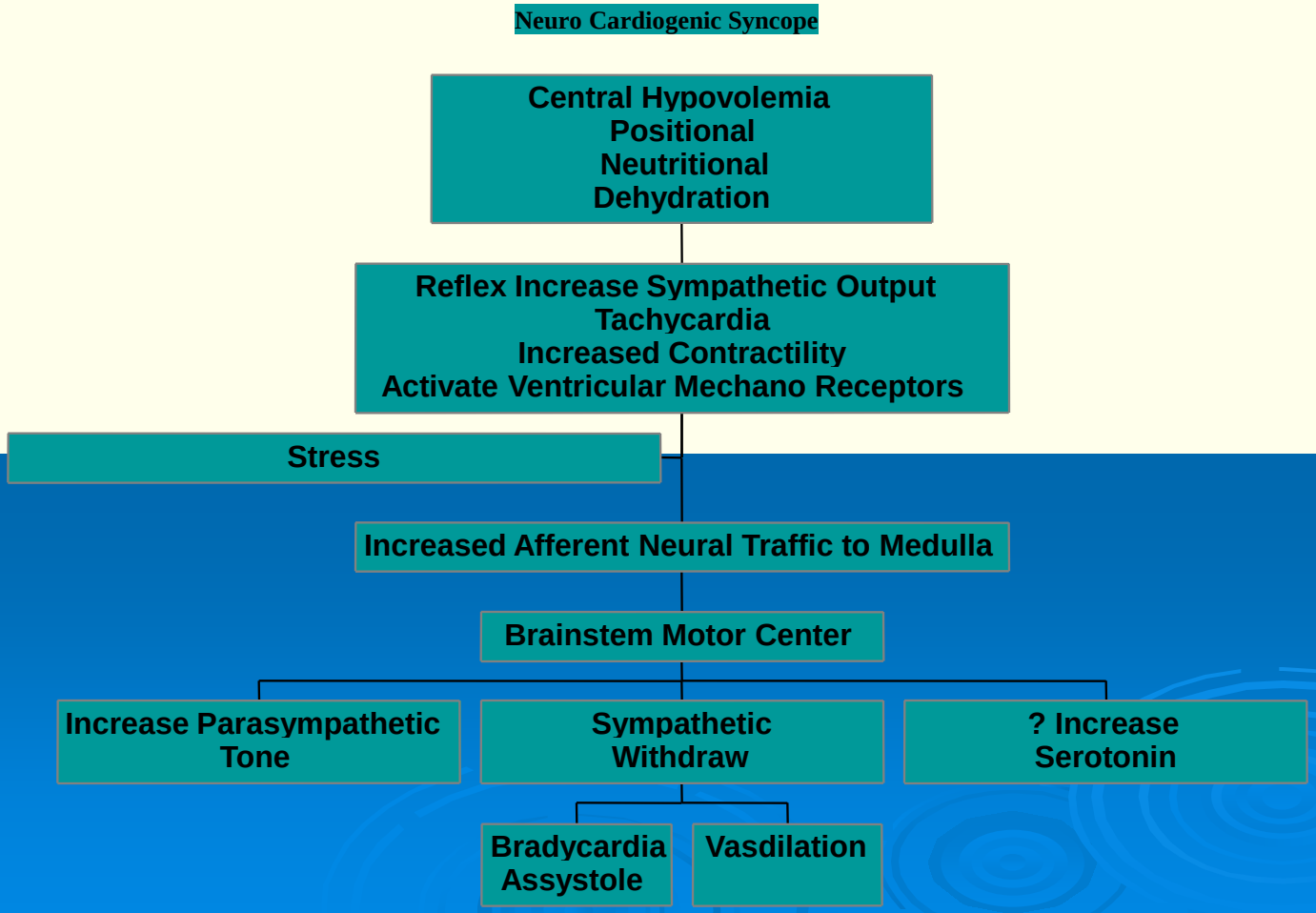
Syncope

- 15% of all children
- Medical attention
  - 72-126 / 100,000
- Peak period 15-19 years of age
- Cardiac etiology 2%-6%

History

- Timing
- Prodrome
- Associated injuries
- Associated motor activity
- Incontinence
- Activities
  - Swimming

