POSTOPERATIVE CARE OF THE TRAUMA

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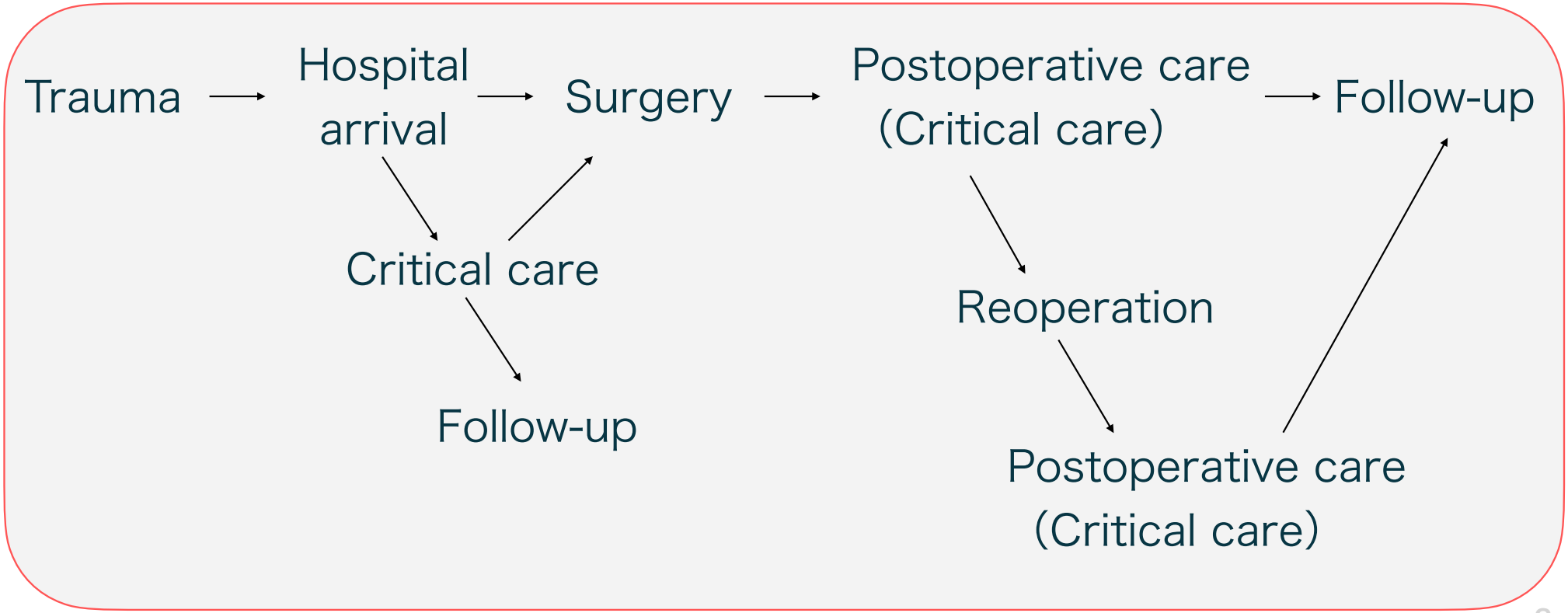
Trauma Management



