# Trauma

## Triage, stabilization and management of the trauma patient

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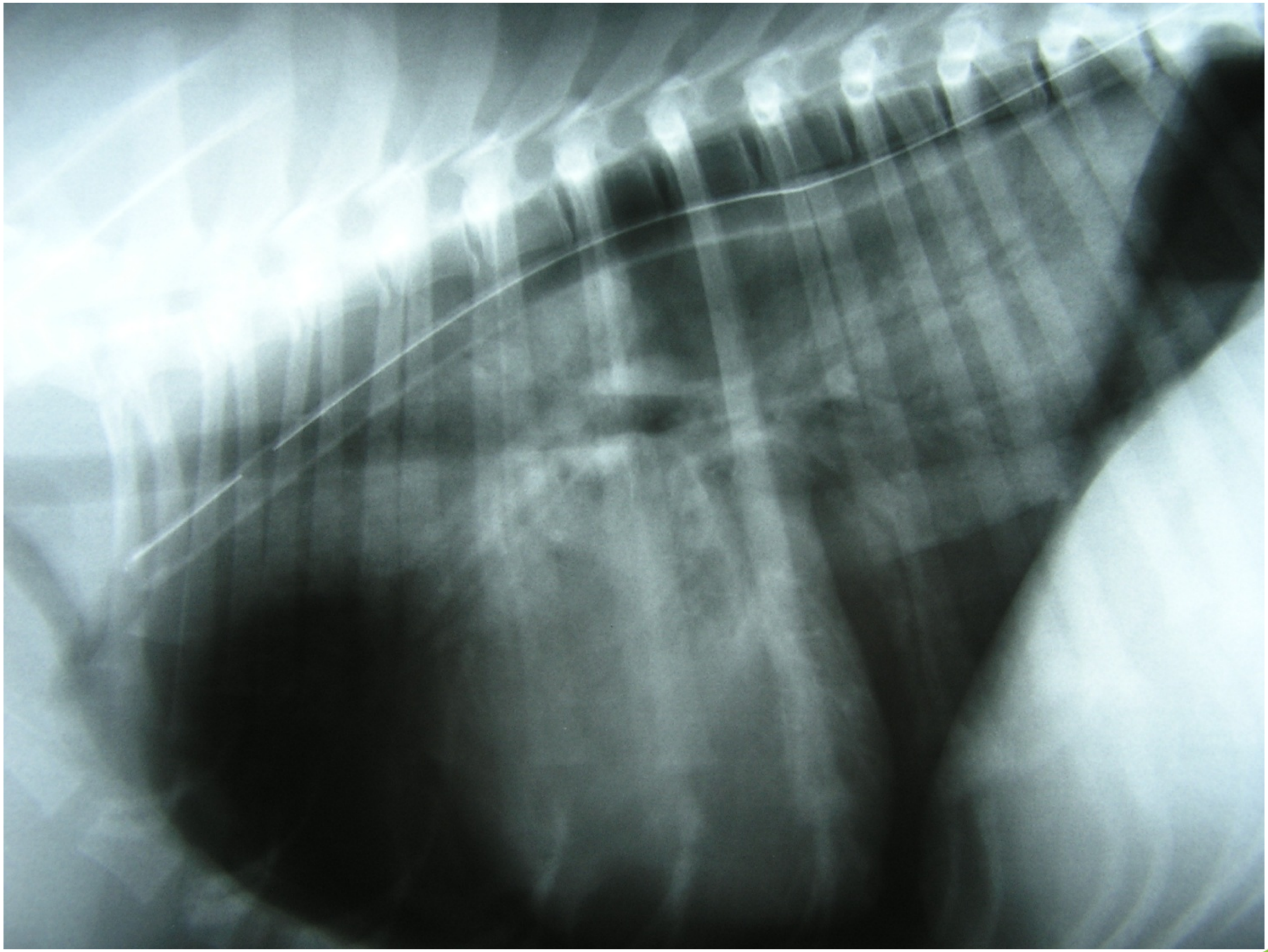
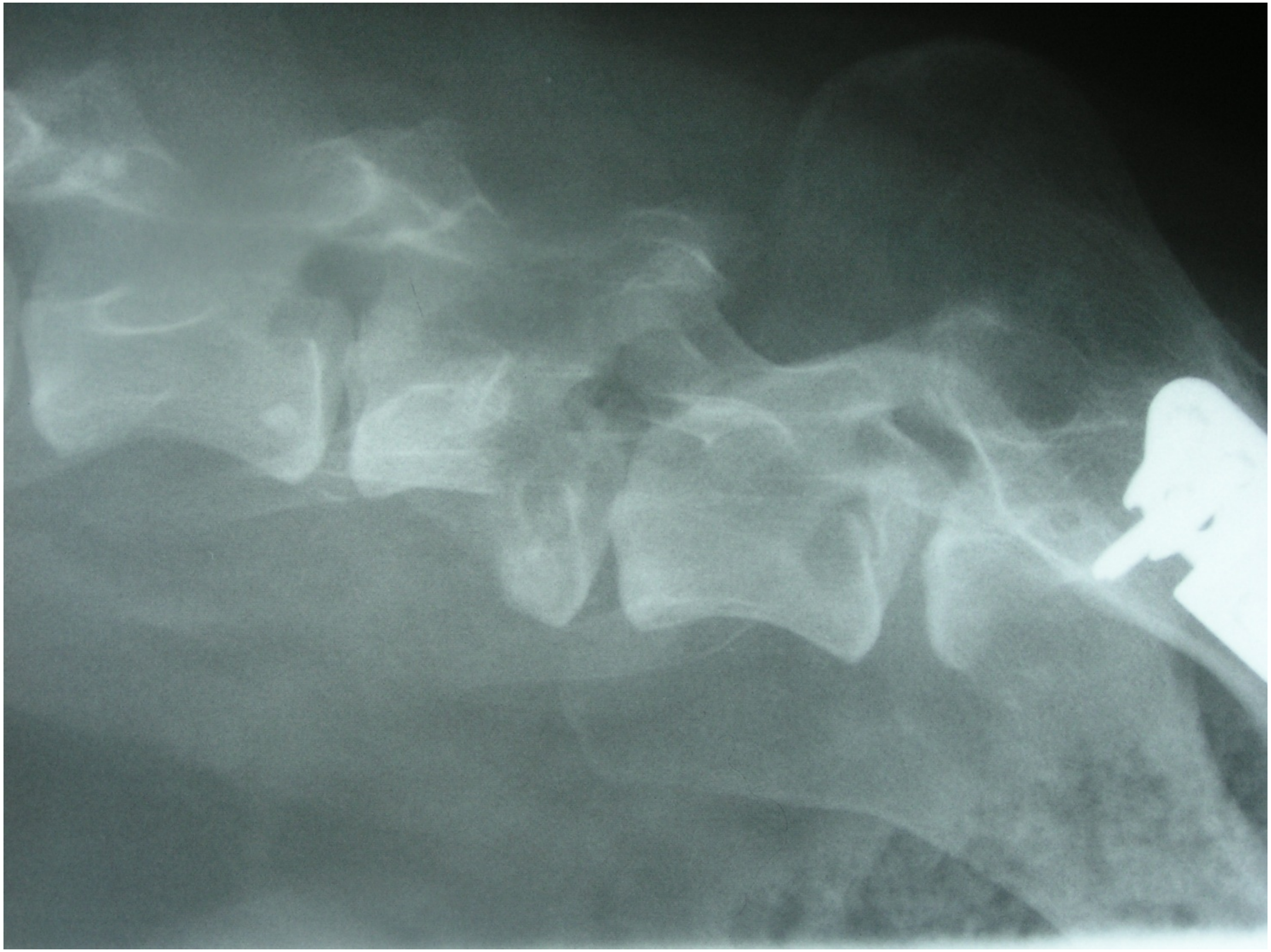
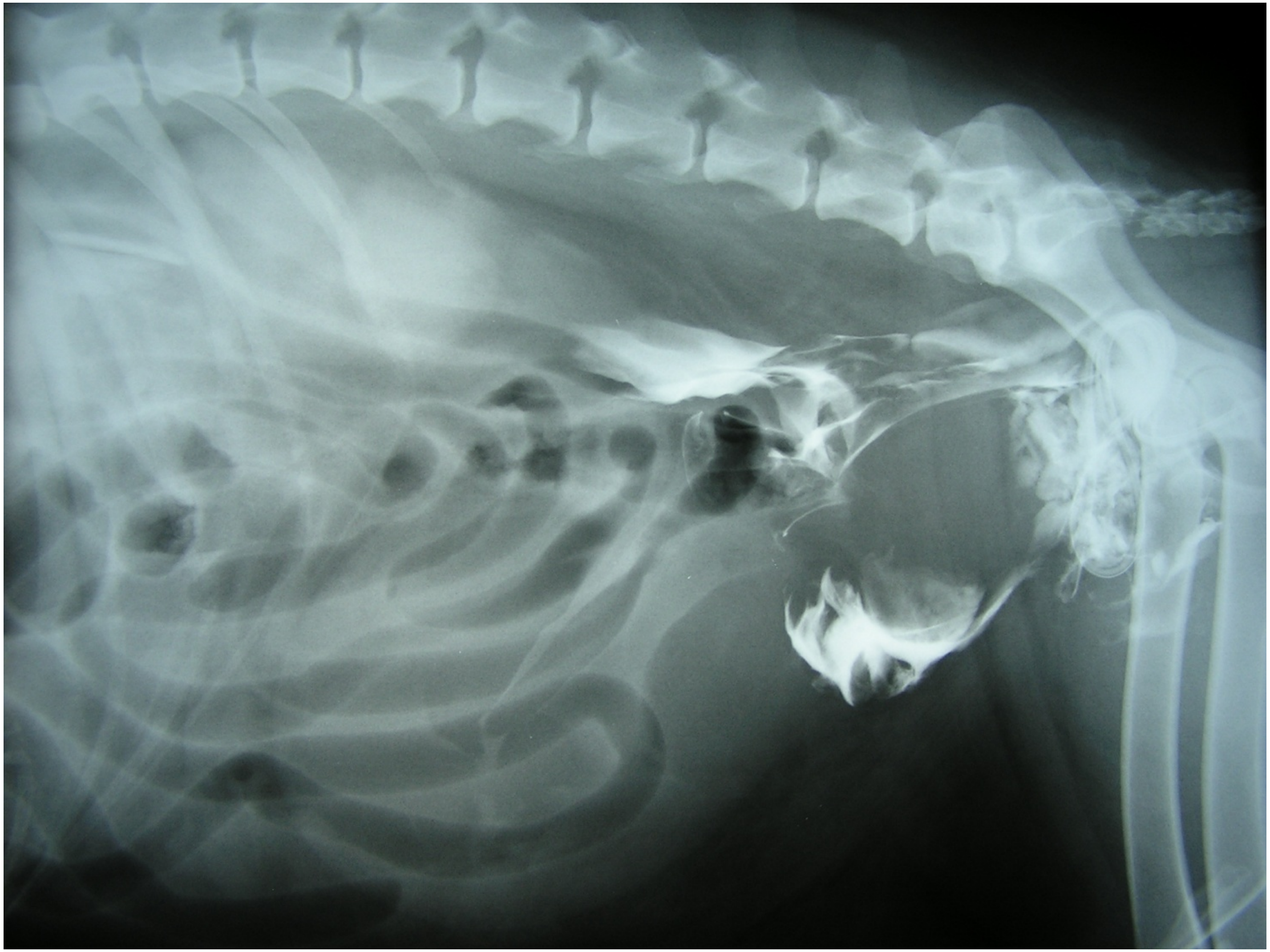
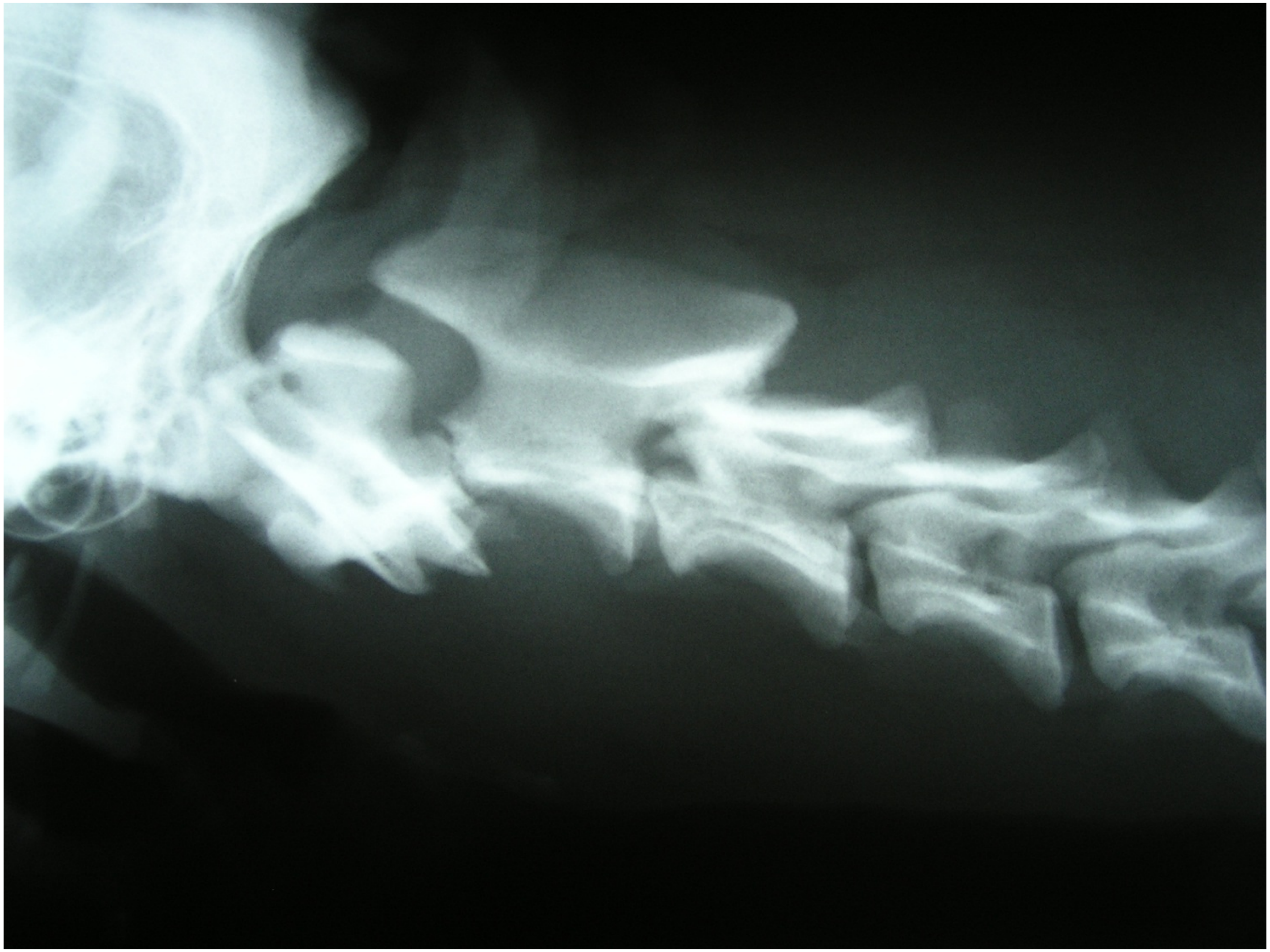








