Traumacology: Pharmacology in Trauma

Krysta Baack, PharmD, BCPS, BCEMP
Pharmacy Program Coordinator, Toxicology/Emergency Medicine

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Nebraska Medicine

Objectives

1. Identify commonly used medications for traumatically injured patients.

2. Develop medication treatment plans for traumatically injured patients.

Primary Survey

- Airway
- Breathing
- Circulation
- Disability
- Exposure

Secondary Survey

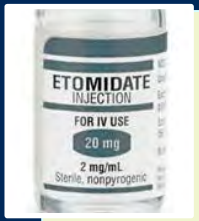
- Analgesia
- Antibiotics
- Tetanus vaccination
- Disease-specific medications (i.e., traumatic brain injury, hemostatic agents, reversal medication(s), etc.)

Pretreatment Medications

			
Push-Dose Pressors Prevents/treats hypotension prior to RSI	**Atropine** Prevents bradycardia in pediatric intubations (no longer routinely recommended)	**Lidocaine** Suppresses cough reflex to mitigate increase in ICP (no longer routinely recommended)	**Fentanyl** Blunts release of catecholamines limiting increase in BP and ICP

Lexi-Drugs. Accessed May 20, 2025.

Induction Agents



Etomidate

- Dose: 0.3 mg/kg IVP
- Onset: 10-15 sec | Duration: 4-10 min
- Hemodynamically neutral – considered gold standard for induction
- Minimal effect on ICP – shown to decrease cerebral blood flow and cerebral metabolic demand, while preserving cerebral perfusion pressure

Midazolam

- Dose: 0.2-0.3 mg/kg IVP (Rarely used on its own due to large dose requirements)
- Onset: 1-5 min | Duration: 30-45 min, full recovery 2-6 hours (clearance reduced in setting of liver dysfunction)
- May be used if intubating a seizing patient
- Large doses normally cause hypotension

Ketamine

- Dose: 1-2 mg/kg IV (slow push over 1-2 min)
- Onset: 30-60 sec | Duration: 1-2 hours
- Relaxes bronchial smooth muscles therefore may be preferred in intubations in patients with reactive airway disease
- Can cause hyper- or hypotension (dependent on catecholamine stores)

Propofol

- Dose: 1-2 mg/kg IVP
- Onset: 30-60 sec | Duration: 2-10 min (the longer the infusion has been running, the slower the time to awakening is)
- Causes bronchodilation, myocardial depression, hypotension, and reduction in cerebral perfusion pressure
- Due to the profound hypotension seen with the dosing requirements needed, limits its use as an induction agent

Lexi-Drugs. Accessed May 20, 2025.

Paralytic Agents

Succinylcholine

- Depolarizing NMBA (contraindicated with FH of malignant hyperthermia)
- Dose: 1-2 mg/kg IVP
- Onset: 30-60 sec | Duration: 4-6 min
- Increases K by ~0.5 mmol/L (caution in renal failure)

