MANAGEMENT OF PROFOUND HYPOTHERMIA: FROM BAIR HUGGERS TO ECMO

CARRIE ALLISON, MD, FACS

TRAUMA AND ACUTE CARE SURGERY, SURGICAL CRITICAL CARE

SALEM HEALTH

Salem Health Hospitals & Clinics

OBJECTIVES

- DEFINE STAGES OF ACCIDENTAL HYPOTHERMIA AND ASSOCIATED PHYSIOLOGIC DERANGEMENTS
- UNDERSTAND CONCEPTS AND TECHNIQUES OF PASSIVE AND ACTIVE REWARMING
- RECOGNIZE WHEN ADVANCE INTERVENTIONS ARE INDICATED

CASE

911

- 2221 911 CALL RECEIVED –
  - 9 YO “FOUND DROWNED IN BATHTUB”
  - FAMILY REPORT CHILD WAS “IN BATHTUB, SHOWER WAS ON, LEFT UNATTENDED 5 MINUTES”
- 2232 EMS AT PATIENT – FOUND ON FLOOR OF HOME PULSELESS - BEGAN CPR
  - COLD TO TOUCH, PUPILS FIXED AND DILATED
  - WET, PALE WHITE, CHEST CLEAR, ABRASION TO FOREHEAD, ABD & PERINEAL BRUISING
- 2235 ASYSTOLE – FAILED INTUBATION
- 2237 I-GEL
- 2240 ETCO2 14
- 2241 IO & 20G IV
- 2242 – 2307 EPI X 5
- 2243 ETCO2 20-30 W/CPR
- 2259 EMS DEPARTS SCENE (27 MIN SCENE TIME)
- REMAINS PULSELESS, CPR IN PROGRESS EN ROUTE

TRANSPORT

- 2304 FULL TRAUMA ACTIVATED
- 2308 BICARB X1
- 2309 V FIB SHOCK X 1
- 2311 PEA
- 2312 EPI
- 2313 ASYSTOLE
- 2315 ARRIVE AT HOSPITAL (16 MIN TRANSPORT, 43 MINUTES OF CPR/PALS)

ARRIVAL SALEM HEALTH LEVEL II TRAUMA CENTER

- 2315 ARRIVAL CPR IN PROGRESS
  - PALE, VOMIT ON FACE/CHEST
  - SCATTERED BRUISING TO BODY
  - NO PULSE CONFIRMED
  - ED & TRAUMA SURG AT BEDSIDE