# OVERVIEW

- Triage
- Pathophysiology of shock
- ABC's and initial management techniques
- Goal directed therapy
- Fluid resuscitation
- Respiratory distress
- Tips for Success


- Triage

: the sorting of and allocation of treatment to patients and especially battle and disaster victims according to a system of priorities designed to maximize the number of survivors

: the sorting of patients (as in an emergency room) according to the urgency of their need for care

: the sorting of problems within a patient in order of urgency

# TRAUMA OBJECTIVES

- ID and correct life-threatening injuries
- Resuscitate and stabilize blood flow to maximize tissue perfusion/$DO_2$
- Determine degree and severity of other injuries (secondary survey)
- Prioritize injuries
- Definitive care for injuries
- Supportive care

# ATLS - HUMAN

- Systematic approach necessary to rapidly identify injuries and stabilize the patient
- This approach is divided into:
  - 1. Primary Survey
  - 2. Resuscitative Phase
  - 3. Secondary Survey
  - 4. Definitive Care Phase

# PRIMARY SURVEY - *ABCDE*

- **A**irway and **a**rterial bleeding
  - Patent airway?
  - Apply direct pressure to active hemorrhage
- **B**reathing
  - Observe respiratory pattern/stance
  - Thoracic auscultation
  - Thoracocentesis
  - Crash ETT – PPV, manual vent
  - Emergency tracheostomy
  - Apnea

# PRIMARY SURVEY

- **C**irculation
  - MM color
  - CRT
  - Pulse deficits
  - Arrhythmias
    - Tachycardia
    - Bradycardia
  - Hydration status

# PRIMARY SURVEY

- **D**isability
  - LOC
  - Deep pain? Motor?
- **E**xternal assessment
  - Quickly examine all areas
  - Hemorrhage, lacerations, punctures, abrasions, etc.

# SECONDARY SURVEY
## *A CRASH PLAN*

- **A**irway – neck, chest, feel, listen; sounds?
- **C**ardiovascular – mm, **CRT**, pulse rate, rhythm, heart tones, BP
- **R**espiratory – effort, rate, pattern
- **A**bdominal – bowel sounds, pain, evaluate skin -bruising, punctures, lacerations
- **S**pine – dorsal spine alignment, pain, evidence of trauma, walking?, deep and superficial pain, anal tone, reflexes
- **H**ead – LOC, pain, anxiety, pupil size, PLR's, cranial nerves, EENT, jaws, teeth

# SECONDARY SURVEY

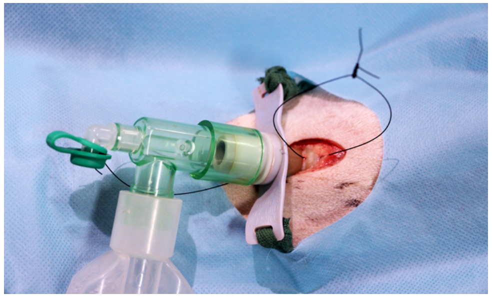
- **P**elvis – palpation, rectal exam, inguinal, femoral
- **L**egs – assess limbs, tail pain, swelling, punctures, lacerations, deformity, movement
- **A**rteries – brachial, femoral, dorsal pedal, cranial tibial – pulse quality, presence
- **N**erves – peripheral nerves, pain, muscle tone

# SECONDARY SURVEY

- Assume occult injury in the trauma patient
- Trauma films in poly-trauma patients
- FAST, TFAST
- Rule out injuries rather than assume they are absent

# AIRWAY, BREATHING, PAIN, ANXIETY

- $O_2$ by mask or flow by
- Sedation/analgesia
- Rapid induction for severe respiratory distress
  - Opioid + BZD + propofol
  - Propofol + BZD
- “slash” tracheostomy
  - Local anesthesia only



# EXTERNAL HEMORRHAGE

- Direct pressure – above and below
- Elevate
- Compressive dressing
- Pressure points – digital pressure
- Increase pressure – pressure cuff, more dressing
- Tourniquet – salvage
- Hemostatic agent
- Surgery

# Shock

# SHOCK - DEFINED

- Kumar and Parrillo (1995) - "The state in which profound and widespread reduction of *effective* tissue perfusion leads first to reversible, and then if prolonged, to irreversible cellular injury."