Rocuronium

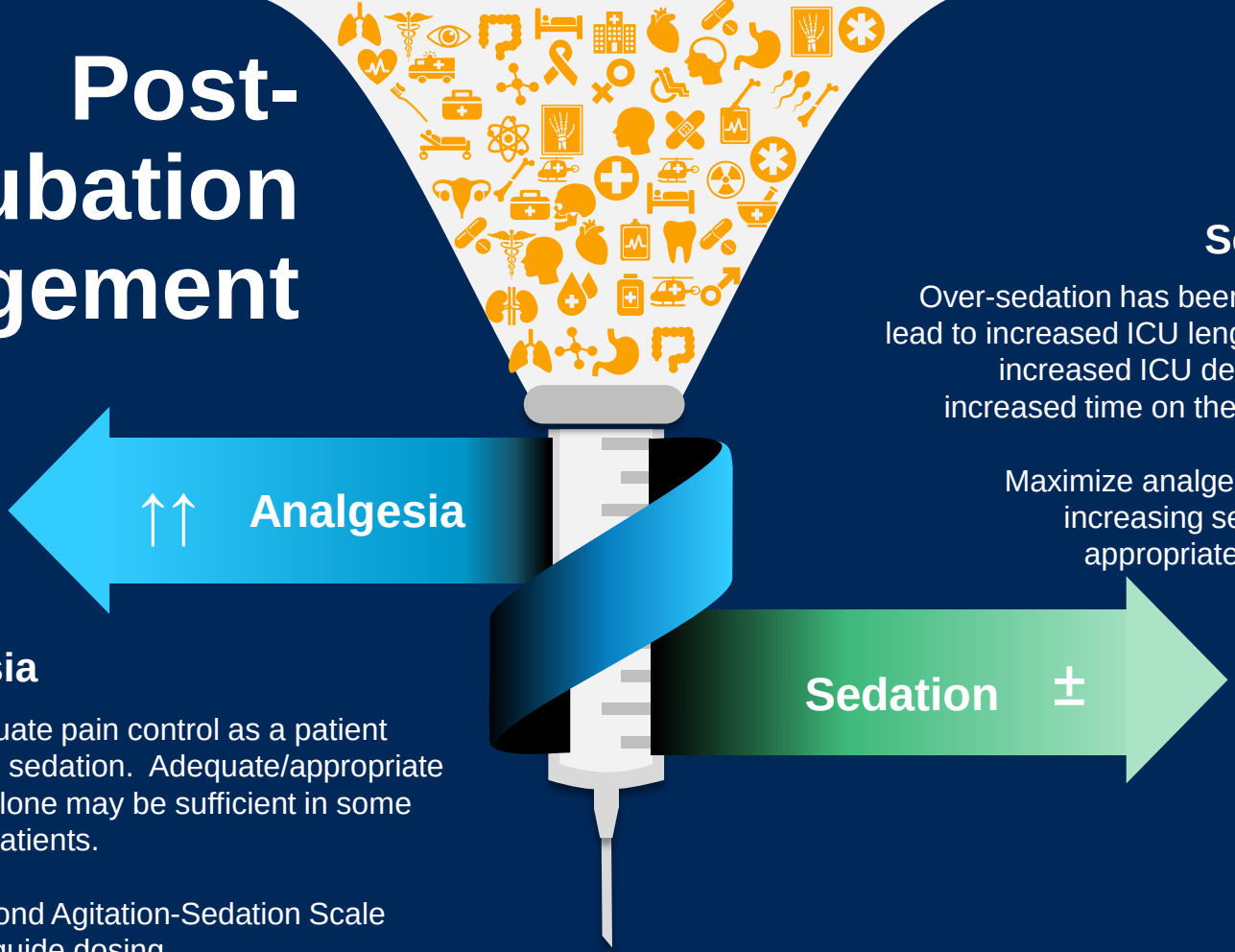
- Non-depolarizing NMBA
- Dose: 0.6-1.2 mg/kg IVP
- Onset: 1-3 min | Duration: 30-60 min

Vecuronium

- Non-depolarizing NMBA
- Dose: 0.1 mg/kg IVP
- Onset: 30-60 sec | Duration: 30-60 min
- Must be reconstituted with 10mL of sterile water

Lexi-Drugs. Accessed May 20, 2025.
Pharmacotherapy. 2016 Jan;36(1):57-63.

Post-Intubation Management



Sedation

Over-sedation has been shown to lead to increased ICU length of stay, increased ICU delirium, and increased time on the ventilator.

Maximize analgesia prior to increasing sedation, as appropriate/available.

Analgesia

Need adequate pain control as a patient wakes from sedation. Adequate/appropriate analgesia alone may be sufficient in some ventilated patients.

Use Richmond Agitation-Sedation Scale (RASS) to guide dosing.