Trauma Management

Damage Control Strategy

DC0 : pre-hospital

DC1 : abbreviated surgery

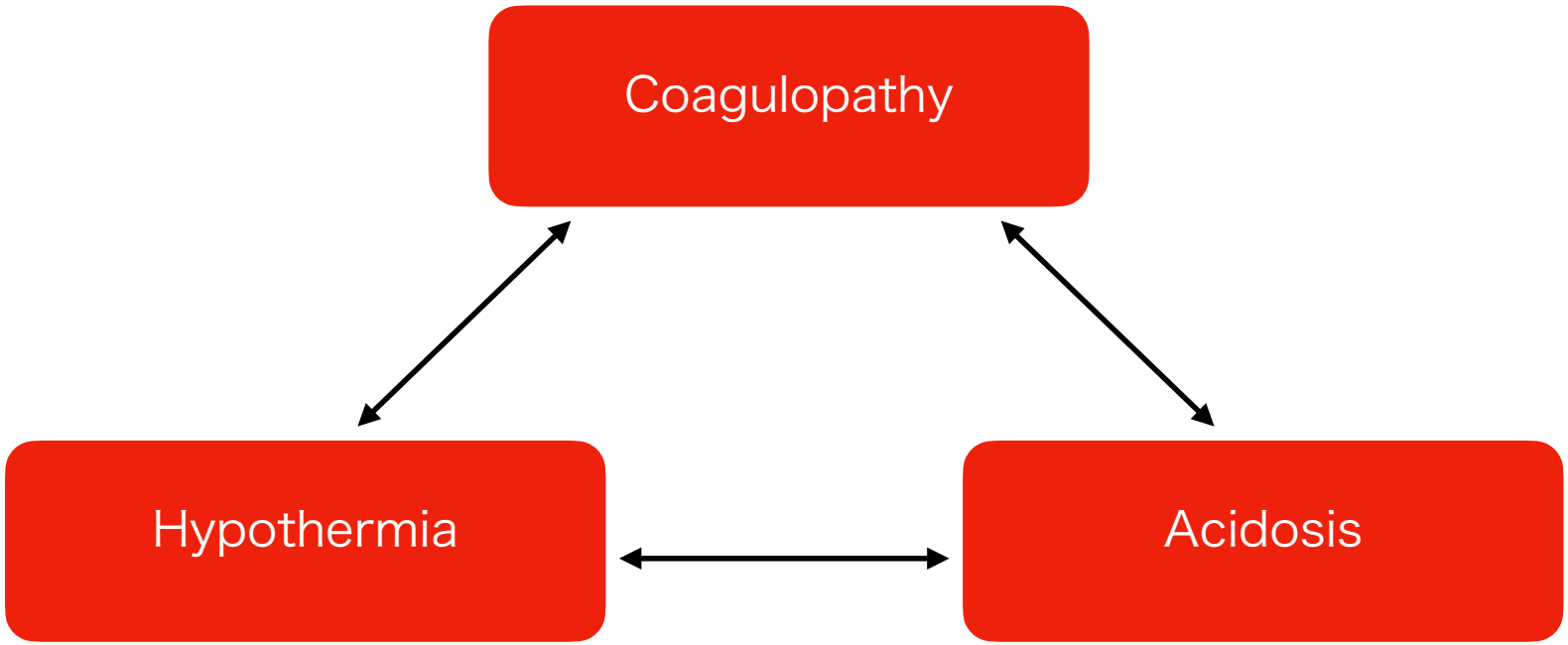
DC2 : critical care

DC3 : planned reoperation

hemostatic resuscitation

permissive hypotension

Trauma Triad of Death



Acidosis

- Metabolic acidosis due to shock
  - Primarily hemorrhagic shock：hemostatic resuscitation
  - Cardiac tamponade, tension pneumothorax：drainage
- Respiratory acidosis due to ventilatory failure
  - Impaired consciousness：mechanical ventilation
  - Pneumothorax, hemothorax：mechanical ventilation, drainage

Postoperative Shock

- Shock persisting from preoperative stage
  →Management of hemorrhagic shock
- Shock due to postoperative rebleeding
  →Management of hemorrhagic shock
- ↑Vascular permeability &↓vascular resistance
  due to trauma and surgical injury（similar to septic shock ）
  → Management according to septic shock

SIRS systemic inflammatory response syndrome

- Triggered by systemic inflammation in response to severe trauma
- Higher mortality rate in trauma patients with SIRS
- Hypotension from ↓vascular resistance and ↑vascular permeability

Ateca et al. J Vet Emerg Crit Care. 2014

- Treatment : fluid resuscitaion+vasopressors +restricted fluid therapy

Vasopressors

- Fluid resuscitation +Vasopressors + Restricted fluid therapy

	Contractility	HR	SVR	BP	Dose
Epinephrine	↑ ↑ ↑	↑ ↑ ↑	↑ ↑ ↑	↑ ↑ ↑	0.05-1 μg/kg/min
Norepinephrine	↑	Variable	↑ ↑ ↑	↑ ↑ ↑	0.05-1 μg/kg/min
Phenylephrine	0	↓	↑ ↑ ↑	↑ ↑ ↑	0.25-5 μg/kg/min
Vasopressin	0	↓	↑ ↑	↑ ↑	0.5-5 mU/kg/min

J Vet Emerg Crit Care. 2015;25(1):48-54 partial modification

Hemostatic Resuscitation

- Hemorrhagic shock：glucose-free crystalloids

  (e.g., Lactated Ringer's or Acetated Ringer's)

- Large volume of extracellular fluid infusion：

  → Cause coagulation disorders, hypothermia, and edema（including pulmonary edema)

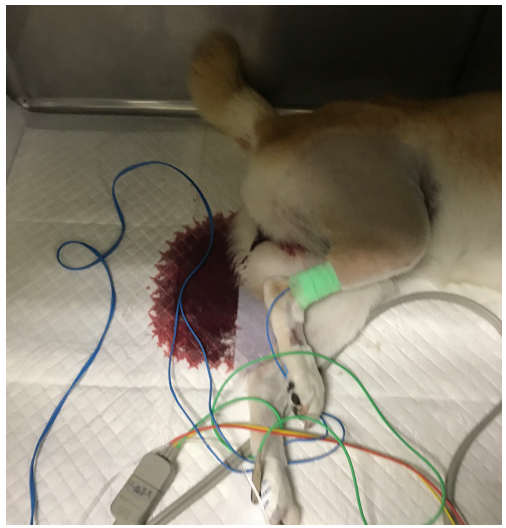
  → Fluid volume should be minimized

- Massive transfusion protocol

  If resistance to initial fluid resuscitation, early blood transfusion is effective

JATEC 外傷初期診療ガイドライン 改訂第6版

Massive Transfusion Protocol



- Red blood cells, platelets, and plasma：

  →pRBC：oxygen delivery

  →platelets, fibrinogen, coagulation factors：hemostasis

  →fluids, albumin, electrolytes：maintain BP

- Not only pRBC, but also FFP and platelets are needed

  (FWB transfusion is also ok)

Increasing the ratio of FFP
achieves effective hemostasis

JAMA. 313, 471-482. 2015

JAVMA, Vol 220, No. 11, June 1, 2002

SMALL ANIMALS/
EXOTIC

Massive transfusion in dogs: 15 cases (1997–2001)

L. Ari Jutkowitz, VMD; Elizabeth A. Rozanski, DVM, DACVIM, DACVECC; Jennifer A. Moreau;
John E. Rush, DVM, MS, DACVIM, DACVECC

- 90 ml/kg within 24 hours or 45 ml/kg within 3 hours
- Abdominal hemorrhage（neoplasia・trauma）, gastrointestinal hemorrhage, GDV, etc
- Mean volume　pRBC 66.5 ml/kg（32-113 ml/kg）
  FFP 22.2 ml/kg（6.5-73 ml/kg）
- Mean transfusion time　8.5 hours　(1-24 hr)

JAVMA, Vol 220, No. 11, June 1, 2002

SMALL ANIMALS/
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- Hypocalcemia (10/10)
- Hypomagnesemia (10/10)
- Hyperkalemia (2/10)
- Thrombocytopenia (5/5)
- PT and aPTT Prolonged (7/10)
- Fever (3)
- Delayed hemolysis (3)
- Vomiting (1)
- Facial swelling (1)

Blood product usage and factors associated with transfusions in cats with hemoperitoneum: 33 cases (2018–2022)

Nicole Bunnell[1], April Blong[2], Debosmita Kundu[2], Jonathan Paul Mochel[2] and Rebecca Walton[2,3]*

frontiers | Frontiers in Veterinary Science

10.3389/fvets.2023.1204864

- Abdominal effusion + PCV effusion ≧ 10%
- Neoplasia, latrogenic(ovariohysterectomy, cytocetesis), liver disease
- Transfusion volume

pRBC 11.8 ml/kg (6-21 ml/kg)

FFP 13 ml/kg (10-15 ml/kg)

FWB 22 ml/kg (19-26 ml/kg)

	Transfusion	Non-transfusion	p value
PCV (%)	20	23	0.32
PCV effusion (%)	20	20	0.91
PLT ($\times 10^3$/ul)	126	135	0.82
Survival	12/16	4/17	0.008