# SHOCK: CLASSIFICATION

- Hypovolemic shock - due to decreased circulating blood volume in relation to the total vascular capacity and characterized by a reduction of diastolic filling pressures

- Cardiogenic shock - due to cardiac pump failure related to loss of myocardial contractility/functional myocardium or structural/mechanical failure of the cardiac anatomy and characterized by elevations of diastolic filling pressures and volumes

- Extra-cardiac obstructive shock - due to obstruction to flow in the cardiovascular circuit and characterized by either impairment of diastolic filling or excessive afterload

- Distributive shock - caused by loss of vasomotor control resulting in arteriolar/venular dilatation and characterized (after fluid resuscitation) by increased cardiac output and decreased SVR

# PATHOPHYSIOLOGY OF SHOCK

- Poor perfusion
- Low or maldistribution of blood flow
- Imbalance $DO_2$ and $VO_2$

# RESUSCITATION: OPTIMAL END-POINT RESUSCITATION

- Traditional endpoints
  - Mentation
  - CRT
  - HR
  - BP
  - Rectal temp
  - Urine output
- Unreliable in many cases

# OPTIMAL END-POINT RESUSCITATION

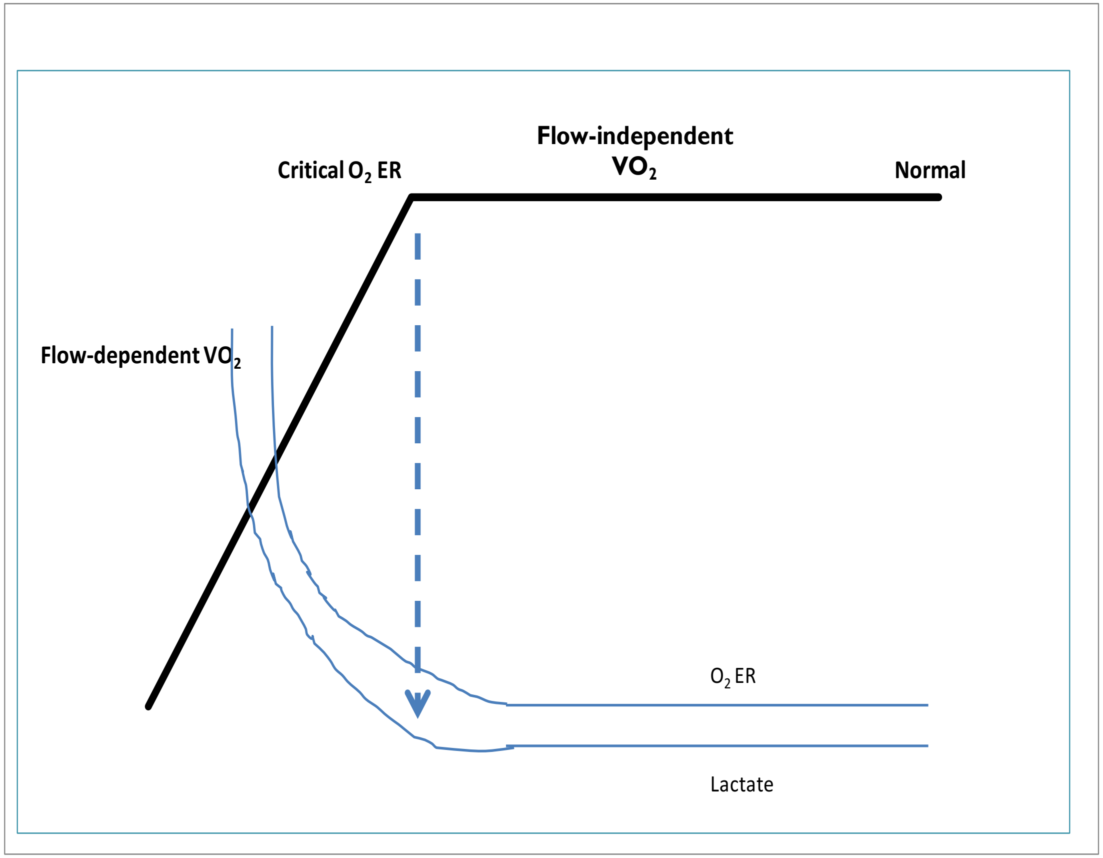
- Compensated shock
  - 85% human trauma patients
    - Ongoing perfusion deficits
    - Tissue hypoxemia
    - Occult $O_2$ debt
- Need for more sensitive markers
  - Lactate
  - Base deficit
  - $S_v O_2$, $S_{cv} O_2$
  - Gastric tonometry

# $DO_2$ AND $VO_2$ RELATIONSHIP

- Healthy patient
  - CO adjusted
  - $DO_2 > VO_2$
- In critically ill
  - Decreased CO
  - $DO2 \neq VO_2$ increase in $O_2$ ER
    - Minimizes $O_2$ debt
- Intervention may correct deficit
- Persistent hypoperfusion
  - Dysoxia
  - Anaerobic metabolism

# $VO_2 = DO_2 \times O_2 ER$

$VO_2$

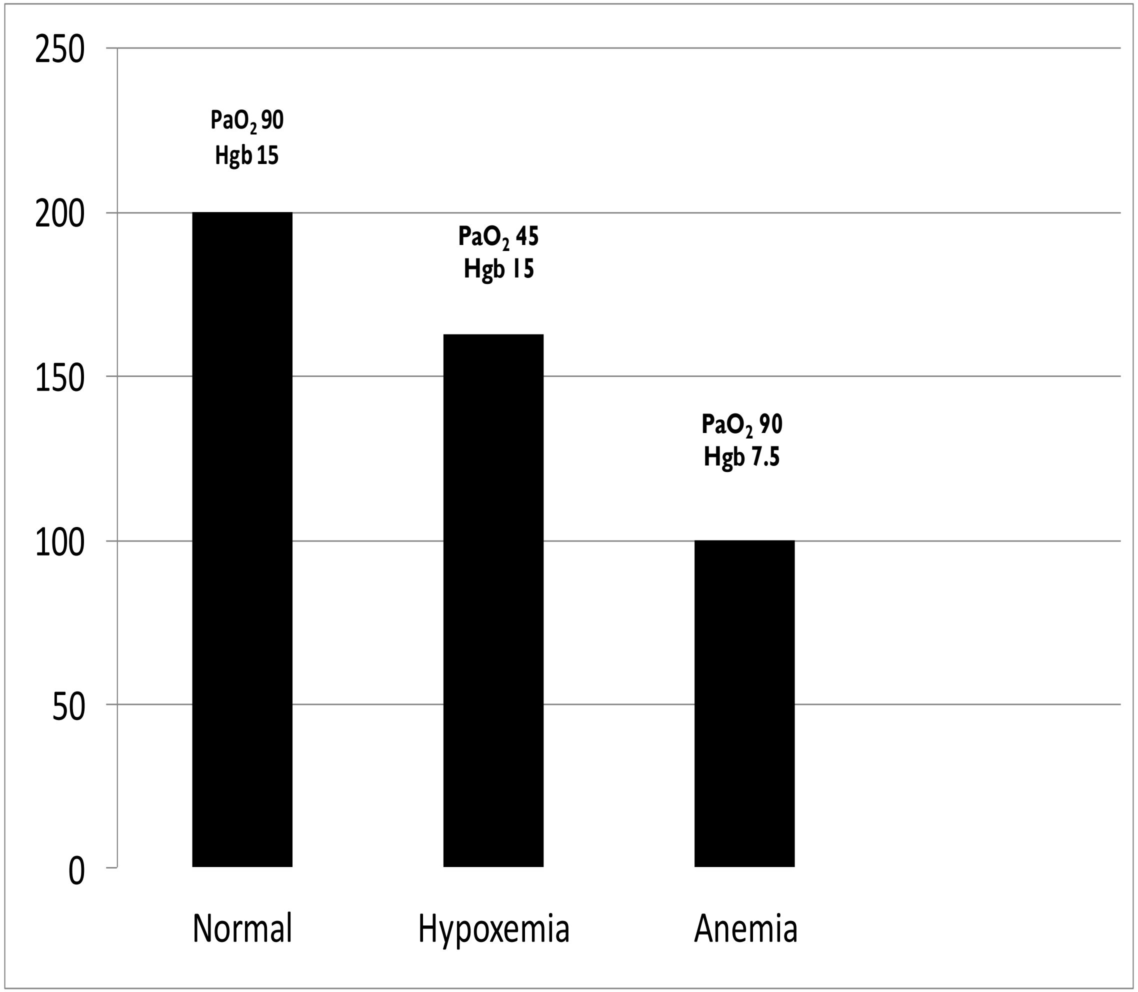



DO2

# HEMODYNAMICS AND $O_2$ TRANSPORT

- $O_2$ Transport affected by
  - CO
  - Hgb
  - $SaO_2$
- $PaO_2$
  - Lesser extent
- $CaO_2$ = **Hgb** (1.34) (**$SaO_2$**)