Am J Health Syst Pharm. 2013 Sept;1;70(17):1513-7.
Crit Care Med. 2018 Sep;46(9):e825-e873.

Post-Intubation Management

Drug	Adult Continuous Infusion Dose	Adult Bolus Dose	Analgesic Properties	Ideal For	Caution In	Premade Available
Fentanyl	25-200 mcg/hr	25-100 mcg	✓	First line agent at NM for most patients	Recent dose of naloxone	?
Propofol	5-80 mcg/kg/min	20mg 0.5-1 mg/kg	✗	Hypertensive patient, TBI	Hypotension	✓
Ketamine	0.1-0.5 mg/kg/hr	0.1-0.3 mg/kg	✓	Reactive airway disease	Significant cardiac history (catecholamine depleted)	✗
Dexmedetomidine	0-1 mcg/kg/hr	NO	✗	Failure of ventilator weaning due to agitation, alcohol withdrawal not responsive to DT protocol	Bradycardia or heart block, EF <30%, high sedative needs, receiving concurrent NMB	✓
Midazolam	1-10 mg/hr	1-3 mg	✗	Status epilepticus, alcohol withdrawal, hypotension	Attempt to avoid due to higher level of sedation and long duration of action	?
Lorazepam	NA	1-3 mg	✗	Status epilepticus, alcohol withdrawal, hypotension	Attempt to avoid due to higher level of sedation and long duration of action	✗

Lexi-Drugs. Accessed May 20, 2025.

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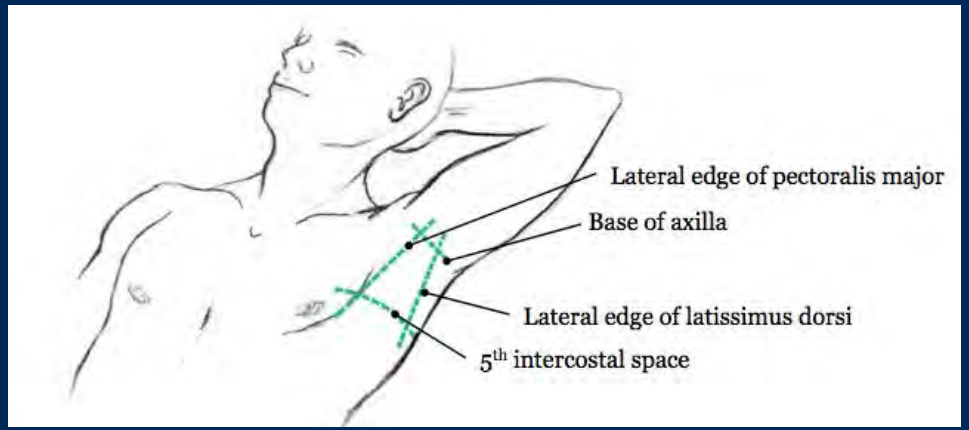
Secondary Survey

Breathing

Chest Tube Placement



Local Anesthetic
- Lidocaine
- Bupivacaine

Anxiolytics
- Midazolam
- Lorazepam

Analgesia
- Fentanyl
- Hydromorphone

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Secondary Survey

Hemostatic Resuscitation

How much fluid to give?

Which type of crystalloid should be given?

Use warmed fluids (crystalloid or blood) to prevent hypothermia

Lactated Ringers	Normal Saline
• Potential for metabolic alkalosis (lactate metabolism regenerates into bicarbonate)	• Potential for non-anion gap hyperchloremic metabolic acidosis (high chloride content)

Early use of blood products vs. large volume of crystalloids
(minimize metabolic derangements, resuscitation-induced coagulopathy, and hemodilution)

N Engl J Med. 1999 Feb 11;340(6):409-17

Composition of IV Fluids

Components (mEq/L)	Normal Saline (NS)	Lactated Ringers (LR)
Sodium	154	130
Chloride	154	109
Potassium	None	4
Calcium	None	2.7
Magnesium	None	None
Lactate	None	28
pH	5.0	6.5

N Engl J Med. 2018 Feb 27; 378:829-839.