Shock index is positively correlated with acute blood loss and negatively correlated with cardiac output in a canine hemorrhagic shock model

JAVMA | JUNE 2023 | VOL 261 | NO. 6

Charles T. Talbot, BVSc, PGDip, MRCVS[1]; Kristin M. Zersen, DVM, DACVECC[1]; Ann M. Hess, PhD[2]; Kelly E. Hall, DVM, MS, DACVECC[1]*

	Before removal	After removal	p value
Heart rate（bpm）	102 ± 31	121 ± 39	0.32
SBP（mmHg）	96 ± 8	68 ± 20	0.02
Shock index	1.08 ± 0.35	1.9 ± 0.73	0.02
Hb（g/dL）	13.5 ± 2.04	13.61 ± 2.18	0.997
pH	7.24 ± 0.05	7.17 ± 0.09	0.05
Lactate（mmol/L）	1.03 ± 0.59	1.65 ± 0.84	< 0.01

Shock index ≧ 1.43 : 71% accuracy in predicting the need for transfusion

Textbook of small animal emergency medicine

Types of Autologous Transfusion

- Preoperative collection：blood is collected and stored
- Isovolemic hemodilution：blood is collected at the start of surgery
- Cell salvage：intraoperative blood salvage and re-transfusion

・Consider risks of bacterial contamination, hemolysis, and fat contamination

・Presence of tumor cells may increase the risk of dissemination

J Vet Emerg Crit Care. 25, 731-738. 2015

https://www.mera.co.jp/medical/product-info/3197/#

Xenotransfusion

- Dog(donor)　→ Cat（recipient)
- Consider when a cat is likely to die within 6 hours without blood and no feline blood is available J Small Anim Pract. 61, 156-162. 2020
- Only if there is no other option
- Transfused blood cells have a shorter lifespan（1-7days)
- Do not repeat Small Anim Crin. 2, 684-687. 1962

Xenotransfusion

	Xenotransfusion (Dog→Cat)	Allotransfusion (Cat→Cat)	p value
All transfusion reactions	39/105（37.1%）	40/206（19.4%）	0.001
Acute transfusion reactions	8/39（20%）	24/40（60%）	< 0.001
Fever	4/8	17/24	0.28
Transfusion-associated dyspnoea	3/8	12/24	0.54
Vomiting	2/8	0/24	NA
Hypersalivation	1/8	0/24	NA
Delayed hemolytic transfusion	33/39（85%）	17/40（43%）	< 0.001

J Feline Med Surg. 25. 2023

Canine Blood Feline Blood

項目	単位	23/08/28 14:31	23/08/29 14:33	23/08/29 16:33	23/08/30 08:50	23/08/31 08:41	23/09/01 08:35	23/09/01 14:38	23/09/02 08:15	23/09/04 08:59
WBC	K/μL	9.30	10.83	22.22	12.98	10.59	14.26			16.43
RBC	M/μL	8.53	4.85	4.36	5.57	7.16	6.02		6.32	6.38
Hemoglobin	g/dL	11.2	9.2	8.5	9.9	12.2	9.9			9.4
PCV	%	31.8	24.3	22.1	26.4	34.6	27.7		27.5	28.8
MCV	fL	37.3	50.1	50.7	47.4	48.3	46.0			45.1
MCH	pg	13.1	19.0	19.5	17.8	17.0	16.4			14.7
MCHC	g/dL	35.2	37.9	38.5	37.5	35.3	35.7			32.6
Platelets	K/μL	442	174	186	107	119	239			291
T-Bil	mg/dL		0.1		0.1	0.1	0.8	2.1	0.1	0.1

Permissive Hypotension
Restrictive Fluid Resuscitation

- Aggressive fluid therapy may promote bleeding
  → Maintain low BP until hemorrhage is controlled
- Adjust infusion volume to maintain SAP 80-90 mmHg, MAP 50-60 mmHg

J Trauma Acute Care Surg. 78, 687-695. 2015

- For severe head trauma, maintain > MAP 80 mmHg
- Abdominal hemorrhage（dogs）: no significant difference in survival or transfusion rates

J Am Anim Hosp Assoc. 50, 1-8. 2014

Colloids/Hypertonic Saline

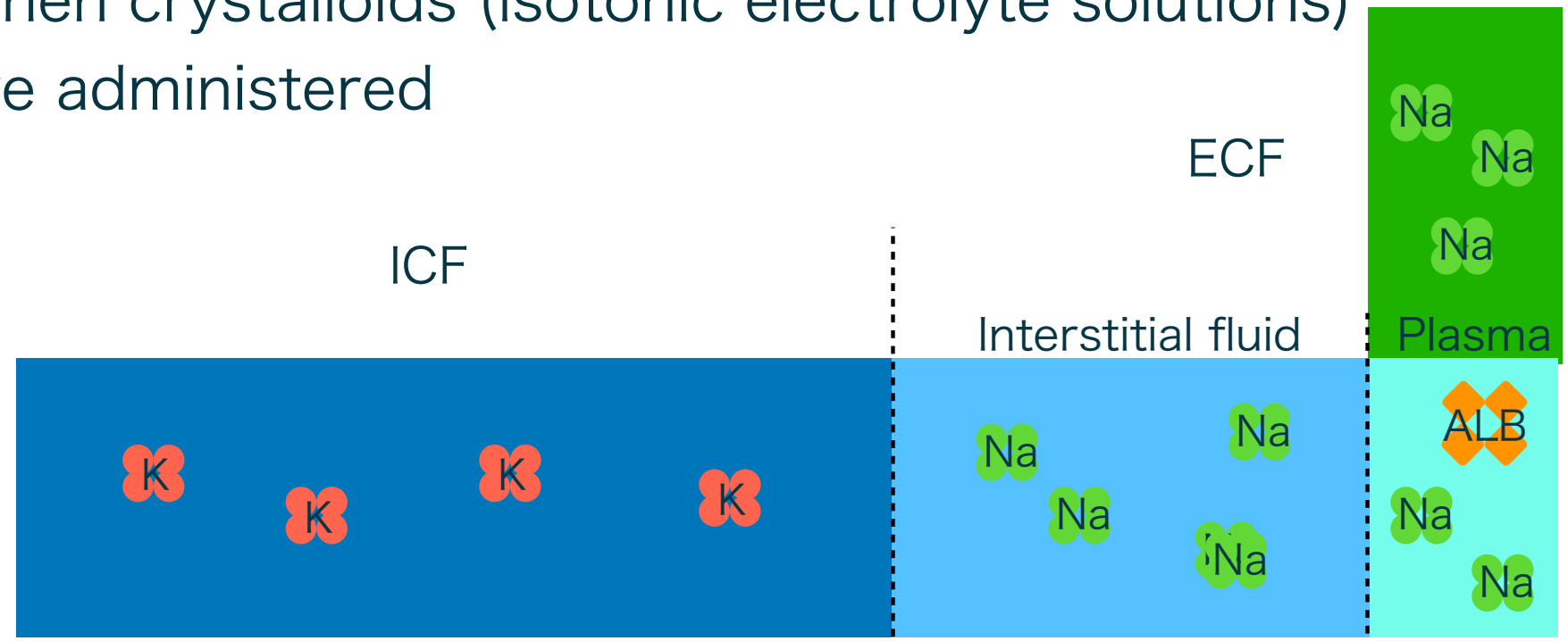
- Colloids：improve the efficiency of blood volume expansion
  - Albumin
  - Synthetic（e.g., Hetastarch ）
  - Fresh frozen plasma（FFP）