$CaO_2$ (mL/L)

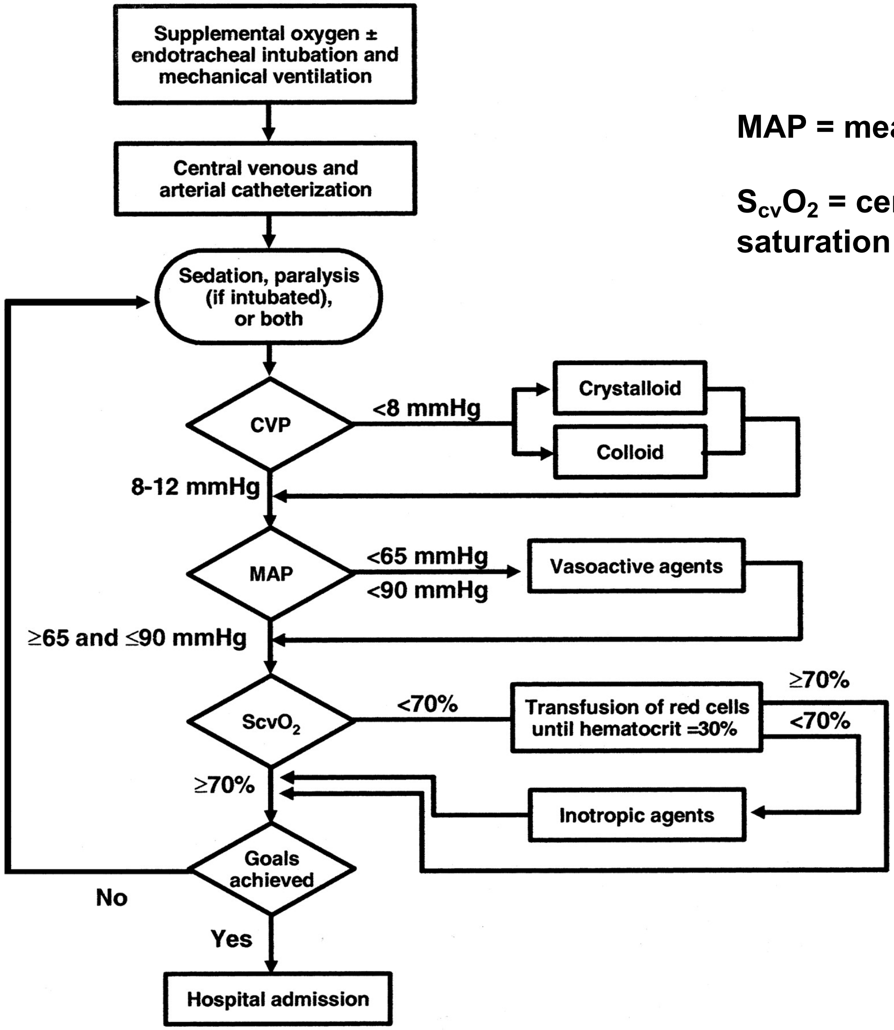


250
200
150
100
50
0
PaO2 90
Hgb 15
PaO2 45
Hgb 15
PaO2 90
Hgb 7.5
Normal
Hypoxemia
Anemia

# EARLY GOAL-DIRECTED THERAPY

- Specific end-points controversial
- $DO_2$, $VO_2$ measurements
  - Cumbersome
  - Requires PAC or other means to measure $O_2$ and/or CO
  - Inconsistent findings
- Early goal-directed therapy
  - Positive affect on human sepsis/shock patient outcome
  - Global markers of perfusion

# Protocol for early goal-directed therapy for patients in shock.




MAP = mean arterial pressure

$S_{cv}O_2$ = central venous oxygen saturation

Levy M. M. Chest 2005;128:547S-553S

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# END-POINTS OF RESUSCITATION – SMALL ANIMAL PATIENTS

- Lactate
  - Evaluated most extensively
- Lagutchik, et.al.
  - Healthy and injured patients
  - Median venous lactate in healthy dogs
    - 1.38 mmol/L
  - Median lactate in injured dogs
    - 2.48 mmol/L
    - 3.48 mmol/L in dogs that died
  - Lactate value correlated with survival

JVECCS VOL. 8, NO.2 AUGUST,1998

# LACTATE - GDV

- Papp et al.
    - GDV
    - Elevated lactate > 6 mmol/L during resuscitation predictive of gastric necrosis
    - Lactate < 6 mmol/l – 99% survival rate
    - Lactate > 6 mmol/L – 58% survival

J Am Vet Med Assoc 1999; 215(1):49–52.

# LACTATE - GDV

- Green, et. al
- Failed to show correlation between lactate > 6 and macroscopic gastric necrosis
- > 50% decrease lactate over 12 hours
  - 70% survival

J Vet Emerg Crit Care 2011; 21(1): 36–44)

# LACTATE - GDV

JAVMA, Vol. 236, No. 8, April 15, 2010

- Zacher, et. al
- Initial lactate > 9.0 mmol/L – 54% survival
- Initial lactate $\leq$ 9.0 mmol/L – 90% survival
- HIL group post resuscitation
  - Lactate >6.4 – 23% survival (< 6.4, 91%)
  - Lactate absolute change $\leq$ 4 – 10% (>4, 86%)
  - Lactate % $\Delta$ < 42.5 % - 15% (>42.5%, 100%)
- Take home
  - Serial measurements throughout the resuscitation process

# Treatment of Shock

# FLUID THERAPY IN TRAUMA PATIENT

- Venous access essential
- MDB
  - PCV
  - TP
  - Blood glucose
  - Electrolytes/iCa and VBG
  - Lactate

# FLUID THERAPY IN TRAUMA PATIENT

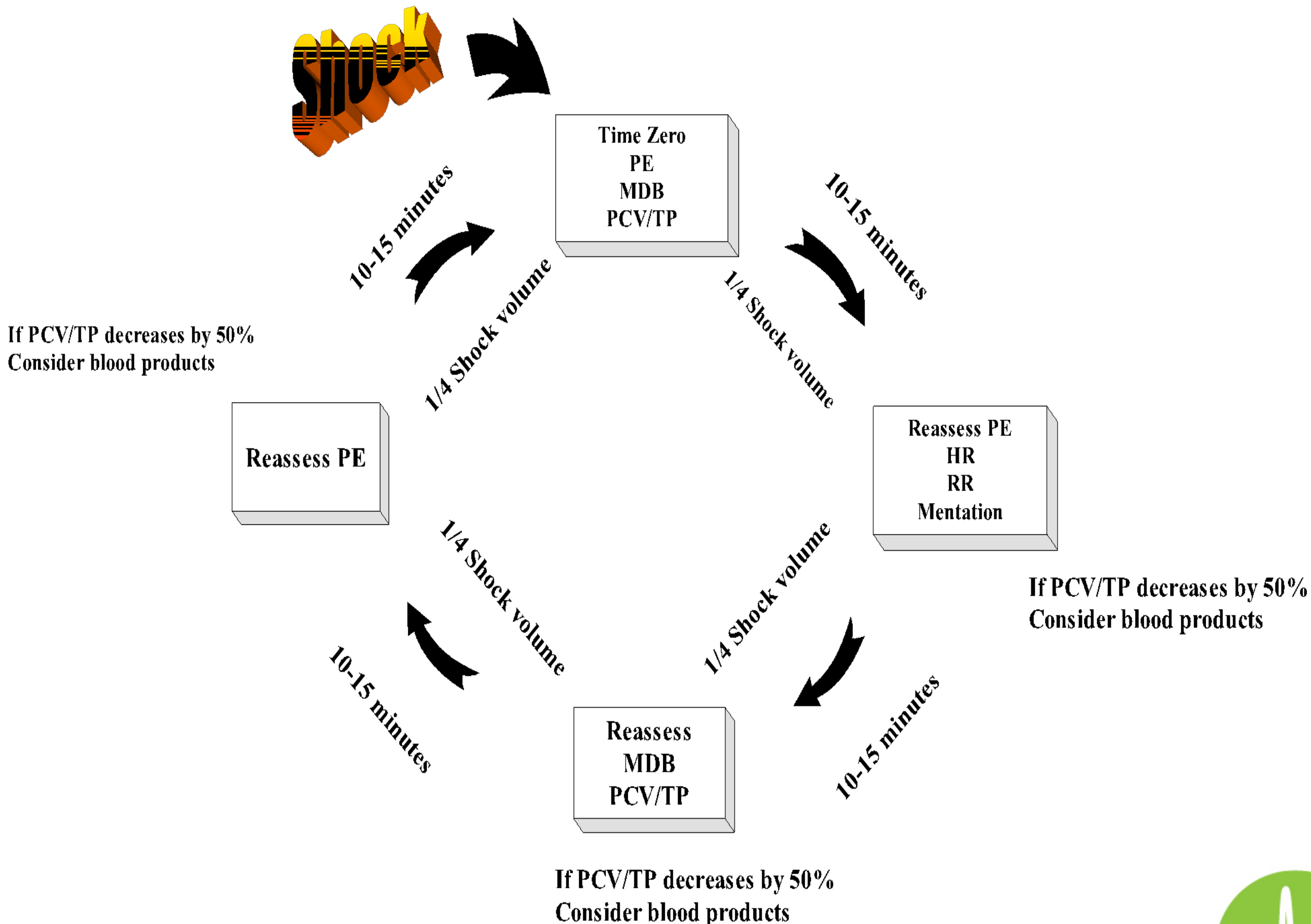
- PCV/TP – normal in early trauma case
- With fluid equilibration
  - Both decrease
- Blood glucose
  - Normal in most patients
  - Hypoglycemia in moribund, hypoperfused