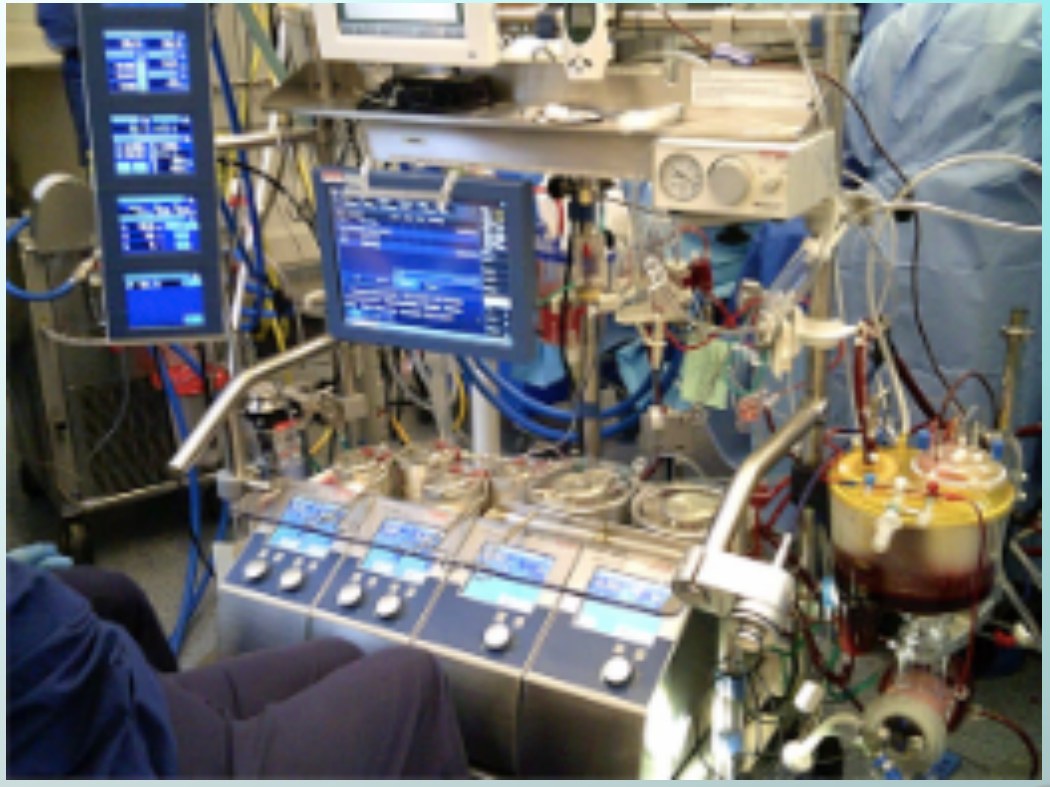
- 2318 LLE IO, CBG 73 BP 63/94 W/CPR, ETCO 35 UNABLE TO OBTAIN TEMP
- BAIR HUGGERS OVER/UNDER PLACED, WARMED FLUIDS
- 2326 R FEMORAL ALSIUS FOR RE-WARMING
- FAST NEGATIVE, + SLOW CARDIAC MOTION
- 2343 CV SURGEON PAGED – BYPASS REQUESTED
- 2351 TRANSFUSED 2:2; CALCIUM
- 0005 RECTAL TEMP OF 22 C
- 0015 TO OR – CPR ONGOING (1:43 TOTAL OF CPR)

OR - SALEM

- INITIALLY ATTEMPTED V/A BYPASS VIA L FEMORAL CANNULATION, UNABLE TO CANNULATE SMALL VESSELS
- 0048 CANNULATED R ATRIUM/AORTA ON CARDIOPULMONARY BYPASS

  TEMP 33.5 C
- 0049 ROSC OBTAINED

  TEMP 37.2 C
- 0154 TRIAL OFF CPB – OXYGEN INADEQUATE
  - SIGNIFICANT PULM EDEMA – UNABLE TO REMOVE BYPASS – DOERNBECHER ECMO TEAM REQUESTED
- 0505 - DR. RAN RAN OHSU/DOERNBECHER ECMO TEAM ARRIVED
- 0545 CPB —> PORTABLE ECMO
- 0717 ONGOING TRANSFUSION REQUIREMENTS AND ABDOMINAL COMPARTMENT SYNDROME
  - EX-LAP, LONG SEGMENT SMALL BOWEL SEROSAL TEAR – RESECTED, DISCONTINUITY, ABTHERA PLACED FOR TEMPORARY ABDOMINAL CLOSURE
- 0835 LEFT OR WITH ECMO TEAM - TO DOERNBECHER



OHSU HOSPITAL COURSE

- HD#1 EX LAP, ABDOMINAL WASHOUT, ONGOING COAGULOPAHTY
- HD#2 L LEG FASCIOTOMIES
- HD#3 MEDIASTINAL EXPLORATION FOR BLEEDING
- HD#4 ECMO DECANNULATION, CHEST CLOSURE, ABDOMINAL CLOSURE
- HD# 10 EXTUBATED
- HD#18 CLOSURE OF LEG WOUNDS
- HD# 24 TRANSFER TO WARD
- HD# 39 DISCHARGE HOME

FOLLOW UP

- GAVE FULL DETAILED REPORT OF ABUSE TO SOCIAL WORK AND LAW ENFORCEMENT
- REMOVED FROM CARE OF PARENTS
- CURRENTLY IN 4TH GRADE, LIVING WITH GRANDPARENTS
- SEEN FOR WELL CHILD CHECK, OFF ALL MEDICATIONS, SOME RESIDUAL CONTRACTURE OF LEFT ANKLE
- LOVES SCHOOL, FAVORITE SUBJECTS: MATH AND PE