Colloids：particle size 1nm - 1μm
Colloids in blood = protein（mainly Albumin）

- Hypertonic saline（7.0 - 7.5%）：
  - Increase osmotic gradient, and pull water from ICF to ECF
  - Reduce intracranial pressure in head trauma patients

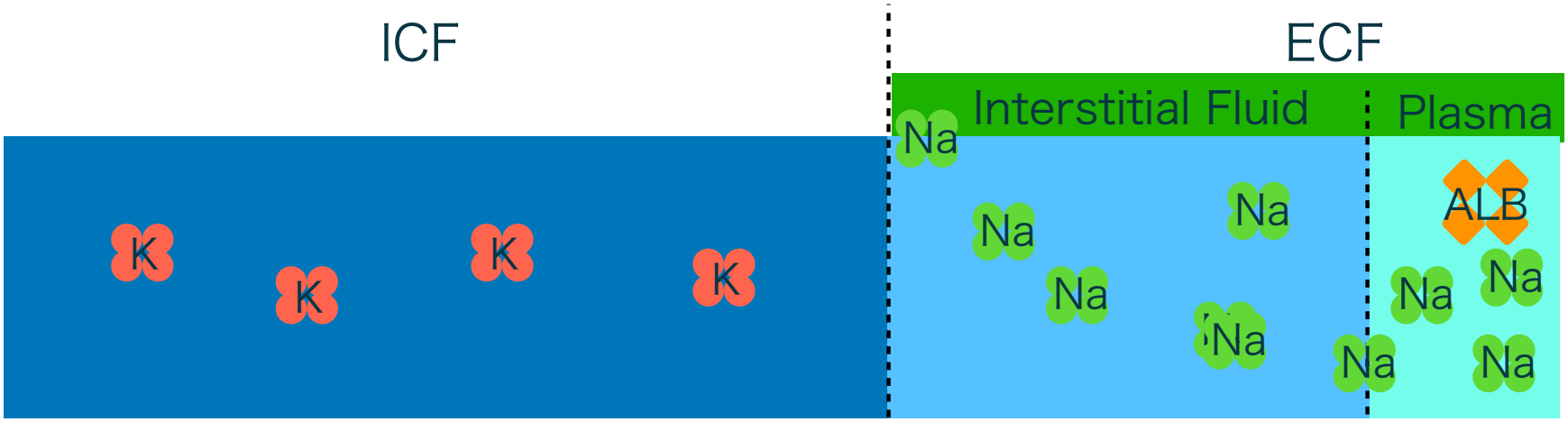
Colloids

When crystalloids (isotonic electrolyte solutions) are administered



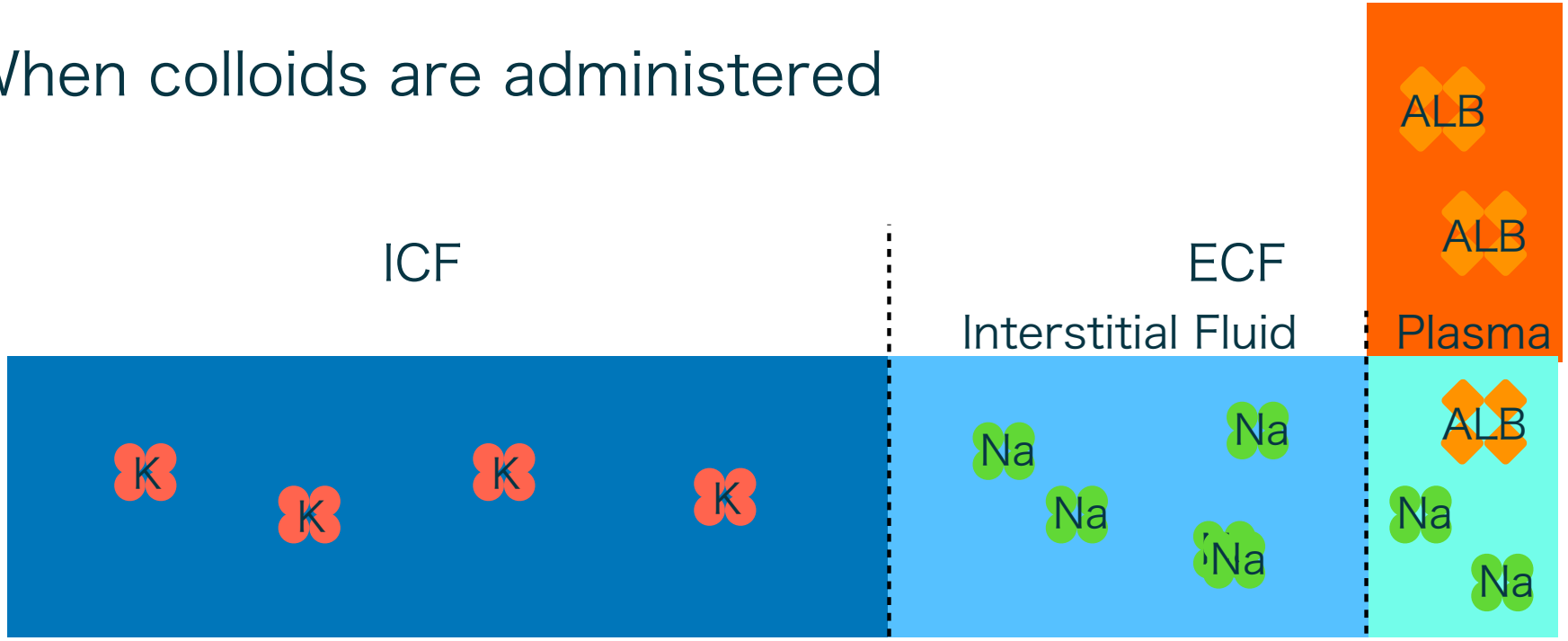
Colloids

When crystalloids (isotonic electrolyte solutions) are administered

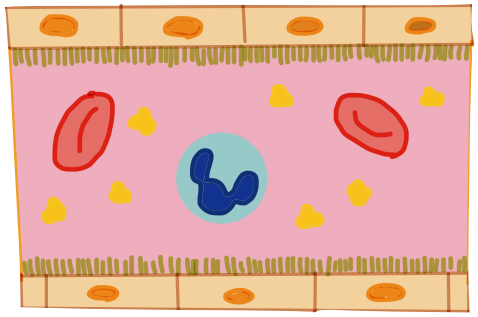


Colloids

When colloids are administered



Glycocalyx Protective Function



Inflammation, fluid overload

↓

Glycocalyx shedding → Vascular leak (water, albumin)

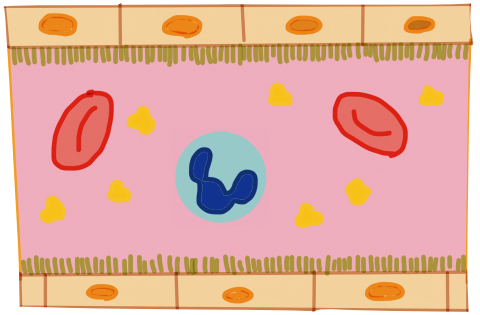
Glycocalyx:

A vascular endothelial lining composed of glycoproteins, glycosaminoglycans, etc.

Functions:

regulate vascular permeability, prevent coagulation, prevent leukocyte adhesion, etc.

Glycocalyx Protective Function



FFP protects the glycocalyx

- FFP reduces glycocalyx degradation products and maintains glycocalyx thickness

Crit Care. 21, 160. 2017

- Plasma albumin and coagulation factors may stabilize the glycocalyx