# FLUID THERAPY IN TRAUMA PATIENT

- Fluid choices
  - Isotonic crystalloids
    - 0.9% NaCl
    - Normosol R
    - Plasmalyte
    - Lactated Ringer's
- Replace intravascular volume
- Improve tissue perfusion
- Balanced fluid ideal

# FLUID THERAPY IN TRAUMA PATIENT

- Shock fluid volumes
  - 60-90 mL/kg – dogs
  - 40-60 mL/kg – cats
- "¼ shock"
  - Dogs = wt in lbs x 10
- Incremental boluses


Shock
Time Zero
PE
MDB
PCV/TP
10-15 minutes
1/4 Shock volume
Reassess PE
HR
RR
Mentation
If PCV/TP decreases by 50%
Consider blood products
1/4 Shock volume
10-15 minutes
Reassess
MDB
PCV/TP
If PCV/TP decreases by 50%
Consider blood products
1/4 Shock volume
10-15 minutes
Reassess PE
If PCV/TP decreases by 50%
Consider blood products
1/4 Shock volume
10-15 minutes

# HYPERTONIC SALINE

- 5 or 7.5% saline
  - Effective, rapid
  - **VERY** short lived
  - Rapid movement of water from interstitial space
  - $Na^+$ equilibrates rapidly
  - Combo with colloid (HES, Dextran)

# HYPERTONIC SALINE

- 4-7 mL/kg - dog
- 2-4 mL/kg – cat
- Bolus over 5-10 mins
- Follow with isotonic or colloidal fluids
  - Reduced volume
  - ¼ to ⅓ of typical shock volumes

# HYPERTONIC SALINE

- Primary indication
  - Head trauma
- Reduces cerebral edema
- Reduces ICP
- Improves CBF and CPP
- Maintains adequate MAP
- Small volume lends itself to improved management.

# HYPERTONIC SALINE

- Contraindications
  - Dehydration
    - Insufficient interstitial water to draw upon
  - Hypernatremia
  - Severe, uncontrolled hemorrhage
    - Rapid increase in MAP can worsen hemorrhage
  - Pulmonary contusions
    - May worsen hemorrhage

# COLLOIDS

- Large molecules
- Not freely diffusible
- Two types:
  - Natural – Albumin
  - Synthetic – HES, Dextran, Vetstarch (Voluven)

# COLLOIDS

- Advantage
  - Remain in intravascular space
  - Maintain volume expansion for longer periods
- Questionable benefit in trauma patient
  - Human comparison study with crystalloids found NO benefit in case outcome
- Cost

# COLLOIDS

- Shock dose
  - 30-60% reduction of the crystalloid dose
  - 10-20 mL/kg – dogs
  - 8-12 mL/kg – cats
- $t_{1/2}$ varies among colloids
  - Size dependent
  - Distribution dependent

# COLLOIDS

- Crystalloid + colloids
  - Reduce dose on both
  - 10 mL/kg HES + 30 mL/kg crystalloid
- HES maintenance
  - 0.5-1.0 mL/kg/h
- Reduce crystalloid volume by ¼ to ⅓
- Colloids and pulmonary contusions
  - Use with caution
  - Small dose, titrate to effect

# COLLOIDS

- Coagulopathy
  - vWf and fVIII impairment
  - Dilutional
  - Doses > 20 mL/kg
    - More significant
- Hemorrhaging patient
  - Use with caution
- Concurrent use of FFP

TABLE 2. HYDROXYETHYL STARCH COLLOID SOLUTIONS[7,8]

| Trade Name | Solution Strength | Wt. Average Molecular Weight (kDa) | Molecular Weight Category | Degree of Substitution | C2:C6 Ratio | COP (mmHg) | Labeled for Veterinary Use? | Theoretical Ceiling Dose |
|---|---|---|---|---|---|---|---|---|
| Hespan (bbraunusa.com) | 6% HES | 450 | High | 0.7 | 4:1 | 32.7 (+/- 0.2) | No | 20 mL/kg/day |
| Hextend (hospira.com) | 6% HES | 670 | High | 0.75 | 4:1 | 37.9 (+/- 0.1) | No | 20 mL/kg/day |
| VetStarch (abbottanimalhealth.com) | 6% HES | 130 | Medium | 0.4 | 9:1 | 37.1 (+/- 0.8) | Yes | 50 mL/kg/day |
| Voluven (hospira.com) | 6% HES | 130 | Medium | 0.4 | 9:1 | 37.1 (+/- 0.8) | No | 50 mL/kg/day |
| Albumin 5% | NA | 69 | NA | NA | NA | 23.2 (+/- 0.1) | Yes | NA |

# BLOOD PRODUCTS

- Trauma patients with significant blood loss may require blood transfusion
- No specific 'trigger'
- No specific PCV or coag time
- Patient 'needs' vary
- Whole blood, PRBC, Plasma or all components

# BLOOD PRODUCTS

- Fresh, whole blood
  - Platelet source
  - 2000-5000 /unit
- 20-25 mL/kg – dogs
  - 10% blood volume increase
- Rule of Ones
  - “1 mL per lb whole blood will raise the PCV 1%”
- Goal PCV 25-30% - dog; 15-20% - cats

# BLOOD PRODUCTS

- Cats
  - 10-15 mL/kg
  - ~10 % blood volume increase
- Administer over 3-6 hrs
- Bolus in hypovolemic
- Source of hemorrhage must be controlled
  - Medical
  - Surgical

# MONITORING DURING FLUID THERAPY

- PE findings
- BP
- CVP
  - 0-8 $cmH_2O$
  - Trends
- Urine output
  - 1-2 mL/kg/h

# MONITORING DURING FLUID THERAPY

- Serial PCV/TP
  - Hemorrhage patients
  - Trauma patients with large volume resuscitation
    - Dilution
  - May require repeat transfusion
    - RBC
    - Plasma – dilutional coagulopathy
- Lactate
  - Initially high in hypovolemic patient
  - Should resolve as perfusion improves


# TIPS FOR SUCCESSFUL OUTCOMES

# THINGS NOT TO MISS

- **Total solids**
  - Major hemorrhage can be hard to assess
  - Splenic contraction in dogs
    - RBC infusion
  - TP < 6 g/dL + Persistent tachycardia despite fluids
    - Further evaluation
  - Pre-existing disease?
    - PLN/PLE