HYPOTHERMIA - RECOGNITION AND TREATMENT

RECOGNITION AND MONITORING

- **MISSED HYPOTHERMIA IS VERY COMMON**
  - NOT SUFFICIENT TO NOTE A PATIENT IS “COLD” AND PLACE WARM BLANKETS/BAIR HUGGER
  - NOT ALL THERMOMETERS WILL READ BELOW CERTAIN BODY TEMPERATURE
  - ESOPHAGEAL, FOLEY OR RECTAL TEMP ARE PREFERRED
  - PULSE OX MAY NOT BE ACCURATE D/T VASOCONSTRICTION, CAN USE TOPICAL NITRO
  - CONTINUOUS ECG MONITORING CRITICAL

HYPOTHERMIA DEFINITION

Hypothermia scale and clinical findings

Stage	Core temperature	Clinical findings
Cold stressed (but not hypothermic)	35 to 37°C (95 to 98.6°F)	Normal mental status with shivering. Functioning normally. Able to care for self.
Mild hypothermia	32 to 35°C (90 to 95°F)	Alert with shivering. Not able to care for self.
Moderate hypothermia	28 to 32°C (82 to 90°F)	Altered level of consciousness. May be conscious or unconscious, with or without shivering.
Severe hypothermia	<28°C (<82°F)	Unconscious. Not shivering.

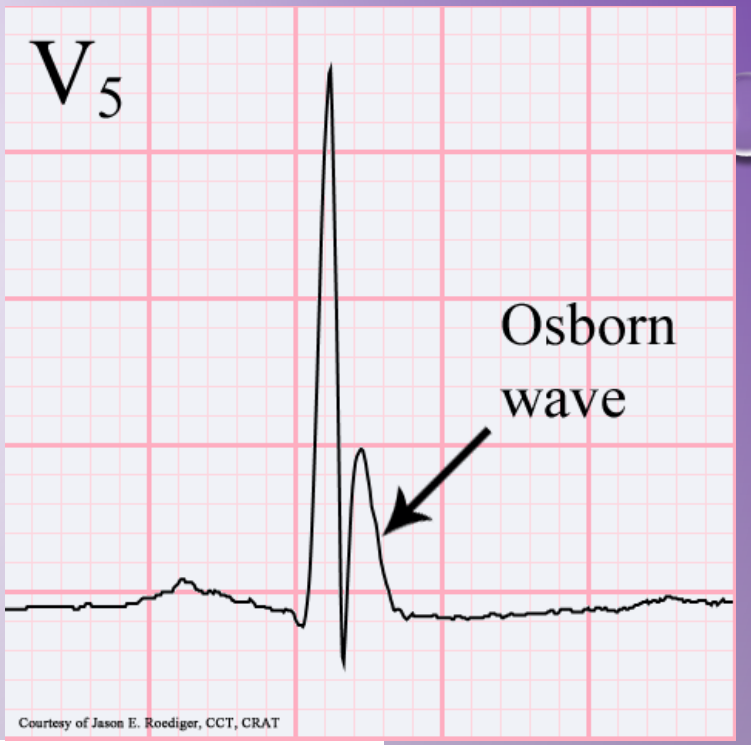
*Level of consciousness alone may be as accurate as core temperature in predicting the risk of cardiac arrest and mortality