Shock. 52, 497-505. 2019

Trauma-Associate Coagulopathy

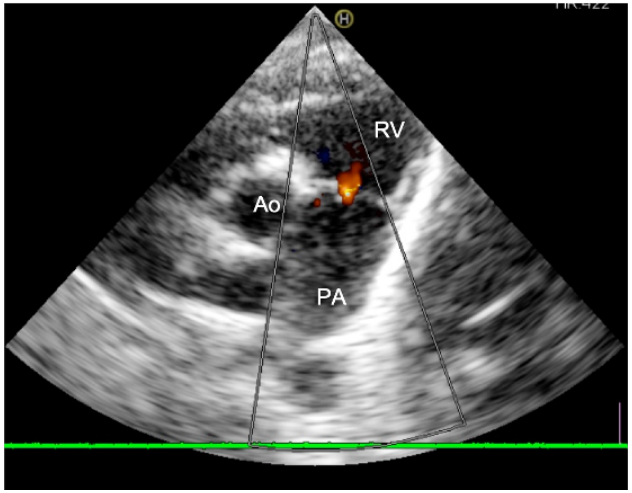
- It depends on the severity and phase of trauma
- In early post-trauma phase, there is a potential for bleeding tendency due to coagulation disorders

  e.g.,activation of tissue factors due to trauma, thrombocytopenia, platelet dysfunction, coagulation factor depletion, acidosis, hypothermia, and dilution from fluid resuscitation（Similar to DIC with fibrinolytic phenotype)
- PT↑, APTT↑, Fibrinogen↓, D-dimer ↑
- Transfusion（Platelets, coagulation factors）, tranexamic acid

J Vet Emerg Crit Care. 32, 791-799. 2022

Trauma-Associate Coagulopathy

- It is crucial to prevent thromboembolism caused by hypercoagulability after surgery
  →Fibrinogen↑, TAT↑, D-dimer↑
- In case of severe inflammation, DIC may occur
  → Risk of MODS
- Anticoagulants:
  e.g., heparin, low molecular weight heparin, DOAC
  (Administer after confirming that there is no risk of bleeding)



EJA

Eur J Anaesthesiol 2017; **34**:332–395

GUIDELINES

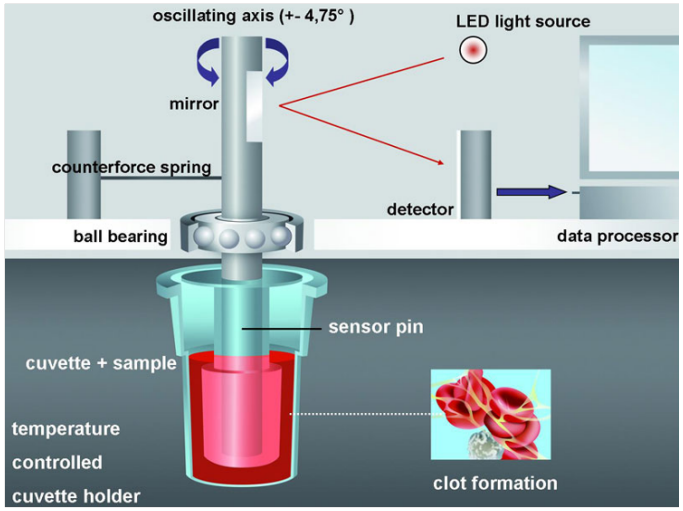
Management of severe perioperative bleeding: guidelines from the European Society of Anaesthesiology