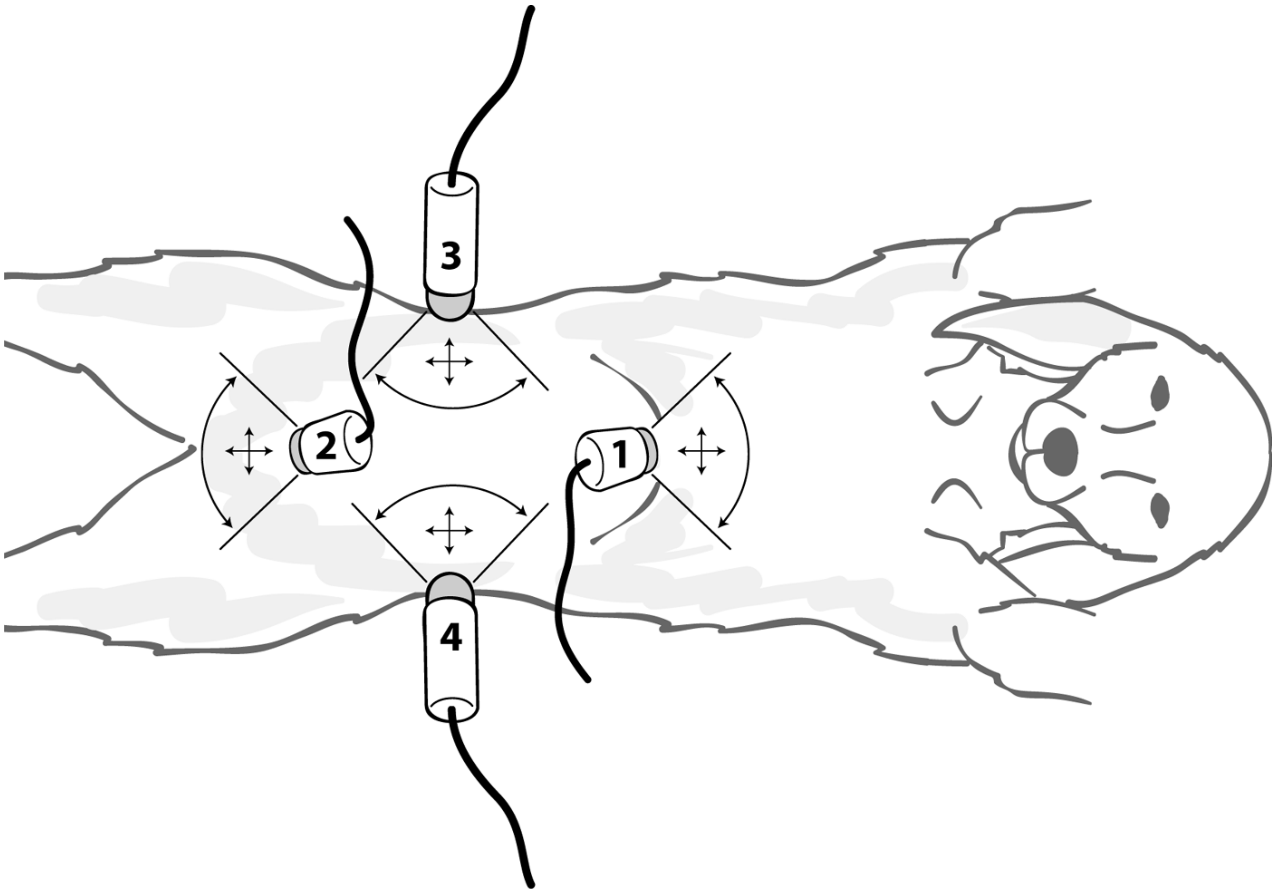
# THINGS NOT TO MISS

- **Learn Focused Assessment with Sonography for Triage (FAST)**
  - Abdominal and thoracic exam
  - Free fluid – chest or abdomen
  - Free Air?  Pneumothorax
  - Easily learned
    - 2 hr training with supervised experience
  - “Is there fluid/air or not ?”

https://fastvet.com/        http://academy.soundvet.com/

# FAST TECHNIQUE

JAVMA, Vol 225, No. 8, October 15, 2004



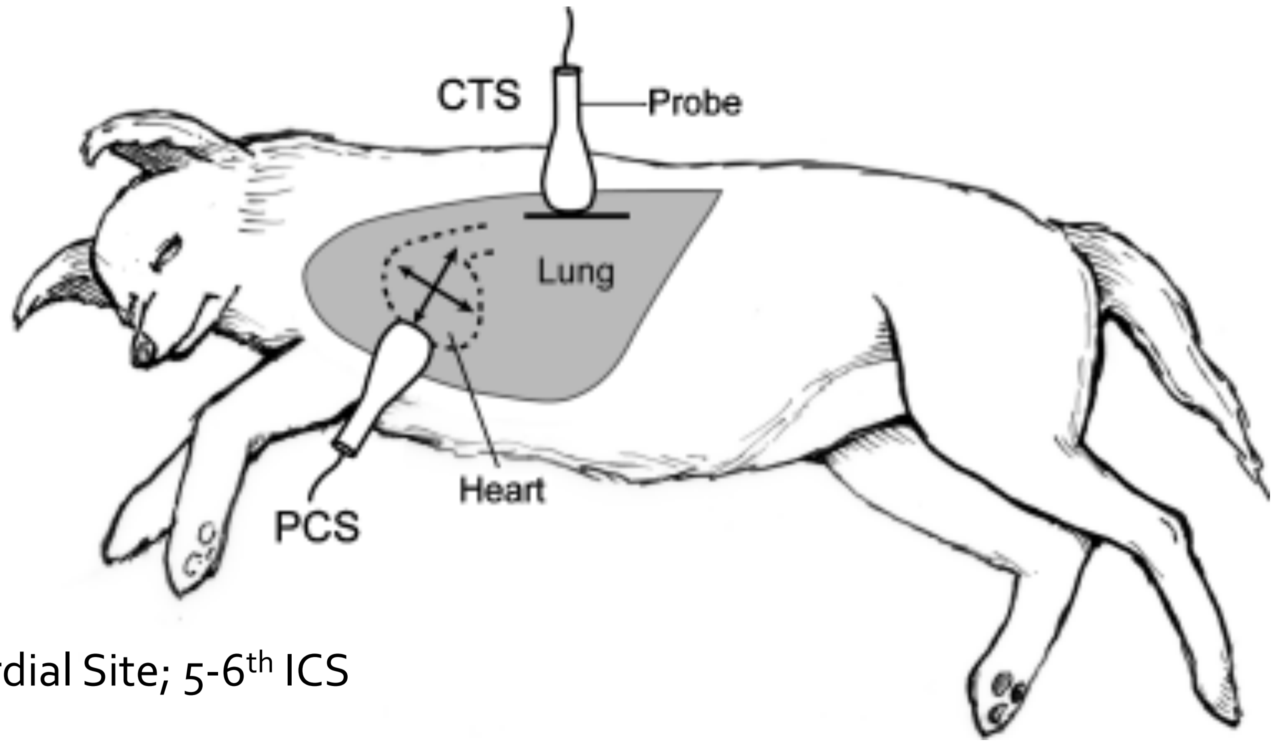
# FAST TECHNIQUE

- Left lateral recumbency (ideally)
- Transverse and longitudinal planes
  - subxiphoid region
  - the midline position over the bladder
  - right  and left flank fan through an angle of 45°
- Long and short axis positions
- Probe moved 1 inch in each of 4 directions (i.e.  cranial, caudal, left, and right)

# TFAST TECHNIQUE

Journal of Veterinary Emergency and Critical Care 18(3) 2008, pp 258–269

Chest Tube Site; 7-9th ICS




Pericardial Site; 5-6th ICS

# TFAST TECHNIQUE

- Bilateral chest tube site (CTS) views and pericardial site (PCS)
- CTS view - US probe is held only horizontally
- in stationary fashion for evaluation of the glide sign
- PCS view - short and long axis views to rule out pleural and pericardial fluid

Journal of Veterinary Emergency and Critical Care 18(3) 2008, pp 258–269

# TFAST TECHNIQUE

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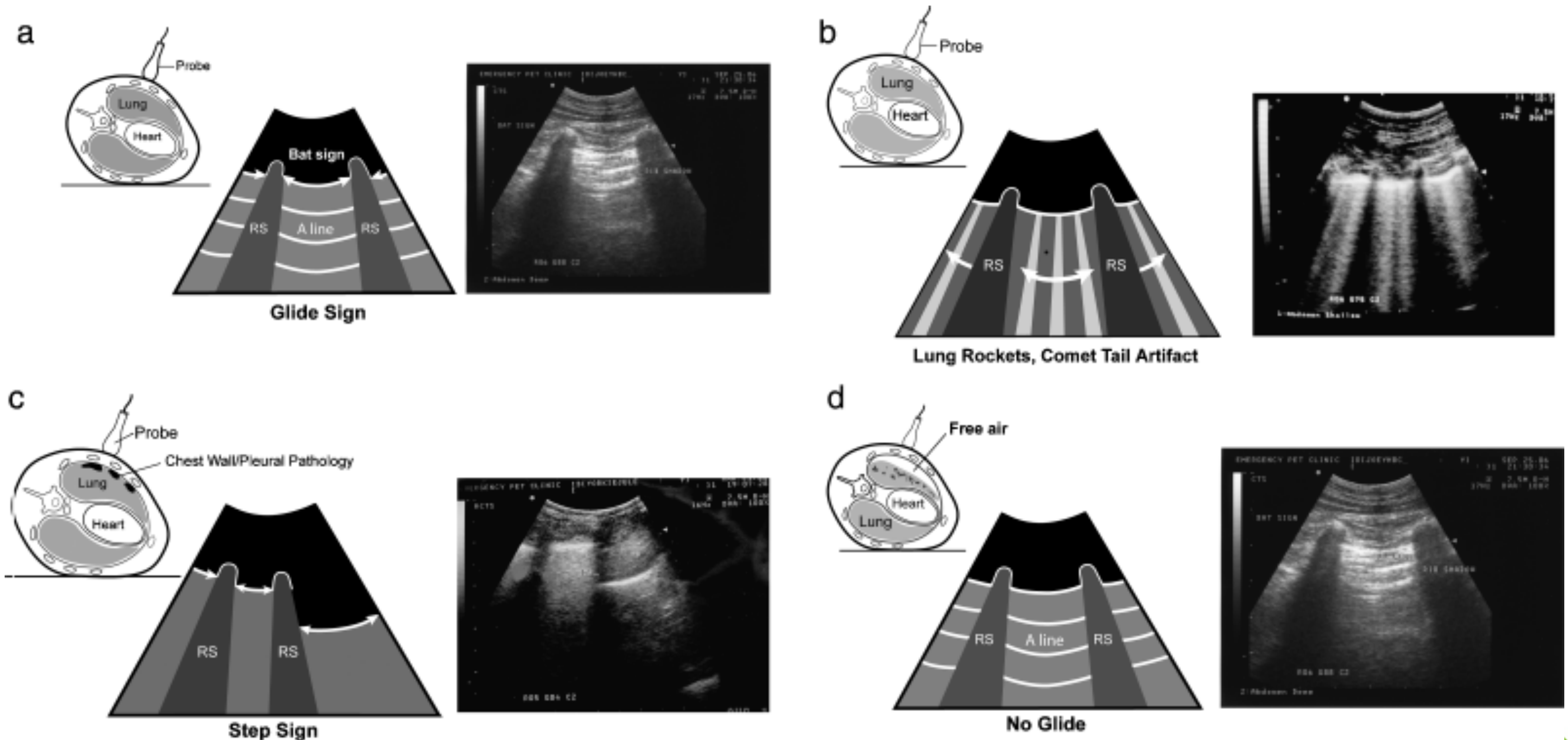