Brain Injury

- Brain injured patients (including traumatic brain injury, subarachnoid hemorrhage, and intraparenchymal hemorrhage) should not receive hypotonic fluids because of the risk of cerebral edema
- Therefore, normal saline is preferrable over lactated ringers for brain-injured patients

Burns

Given the pathophysiology of burn injury, patients with burn injury are at risk of hypovolemic shock and potentially an element of distributive shock during the first 12–24 hours post-injury. Resuscitation using intravenous fluids is typically warranted for both adult and pediatric patients with injuries of at least 15% TBSA

The ideal burn resuscitation is the one that effectively restores plasma volume, with no adverse effects. Isotonic crystalloids, hypertonic solutions and colloids have been used for this purpose, but every solution has its advantages and disadvantages.

- None of them is ideal, and none is superior to any of the others.

Brit J Anesth 2016; 117(3): 284-96.

Initial Resuscitation Requirements for Adult Patients with Burn Injury

Formula	Choice of Fluid	Calculation
Modified Parkland	Lactated Ringers	2-4 mL/kg/%TBSA burned: ½ given over 1st 8 hrs, remainder over following 16 hrs
	Colloid	(Original Parkland included colloids, no longer recommended)
Brooke	Lactated Ringers	1.5 mL/kg/%TBSA burned over 24 hrs
	Colloid	0.5 mL/kg/%TBSA burned over 24 hrs
Modified Brooke	Lactated Ringers	2 mL/kg/%TBSA burned, ½ given over 1st 8 hrs, remainder given over following 16 hrs
	Colloid	None
Slater	Lactated Ringers	2 L over 24 hrs (i.e., 83 mL/hr), without titration
	Fresh Frozen Plasma	75 mL/hr x 36 hrs, titrated to maintain urinary output goal
Evans	Normal Saline	1 mL/kg/%TBSA burned over 24 hrs
	Colloid	1 mL/kg/%TBSA burned over 24 hrs

Brit J Anesth 2016; 117(3): 284-96.

Commonly Used Vasopressor Agents

Vasoactive Agent	Alpha-1 Vasculature Constriction	Beta-1 Myocardium Chronotropy, iontropy	Beta-2 Pulmonary Bronchodilation	Dopamine Vasculature and kidney Dilation	Vasopressin-1 Vasculature Constriction	SVR/MAP	CO/HR
							
Dopamine	+++	++++	++	+++++	0	Dose dependent Low dose ↔ Mid-High dose ↑	Dose dependent Low-mid dose ↑ High dose ↔/↓
Epinephrine	+++++	++++	+++	0	0	↑	↑
Norepinephrine	+++++	+++	++	0	0	↑	↔
Phenylephrine	+++++	0	0	0	0	↑	↔/↓
Vasopressin	0	0	0	0	+++++	↑	↔

0 = no significant receptor activity

+ through +++++ = minimal to maximal receptor activity

Lexi-Drugs. Accessed May 20, 2025.

Commonly Used Vasopressor Agents

Vasoactive Agent	Standard Concentration	Typical Starting Dose	Titration Parameters	Max Dose
Dopamine	200mg/250mL	5 mcg/kg/min	↑ 2 mcg/kg/min Q10min	20 mcg/kg/min
Epinephrine	4mg/250mL	1 mcg/min (non-weight-based dosing)	↑ by ~1 mcg/min Q10min	30 mcg/min (soft max)
Norepinephrine	4mg/250mL	5 mcg/min (non-weight-based dosing)	↑ by ~4 mcg/min Q10min	30 mcg/min (soft max)
Phenylephrine	20mg/250mL	50 mcg/min	↑ by 50 mcg/kg/min Q5min	150 mcg/min
Vasopressin	20units/100mL	0.03 units/min	None	0.04 units/min