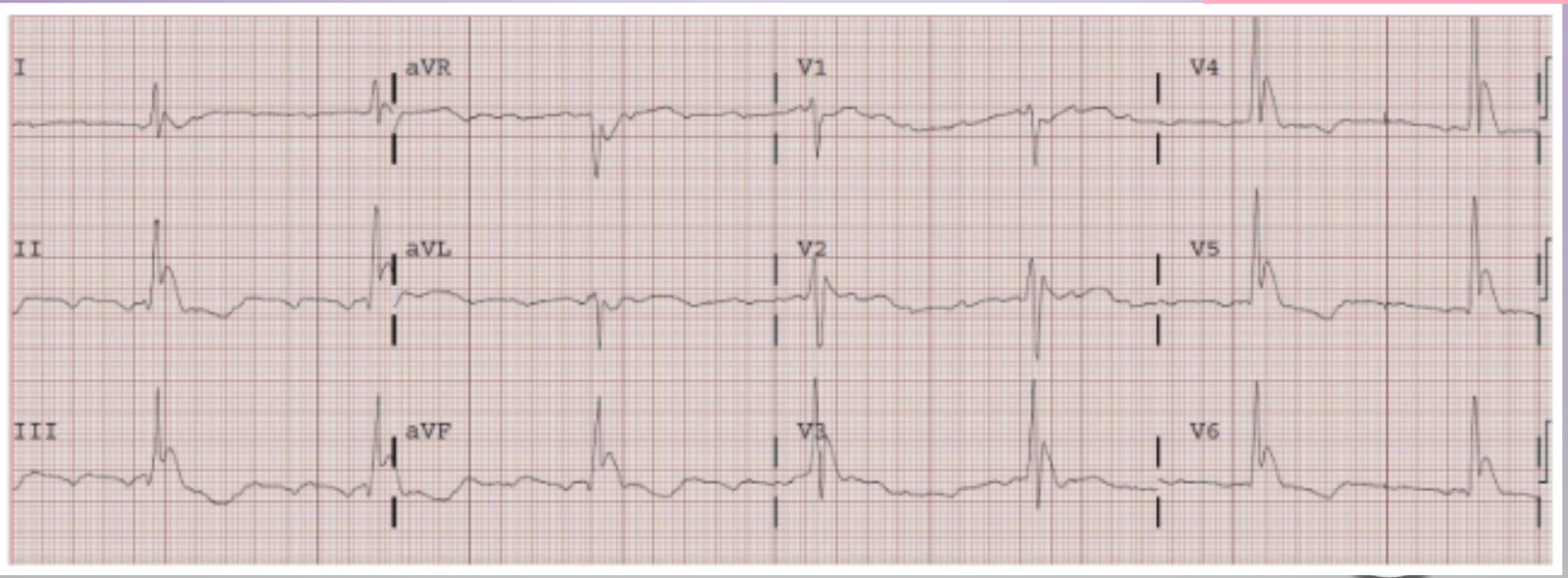
Progressive clinical manifestations of accidental hypothermia

	Mild	Moderate	Severe
Neurologic	confusion ->	lethargy, hallucinations -—>	coma, loss of ocular/pupillary reflexes
Cardiovascular	tachycardia ->	bradycardia/hypotension —-> J /Osborne wave	v fib, PEA, asystole
Respiratory	tachypnea ->	hypoventilation —->	pulmonary edema/apnea
Renal	bladder atony ->	cold diuresis -—>	oliguria
Musculoskeletal	shivering ->	decreased shivering/muscle rigidity ——>	"pseudo-rigor mortis"
Metabolic	increased met rate	——>	decrease metabolic rate
Hematologic	increased hematocrit, decrease platelet	——>	DIC

*signs that portend a poor prognosis in a normothermic patient (i.e. fixed and dilated pupils, loss of brainstem reflexes, rigor mortis) are **expected** and **reverse** with rewarming if the patient survive

- Rhythm abnormalities common
- Intervals may be prolonged (PR, QRS, QTc)
- Osborn J waves
- Defibrillation may be attempted but is often unsuccessful until rewarmed





Rewarming method	Rate
Passive EXTERNAL rewarming	
Warm room, warm blanket	0.5-1C/hr
Active EXTERNAL warming	
Bair Hugger	1-2C/hr
Active INTERNAL warming	
Warmed fluids	Minimal (should not be used as an isolated strategy d/t high volumes required to increase temperature)
Body cavity lavage (chest, bladder, peritoneum)	2-4C/hr
Alsius	2-4C/h
Extracorporeal (cardiopulmonary bypass, ECMO)	6-18C/h

Our pt temp on arrival = <22C

Goal temp = 37C

△ > 15C

PROGRESSIVE HYPOTHERMIA TREATMENT ALGORITHM

COLD STRESSED (35-37C)
Warm blanket, warm room

MILD (32-35C)
Bair hugger, warmed fluids

MODERATE (28-32C)
Internal rewarming (bladder, pleural and/or peritoneal irrigation), Alsius