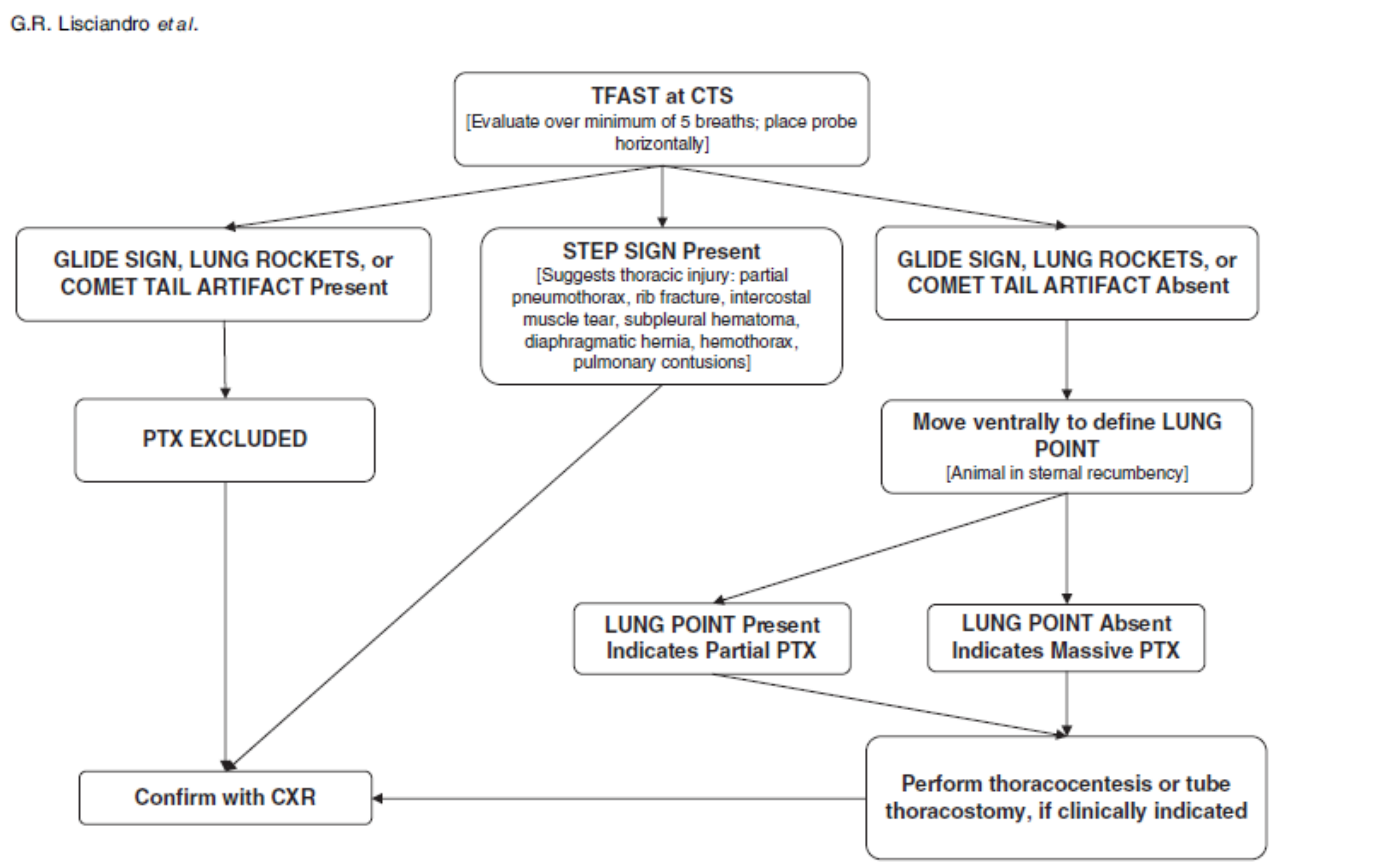
# TFAST INTERPRETATION

- Pneumothorax = NO ‘glide sign,’ defined as the lack of the normal dynamic interface between lung margins gliding along the thoracic wall during respiration.
- Thoracic trauma is diagnosed by the presence of pleural or pericardial fluid or the presence of a ‘step sign,’ defined as an abnormal glide sign

Journal of Veterinary Emergency and Critical Care 18(3) 2008, pp 258–269

# TFAST ALGORITHM

Journal of Veterinary Emergency and Critical Care 18(3) 2008, pp 258–269

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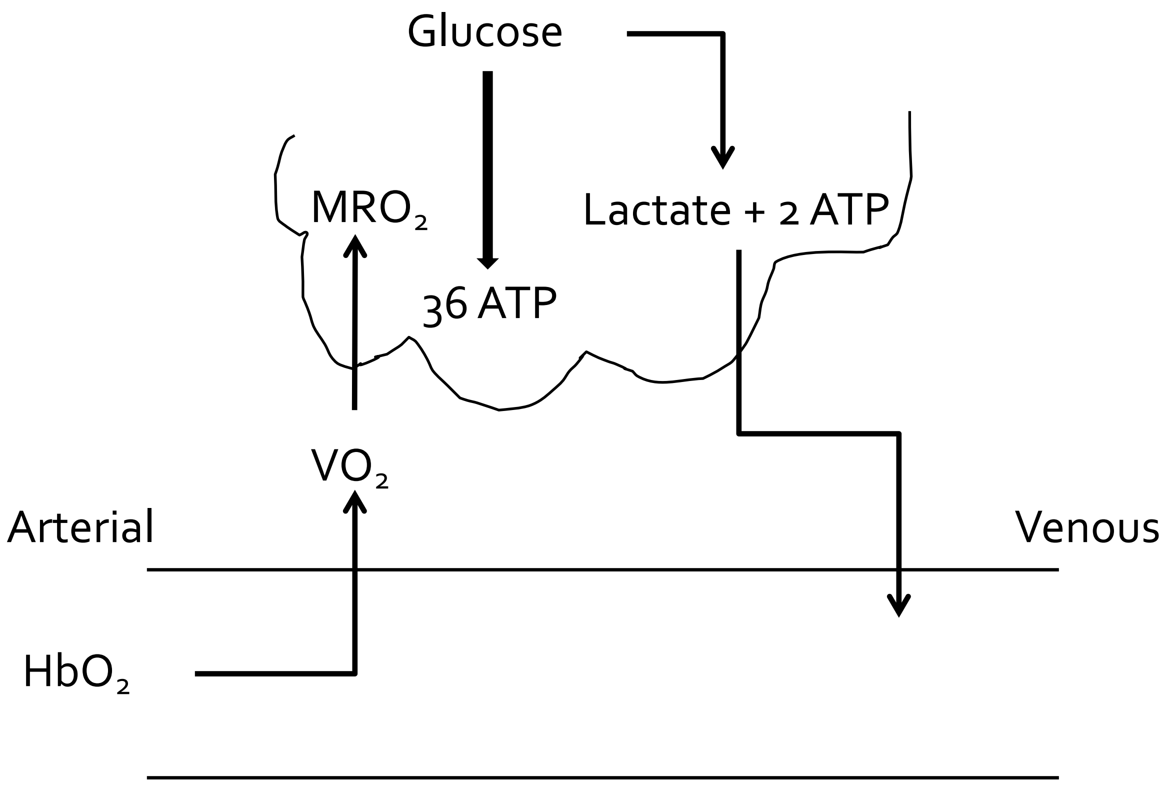
# LACTATE




$VO_2 < MRO_2$ = SHOCK

# LACTATE

- Lactate increases as a consequence of dysoxia
- Directly correlated to survival
- Other sources of lactate
  - Hepatic insufficiency
  - Severe sepsis
  - Intracellular alkalosis

# LACTATE

- Lactate elevations
  - Excess production
  - Decreased utilization
  - Combination

# TISSUE HYPOXIA/HYPOPERFUSION

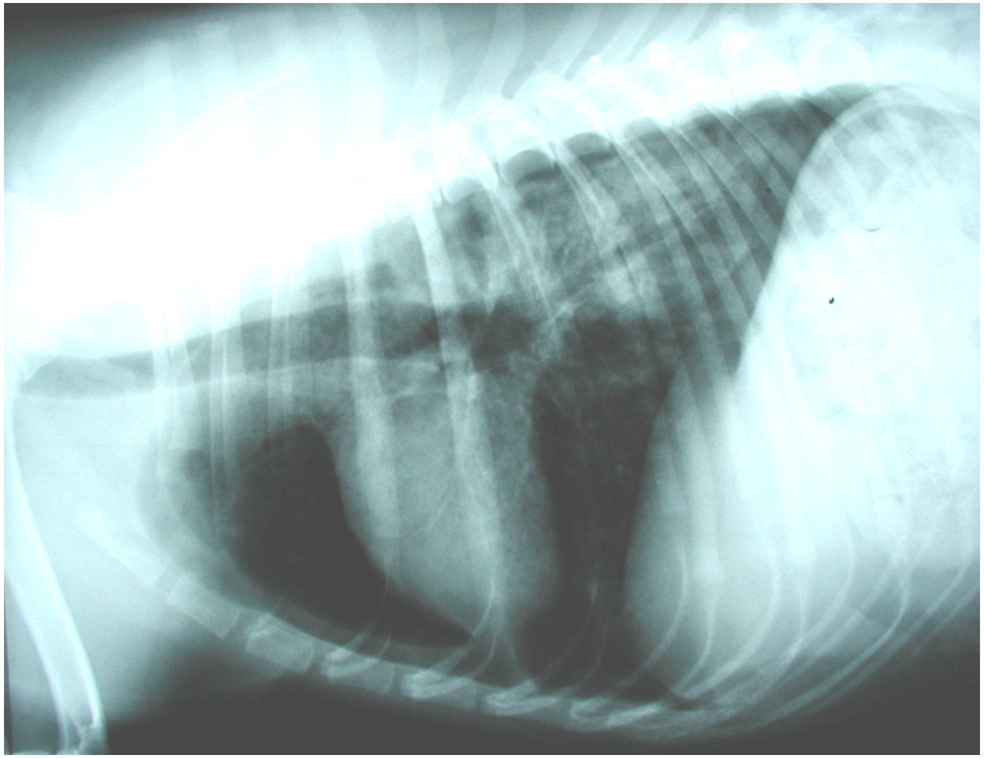
- Most common cause of hyperlactatemia
- Lactate as a marker
  - Good
  - Some limits
    - Type B causes
    - Regional v global
  - Use concurrent perfusion data
    - Not a solo marker
    - Use other clinical data
- Serial measurements