We recommend the application of intervention algorithms incorporating pre-defined triggers and targets based on viscoelastic haemostatic assay (VHA) coagulation monitoring to guide individualised haemostatic intervention in the case of perioperative bleeding. **1C**

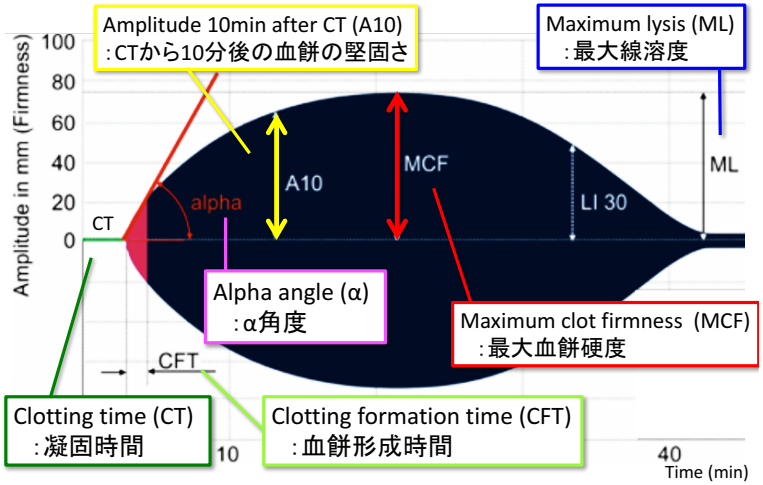
Thromboelastometry : ROTEM

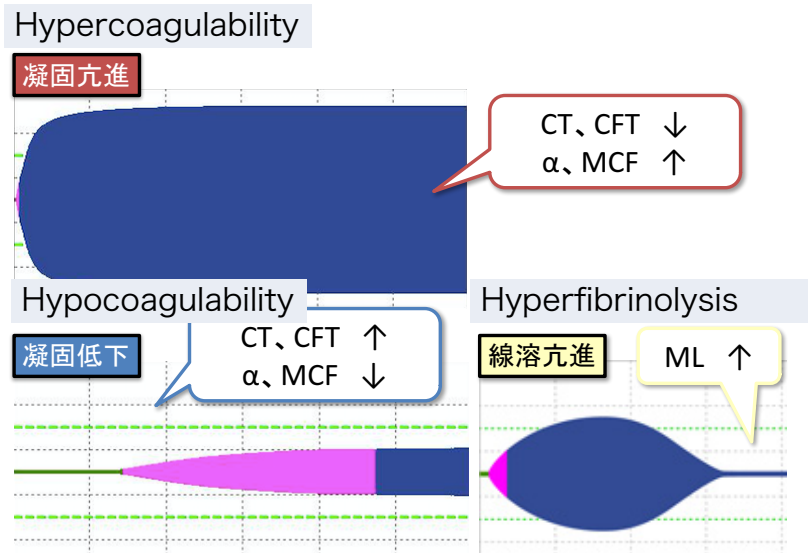
1. Evaluate the interaction between platelets and coagulation factors
2. Measure clot strength
3. Measure the speed of coagulation reaction
4. Fibrinolytic system is also evaluated

- The cuvette is fixed, and the pin is rotated
- As a clot forms and strengthens, the resistance to the pin's rotation increases
- The light reflected off the pin is measured by a detector



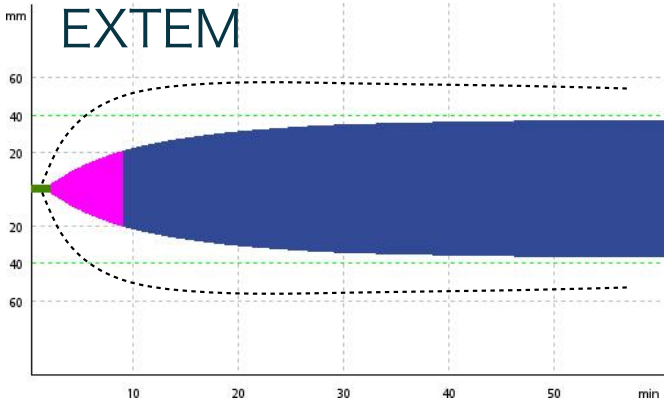
Measuring Principle of ROTEM

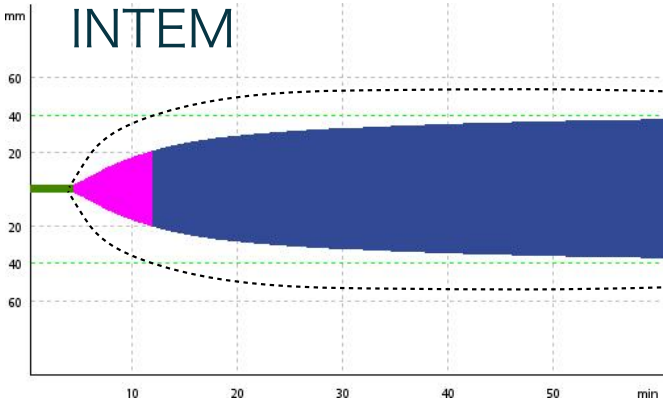




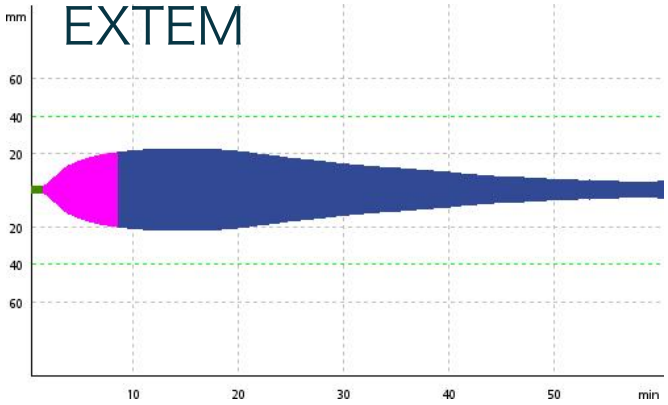
	Used reagent	Investigated area
INTEM	Ellargic acid	Intinsic coagulation pathway
EXTEM	Tissue factor	Extrinsic coagulation pathway