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Secondary Survey

Mental Status Assessment

Glasgow Comma Scale

15

3

Eyes	Verbal	Motor
		
(+4) Spontaneous	(+5) Oriented	(+6) Obeys commands
(+3) To sound	(+4) Confused	(+5) Localizing
(+2) To pressure	(+3) Words	(+4) Normal flexion
(+1) None	(+2) Sounds	(+3) Abnormal flexion
	(+1) None	(+2) Extension
		(+1) None

Seizure Prophylaxis Needed for Post Traumatic Head Injury

Risk Factors for Development of Post Traumatic Seizures
GCS <10
Cortical contusion
Depressed skull fracture
Subdural hematoma
Epidural hematoma
Intracerebral hematoma
Penetrating head wound
Seizure within 24H of injury

J Pharm Pract 2011; 24(2): 146-159.

Elevated Intracranial Pressure

Sweet

Mannitol

0.5-1 g/kg IV over 20 min

20% 500mL bag (total 100g in bag)

Must use filter; watch for crystal formation in bag
Central line preferred; if use peripheral line used, 18G or higher

Can lower blood pressure

Mannitol

Mechanism by which it is thought to work is through exertion of its osmotic effects as a solute of a small size being confined to the extracellular space.
This hinders water reabsorption and enhances sodium and chloride osmolarity. This increase induces the movement of intracellular water to the extracellular and vascular spaces (reducing ICP)

↑ ICP after TBI

Poor patient outcomes

Reduces cerebral blood flow leading to brain herniation and death

Both the American Stroke Association Stroke Council and European Stroke Initiative Guidelines recommend the use of either hypertonic saline or mannitol to help maintain intracranial pressure

Initiate therapy to lower ICP as soon as possible: Hyperosmolar therapy

Salty

Hypertonic Saline

3% 3-5mL/kg or 250-500mL over ~15 min

3% 500mL bag
Central line preferred
If peripheral line used, 18G or higher

23.4% 30mL IV over 20 min

Undiluted, commercially available electrolyte solution
Central line preferred
If peripheral line used, 18G or higher

Both concentrations can slightly increase blood pressure

Hypertonic Saline

Mechanism by which it is thought to work is through a reduction of water content in the brain through its osmotic effects.
Very little sodium can cross the blood brain barrier. Therefore, through systemic HTS administration, sodium can pull water/fluid from the intracranial space, thus reducing ICP.

J Pharm Pract 2011; 24(2): 146-159.

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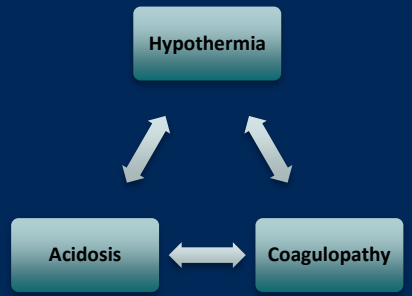
Secondary Survey

Hypothermia

“Trauma Triad of Death”



Hypothermia Prevention

Pre-Hospital

- Remove wet clothing
- Apply vapor barrier, insulation foils, blankets
- Increase ambient temp (if able)

Hospital

- Increase ambient temp
- Warmed blankets
- Active external warming (i.e., heat packs, Bair Hugger)
- Warmed IV fluids
- In-line blood warmer

Int J Environ Res Public Heath 2021; 18: 8719.