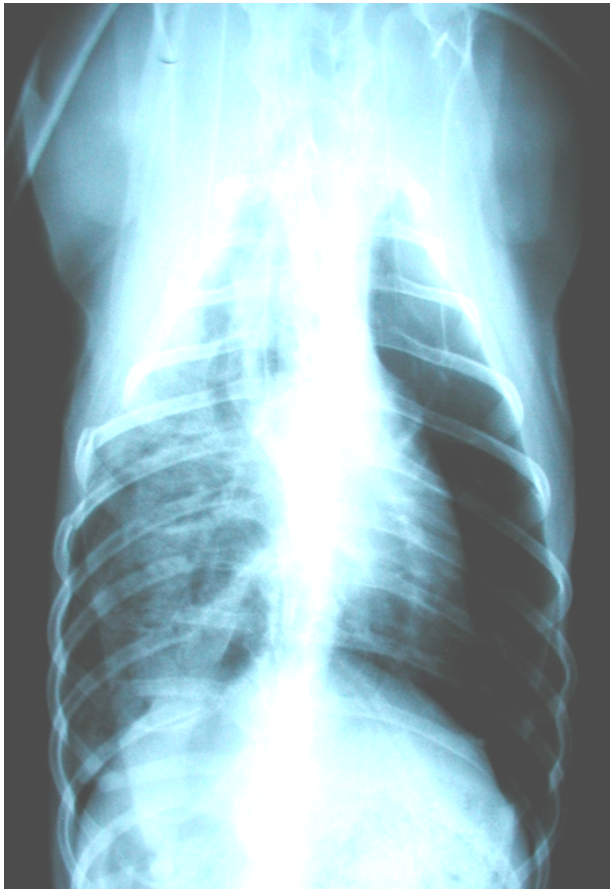
# MONITORS

# CHEST RADIOGRAPHS

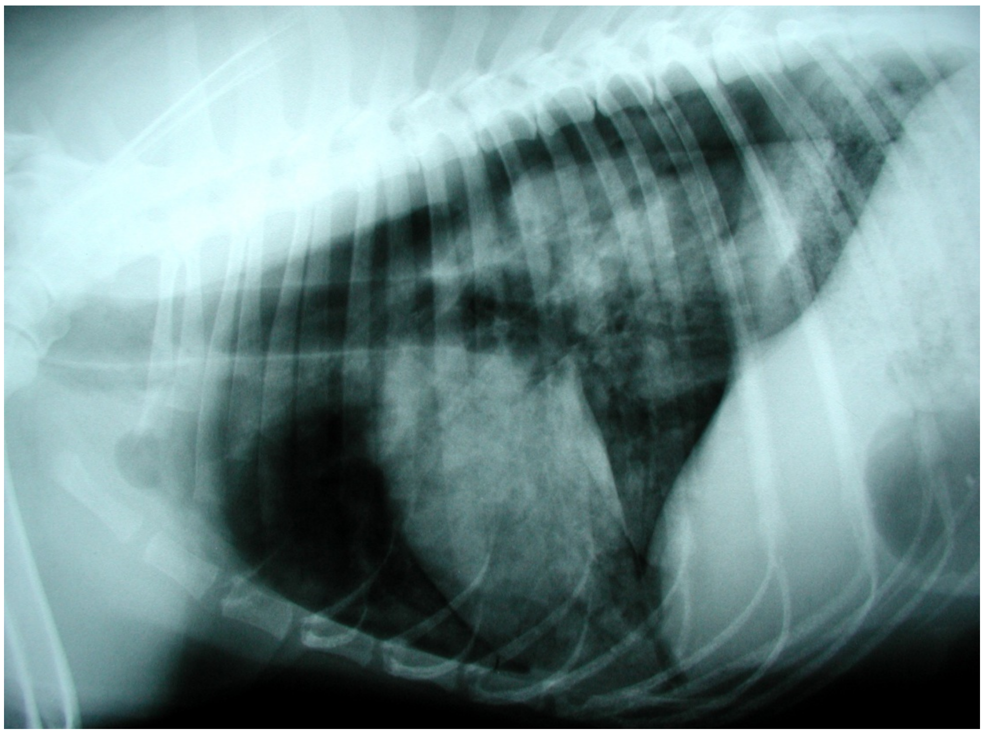
- In all trauma patients
- Rule-out
  - Diaphragmatic hernia
  - Pulmonary contusions
  - Pneumothorax
- Significant contusions
  - Clinically evident
- Change in radiographic findings
  - Little importance

# HBC – PULMONARY CONTUSIONS





# 24 HR POST INJURY



# DO THE LEGS WORK?

- Spinal cord injury
  - Schiff-Sherrington posture
  - Deep Pain?
    - Yes – fair to good PX
    - No – poor to grave PX
- Long bone fractures?
  - Adds to the expense of care

# TRANSFUSION – EARLY AND OFTEN

- Normal PCV in most trauma patients BEFORE injury
- 40% ⟶ 27% PCV in a otherwise healthy dog represents a 30% RBC loss
- Dilution effects
  - Hard to predict
- Transfuse early
  - Avoid playing catch up
- Avoid microvascular hypoperfusion

# TRANSFUSION – EARLY AND OFTEN

- Untreated hemorrhage
  - Poor perfusion
  - Neuroendocrine cascade
    - With or without hypotension
  - Sequential organ failure
- Treatment goals
  - Early, goal directed resuscitation
  - Stay ahead of the curve

# TRANSFUSION – EARLY AND OFTEN

- Dogs
  - Non-type specific OK
- Cats
  - TYPE specific a MUST
  - Cross ideally
- Consider need for plasma
  - Coagulopathic?
  - 1:1 in some cases
  - Not economically feasible in many cases

# OLIGURIA IN TRAUMA PATIENTS

- Inadequate volume resuscitation
- Easy to under-estimate volume requirements
- Serial re-assessment
- Evaluate volume needs first before looking for other things

# SLOW ROLL-OVERS

- Ruptured bladder
  - Imaging
  - Abdominal fluid analysis
- Effusion chemistries
  - Higher potassium and creatinine than serum
- Painful
  - Chemical peritonitis
- Need contrast study to locate site
  - Cystourethrogram or cystogram
  - IVP

# SLOW ROLL-OVERS

- Diaphragmatic hernia
  - Radiographs usually sufficient
- Ultrasound
- Contrast studies
- Exploratory surgery

# SLOW ROLL-OVERS

- Ruptured bladder
  - Repair once patient stable
  - May require abdominal catheter
    - Drain abdomen
    - Divert urine
  - Urinary catheter
- Peritoneal dialysis
- Hyperkalemia
  - Needs to be corrected BEFORE anesthesia

# SLOW ROLL-OVERS

- Diaphragmatic hernia
  - Repair when stable
  - "Timely fashion"
  - Older literature recommended waiting 24hrs
    - Flawed study
    - No need to wait if patient is stable

# DEGLOVING WOUNDS

- Look bad
  - Most heal well
- Good wound management needed
- Judicious debridement once stable
  - Don’t get carried away
  - Let tissue ‘declare’ itself as nonsalavageable
- Wet-to-dry bandage initially
- Non-adherent bandage once granulation bed has formed and wound is ‘clean’.
- Avoid closing the wounds too soon
  - Tension

# YOU CAN'T KEEP A GOOD CAT DOWN

- Fractures
  - Young cats are healing machines
- Pelvic and distal limb fractures can heal when surgery isn't possible

# PROTOCOL DRIVEN THERAPIES

- Trauma protocols
- Improve compliance and outcome
  - Numerous human studies to support
- Establish a list of essentials
- Step-by-step, goal directed
- Helps less experience staff
- Minimize errors
- Good medicine, good practice stewardship

# EXAMPLE – TRAUMA PROTOCOL

Alert senior staff of ETA and case type

Arrival

1) Primary survey + BP
2) Place 2 large ga IVC. Begin crystalloid bolus
3) Collect samples for point of care testing
    1) PCV/TP/BG/Azo/lactate/Lytes
4) IF TP < 6g/dL – FAST exam, source of hemorrhage
5) Resuscitated till HR < 140 bpm
6) Titrated analgesic – pure mu opioids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