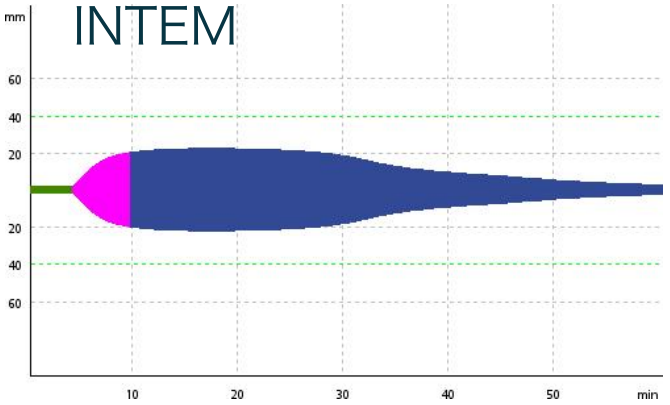
Hemorrhage of the splenic tumor





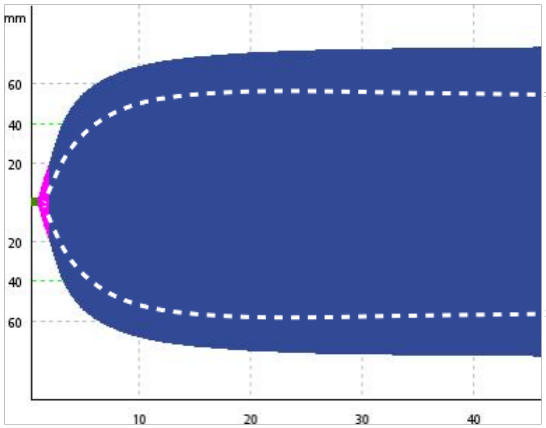
Subcutaneous hematoma, purpura



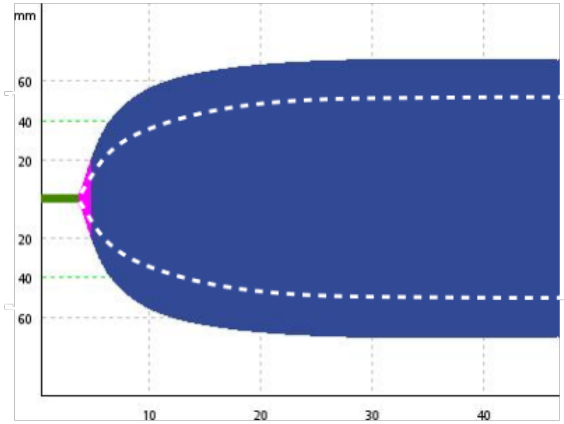


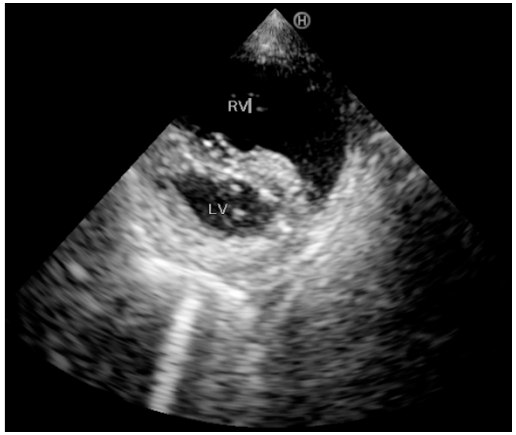
Post pulmonary lobectomy

EXTEM



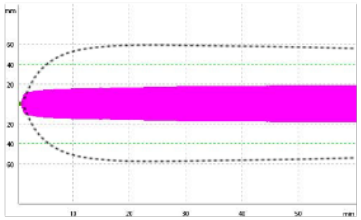
INTEM

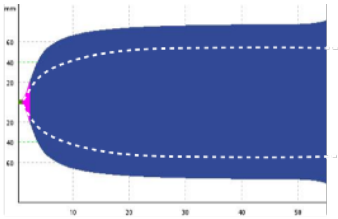




	Reference Range	Onset	Post 4 days	Post 7 days
PT (sec)	7.4-8.8	9.1	7.4	7.5
APTT (sec)	12.0-28.0	25.3	21.9	19.9
Fib (mg/dl)	113-385	81	>650	492
D-dimer (μg/ml)	<1.0	>40	28	22
TAT (ng/ml)	<0.2	15.1	6.3	2.7
PLT (K/μl)	200-500	8.2	227	418

EXTEM





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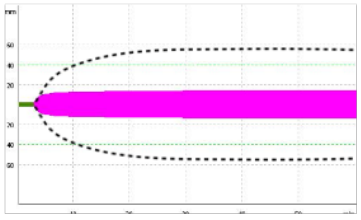
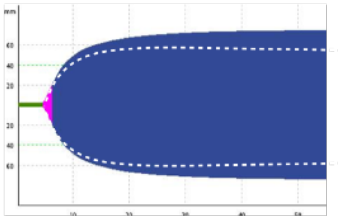


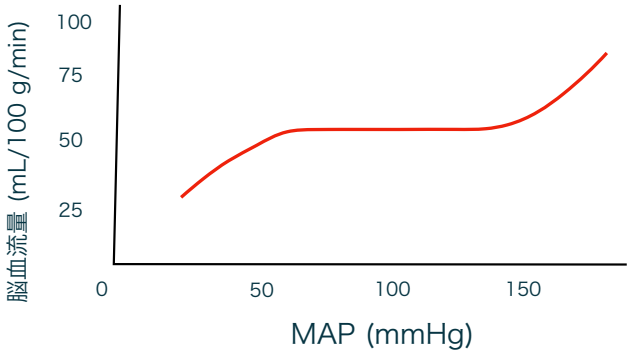


Postoperative Injury or Injury Discovered after Surgery

- Cranial：increased intracranial hemorrhage
- Thoracic：increased hemothorax, pneumothorax, diaphragmatic hernia
- Abdomen：increased intra-abdominal hemorrhage,

  gastrointestinal injury, biliary tract injury, urinary tract injury
- Other：spinal cord injury