SEVERE (<28C)

HD Stable	**HD Unstable or Cardiac Arrest**
Treat as Moderate	ECMO or CPB

Airway
Breathing
Circulation
Check labs
Start IVF

FAILURE TO REWARM

- CONSIDER REVERSIBLE/TREATABLE CAUSES
  - TRAUMA/BLEEDING
  - SEPSIS
  - ADRENAL INSUFFICIENCY
  - HYPOGLYCEMIA
  - HYPOTHYROIDISM
  - SEVERE ELECTROLYTE ABNORMALITIES

Clinical characteristics and outcomes of witnessed hypothermic cardiac arrest: A systematic review on rescue collapse

C. Frei, T. Darocha, G. Debaty, F. Dami, M. Blancher, P.N. Carron, M. Oddo and M. Pasquier

Resuscitation, 2019-04-01, Volume 137, Pages 41-48, Copyright © 2019 Elsevier B.V.

- Systemic review of 214 pts, average body temp of 23.9 +/- 2.7°C
- 30% had asystole
- Survival rate was 73%
- Most survivors had favorable neurological outcomes (89%)

HOPE

Hypothermia Outcome Prediction after ECLS

Hypothermia Outcome Prediction after Extracorporeal Life Support for Hypothermic Cardiac Arrest Patients. Estimation of the survival probability using HOPE.

HOPE is the result of an international collaborative project initiated and led by the Emergency Department of the University Hospital of Lausanne, Switzerland.

HOPE provides a prediction of the survival probability in hypothermic cardiac arrest patients undergoing Extra-Corporeal Life Support (ECLS) rewarming. The survival probabilities range from 0% to 100% chance of survival to hospital discharge.

A cutoff of 10% to decide which hypothermic patients in cardiac arrest would benefit or not from ECLS rewarming was evaluated in an external validation study. The negative predictive value of a HOPE probability <10% was of 97%, and the AUC under the ROC curve was of 0.825 which suggest excellent discrimination.

HOPE should not be considered a substitute for clinical judgment or assessment. Of note, one is of course free to use a different cut-off than the proposed threshold of 10% for different subgroups of the population (e.g. for children). The proportion of avalanche victims was low in the validation HOPE study (4%). We recommend to use HOPE cautiously in this specific group of patients.

Estimates are desirable if variables are not known (e.g. age, CPR duration and temperature).

https://www.hypothermiascore.org/

The HOPE survival probability is: 54 %.

The submitted data were:

Age: 9, sex: female, hypothermia with asphyxia, CPR duration: 60 min, potassium: 6.2 mmol/l, temperature: 22 Celsius

○ without asphyxia (immersion, outdoor or indoor cold exposure)

The HOPE survival probability is: 89 %.

The submitted data were:

Age: 9, sex: female, hypothermia without asphyxia, CPR duration: 60 min, potassium: 6.2 mmol/l, temperature: 22 Celsius

POOR PROGNOSTIC FACTORS

Accidental hypothermia prognostic factors in adults

Asphyxia (drowning, avalanche burial)
Unwitnessed cardiac arrest
Asystole
Hyperkalemia
Elevated serum lactate
Hemodynamic instability
Age >75 years
Kidney injury (elevated creatinine)

While evidence is limited, the factors listed above are associated with worse outcomes following hypothermia due to environmental exposure.

* Evidence about accidental hypothermia is limited. These factors are drawn primarily from retrospective, observational studies. They are not necessarily independent risk factors. There are many potential confounders.

*None of these alone is a contraindication to rewarming. Remember, fixed/dilated pupils and low ETCO2 are **expected** and **not considered to be poor prognostic indicators**.

CONTROVERSIES

- PERFUSING/ORGANIZED RHYTHM BUT NO PULSE —-> CPR OR NO CPR ?
- DEFIB SHOCKABLE RHYTHMS WHEN SEVERELY COLD ?
- HOLD ACLS MEDICATIONS OR DECREASE INTERVAL UNTIL REWARMED ?