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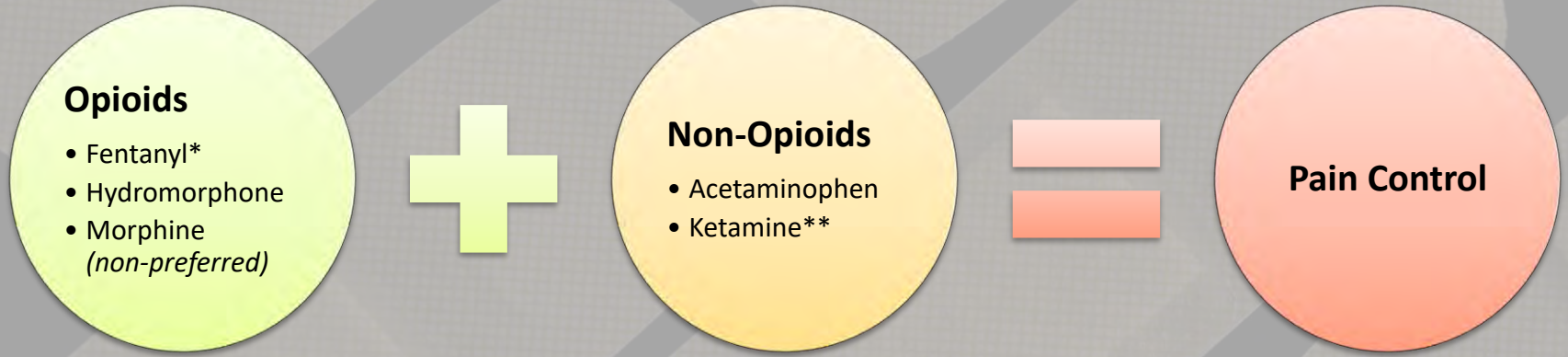
Secondary Survey

Secondary Survey Medications

Pain management (i.e., fentanyl) **Adults and Pediatrics** Help expedite pain management (appropriate dose) **Analgesia**	**Tdap ≥7 years** **DTaP <7 years** Help expedite vaccination administration (appropriate formulation) **Tetanus Vaccine**	**Open Fracture Prophylaxis** **Ceftriaxone, Cefazolin, other** Help expedite antimicrobial agents (appropriate drug and dose; allergy clarification) **Antimicrobials**	**Anticoagulation Reversal** Prothrombin Complex Concentrate Andexanet Alfa Tranexamic Acid Calcium **Disease Specific Medications**

Pain Management



*consider intra-nasal drug delivery, if no IV access
**careful with dosing (indication and route-specific dosing)

Secondary Survey Medications

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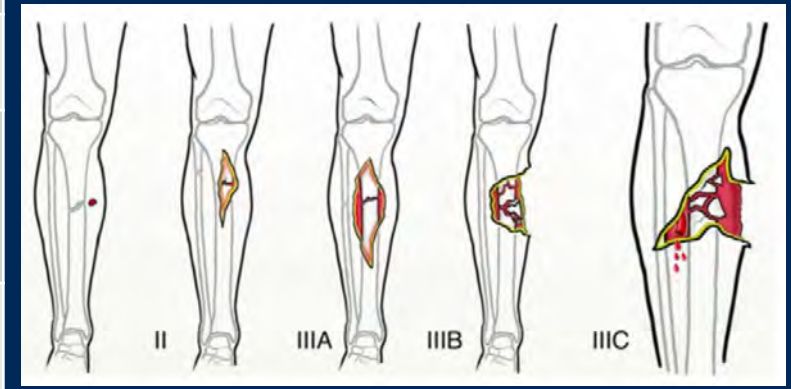
Open Fracture Prophylaxis

Gustilo-Anderson Classification	
Type I Fracture	Open fracture with clean wound <1 cm long
Type II Fracture	Open fracture with laceration >1 cm but <10 cm long without extensive soft tissue damage, flaps, avulsions
Type IIa Fracture	Open fracture with adequate soft tissue coverage of a fractured bone despite extensive soft tissue laceration or flaps, or high-energy trauma (GSW, farm injury) regardless of size of the wound
Type IIb Fracture	Open fracture with extensive soft tissue loss and periosteal stripping and bone damage. Usually associated with massive contamination. Will often need further soft tissue coverage procedure (i.e., free flap or rotational flap)
Type III Fracture	Open segmental fracture, open fracture with extensive soft tissue damage or traumatic amputation



Nebraska Medicine Antibiotic prophylaxis in open fractures protocol.