Blood Pressure Management in Intracranial Hemorrhage



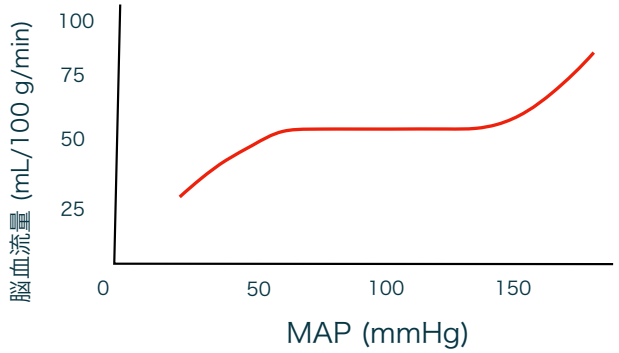
Cerebral perfusion pressure(CPP)

= Mean arterial pressure(MAP) – Intracranial pressure(ICP)

- In case of intracranial hemorrhage with elevated ICP, managing BP is crucial to maintain CPP
- Slightly high blood pressure is recommended： SAP ≧ 110 mmHg, MAP ≧ 90 mmHg

  Guideline of the Management of Severe Brain Traumatic Injury 4th edition
- Within the range of auto-regulation, high blood pressure reduces ICP

Blood Pressure Management in Intracranial Hemorrhage



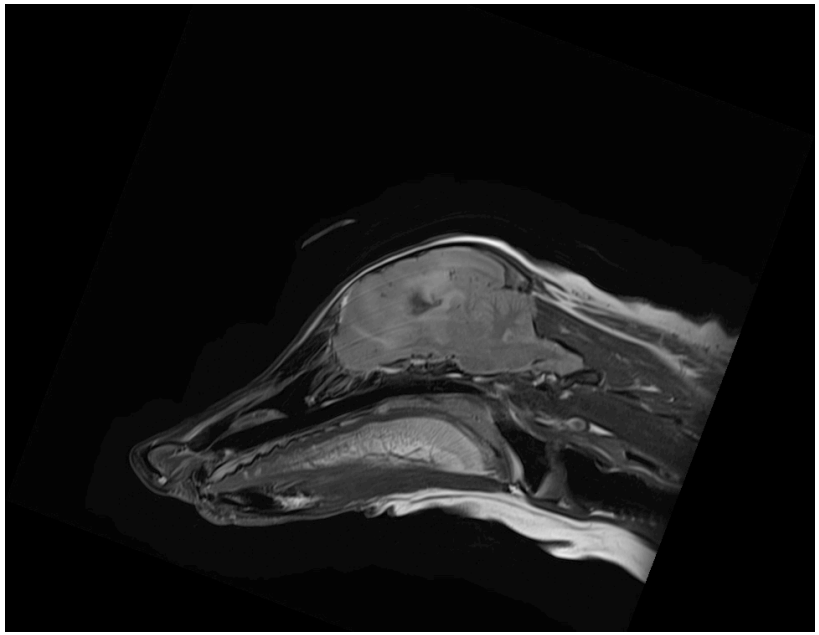
Cerebral perfusion pressure(CPP)

= Mean arterial pressure(MAP) – Intracranial pressure(ICP)

- Excessive hypertension：increase ICP（↑cerebral blood flow），promote bleeding
- Excessive hypertension may sometimes require antihypertensive treatment

→Also helps reduce ICP：sedation, analgesia, osmotic diuresis, mild hyperventilation

Blood Pressure Management in Intracranial Hemorrhage

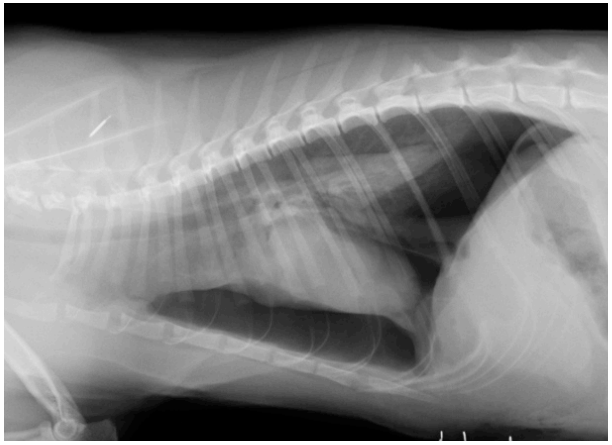


Blood Pressure Management in Intracranial Hemorrhage; Antihypertensive Treatment

Indication	Drug	Dose	Comments
Sedation	Propofol	3 - 15 mg/kg/hr	Adjust based on the level of sedation
	Midazolam	0.1 - 0.5 mg/kg/hr	Alone or in combination with propofol
Analgesia	Fentanyl	2-5 μg/kg/hr	1-3 μg/kg iv followed by CRI
Blood pressure reduction	Nicardipine	0.2 - 5 μg/kg/min	No clinical data for dogs and cats Caution for tachycardia
	Diltiazem	2 - 6 μg/kg/min	0.1-0.2 mg/kg iv followed by CRI Caution for cardiac suppression
	Nitroprusside	0.5 - 10 μg/kg/min	Caution for tachycardia
Intracranial pressure reduction	Mannitol	1.0 - 2.0 g/kg	CRI over 30 minutes Cause a rebound
	Glycerol	0.5 - 2.0 g/kg	CRI over 30 minutes

Tension Pneumothorax

- Air evacuation via chest tube
  →intermittent or continuous suction if needed
- Surgery may be needed if drainage cannot keep up or if air leakage persists for more than a few days
- Not a surgical candidate： difficult to identify the leak site, multiple pulmonary lesions
- Blood patching



Textbook of Small Animal Emergency Medicine
Veterinary surgery small animal 2nd ed
Moloney, et al., J Vet Intern Med. 2022;1–6.

Continuous Suction（chest tube)

- When frequent drainage is necessary
- Negative pressure 5 -15 cmH_2O
  (Max 20 cmH_2O)

Small Animal Surgery fifth ed

Textbook of Small Animal Emergency Medicine