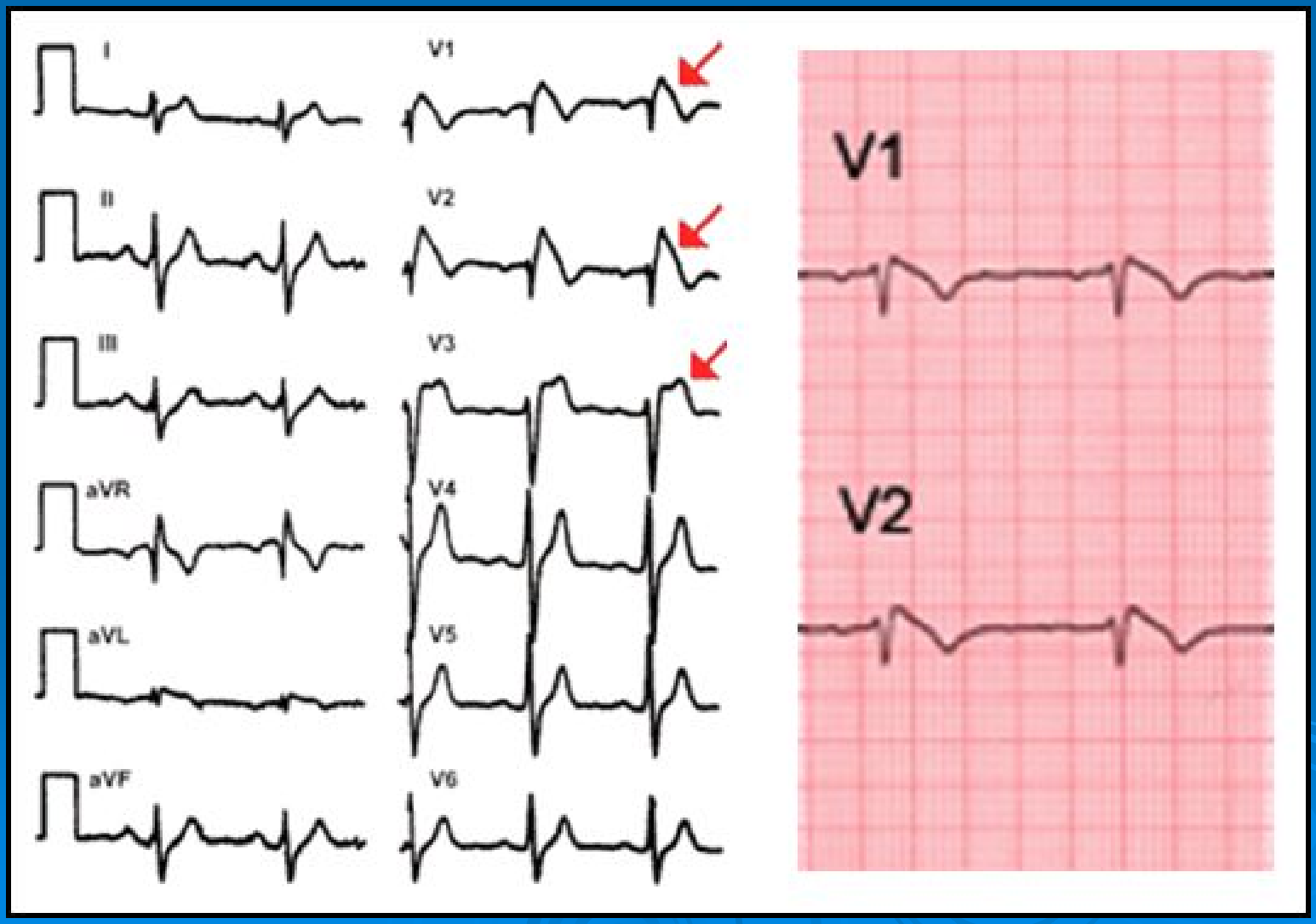
Neuro Cardiogenic Syncope



EKG

- Arrhythmia identified
- Brugada Syndrome
  - Anterior ST-T changes
- Prolonged QTc
  - QTc < 0.44 unlikely LQTS
  - QTc > 0.48 high risk LQTS
- Abnormal coronary syndromes

Brugada Syndrome



Management

- Normal Exam
- Normal Work Up
- No Diagnosis

- Limit Dangerous Activities
  - Stress test
- Outpatient Consultation

Summary

- Neonatal emergencies
  - Prostaglandin E1
  - Balance open circulations
- Rheumatologic Emergencies
  - Identify, consult and move on
- Arrhythmias
  - Same as adults
- Syncope
  - QTC

A Modern Parable

The disturbing consequences of impatient action which I have reviewed recall an apocryphal saying in factories which manufacture fireworks:

It is better to curse the darkness, than to light the wrong candle