Open Fracture Prophylaxis

Antibiotic Prophylaxis, Nebraska Medicine	
Type I Fracture **Type II, IIa, and IIb Fractures**	• (Preferred) Cefazolin 2 g (3 g if > 120 kg) IV q8h x24H • (Severe beta-lactam allergy) Clindamycin 900mg IV Q8H x 24H
Type III Fracture	**No Gross Contamination:** • (Preferred) Ceftriaxone 2 g IV Q24H x24-48H after wound closure • (Severe beta-lactam allergy) Clindamycin 900 mg IV Q8H **PLUS** levofloxacin 500mg IV x24-48H after wound closure
	Contamination with soil or fecal matter: • Ceftriaxone 2 g IV Q24H **PLUS** metronidazole 500 mg IV Q8H x24-48H after wound closure • (ETOH intoxication) Zosyn 4.5 g IV Q8H x24-48H after wound closure • (Severe beta-lactam allergy) Clindamycin 900 mg IV Q8H **PLUS** levofloxacin 500mg IV x24-48H after wound closure
	Contamination with standing water: • (Preferred) Zosyn 4.5 g IV Q8H x24-48H after wound closure • (Severe beta-lactam allergy) Levofloxacin 500 mg IV Q24H **PLUS** metronidazole 500 mg IV Q8H x24-48H after wound closure

Nebraska Medicine Antibiotic prophylaxis in open fractures protocol.

Open Fracture Prophylaxis

American College of Surgeons (ACS) TQIP Guidelines: Open fracture antibiotics should be started within

1 HOUR

from time of presentation

Secondary Survey Medications

Pain management (i.e., fentanyl) **Adults and Pediatrics** Help expedite pain management (appropriate dose)	**Tdap ≥7 years** **DTaP <7 years** Help expedite vaccination administration (appropriate formulation)	**Open Fracture Prophylaxis** **Ceftriaxone, Cefazolin, other** Help expedite antimicrobial agents (appropriate drug and dose; allergy clarification)	**Anticoagulation Reversal** Prothrombin Complex Concentrate Andexanet-Alfa Tranexamic Acid Calcium
Analgesia	**Tetanus Vaccine**	**Antimicrobials**	**Disease Specific Medications**

Prothrombin Complex Concentrate (4F-PCC, Kcentra)

TIMI Criteria

- Intracranial Hemorrhage
- ≥5 g/dL drop in Hgb
- ≥15% absolute drop in Hct

GUSTO Criteria

- Intracranial hemorrhage
- Bleeding that causes hemodynamic compromise and requires intervention

Who needs PCC?

Known anticoagulant use **AND** at least one listed criteria

Prothrombin Complex Concentrate (4F-PCC, Kcentra)

- 4-Factor PCC, inactive clotting factures II, VII, IX, and X
- Contains small amount of heparin (contraindicated with history of HIT)
- Small volume
- Needs dedicated line for administration (<30 min)

PCC may be considered (off-label) in massive transfusion, without DIC.

Circulation Jun 2011; 123(23): 2736-2747.

Andexanet-alfa (Andexxa)

Reversal Agent for Factor Xa Inhibitors

Apixiban (Eliquis)	Rivaroxaban (Xarelto)

Level of Evidence

Multiple studies with limitations or conflicting results

Andexanet alfa (Andexxa)