SUMMARY

- YOU'RE NOT DEAD UNTIL YOU'RE **WARM AND DEAD**
- HYPOTHERMIC PATIENTS WITH DIMINISHED CONSCIOUSNESS OR HEMODYNAMIC INSTABILITY NEED **ADVANCED INTERVENTIONS** TO REWARM
- ECMO/CPB SHOULD BE CONSIDERED FOR **UNSTABLE/PULSELESS** HYPOTHERMIC PATIENTS
- SURVIVAL AND NEUROLOGIC OUTCOMES ARE GOOD FOR THOSE WHO REWARM

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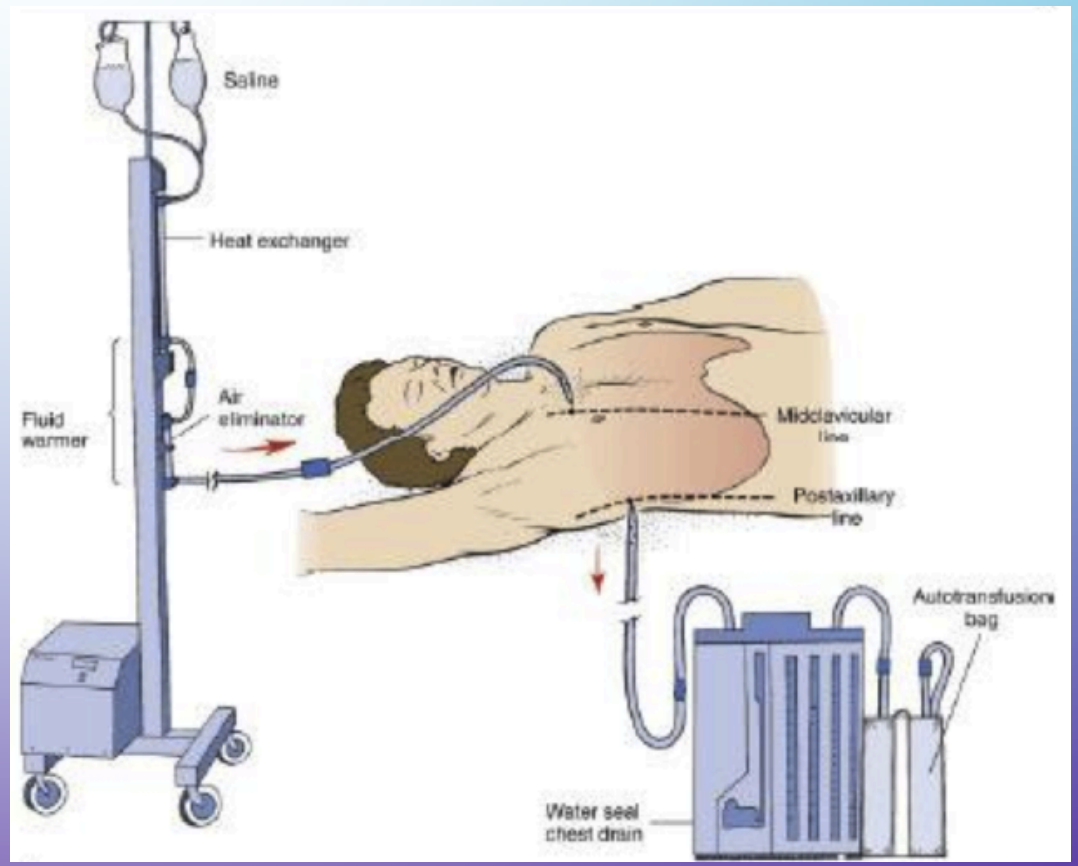
THORACIC LAVAGE TECHNIQUE

One Two System

- single large bore chest tube
- allow warmed fluid to dwell for 15-20 minutes then drain

Two Tube System

- anterior & lateral tubes
- infuse 200-300mL/hr warmed fluid via anterior tube
- continuously drain to Atrium via lateral tube



PERITONEAL LAVAGE TECHNIQUE

- Access the abdominal cavity via
  - DPL (diagnostic peritoneal lavage) catheter
  - Veress needle
  - direct cutdown

- Insert large bore catheter

- Instill warmed fluid via 3L saline irrigation and dwell 10-15 minutes, then drain