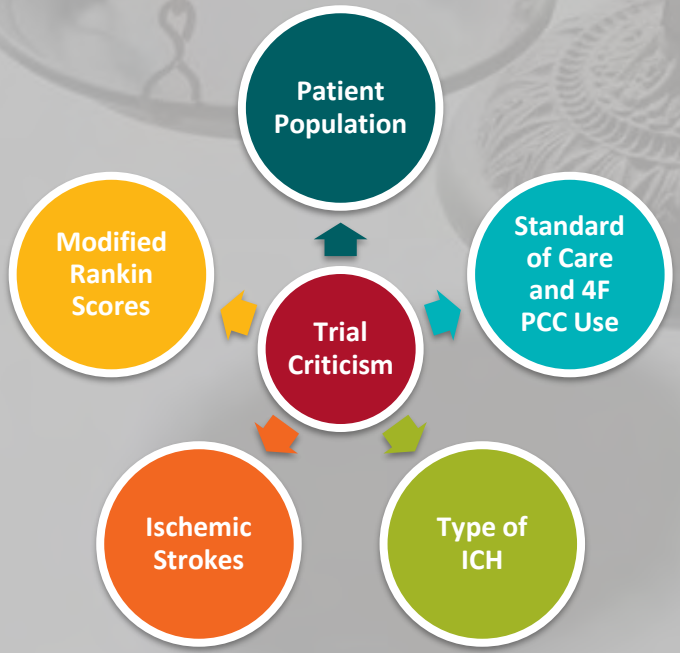
Modified recombinant inactive form of factor Xa → binds and sequesters factor Xa inhibitor molecules, rapidly reducing anti-factor Xa activity, restoring thrombin generation

ANNEXA-I Trial, *NEJM* 2024

Andexanet (N=263) vs standard of care (including 4F-PCC, 85.5%) (N=267)	**Hemostatic Efficacy:** Andexanet 67% vs Standard of Care 53.1% (P=0.003)	**Thrombotic events:** Andexanet 10.3% vs Standard of Care 5.6%, P=0.048

N Eng J Med 2024;390(19):1745-1755

Andexanet's Role in Therapy



Pros

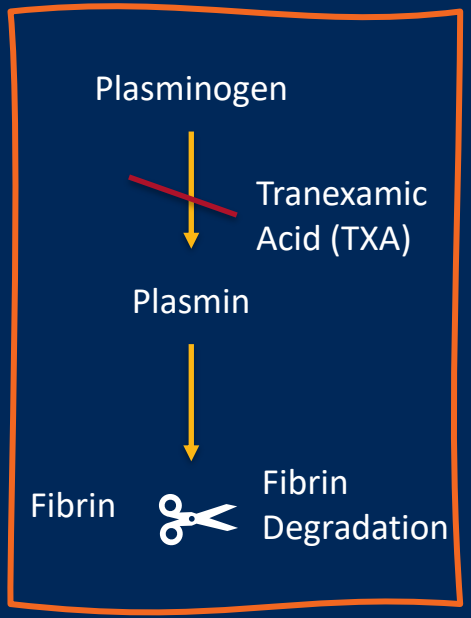
- ACC and ACCP recommends its use in reversal of life-threatening bleeds (recommendations predate more recent literature)
- Potentially better hemostatic efficacy
- Potentially reduced all-hospital and all cause 30-day mortality

Cons

- Conflicting efficacy evidence
  - Lack of high-quality evidence in trauma population (Andexanet vs 4F-PCC)
- Cost
- Hospital Drug Formulary Restrictions/Unavailable
- National survey showed only 33.7% of respondents are using Andexanet in trauma patients

N Eng J Med 2024;390(19):1745-1755

Tranexamic Acid



Role of TXA in Trauma

Synthetic lysine analogues such as TXA have been used as antifibrinolytic agents for more than 50 years. TXA works by binding to plasminogen and preventing its interaction with fibrin, thus inhibiting the dissolution of fibrin clots.

Literature Summary

CRASH-2
2010

Dose: 1g IV bolus over 10 min followed by 1g IV infusion over 8 hours

Results: early administration (within 3 hrs) reduced all-cause mortality

MATTERS
2012

Dose: 1g IV bolus

Results: TXA and blood product - based resuscitation improves markers of coagulation and results in lower mortality

CRASH-3
2019

Dose: 1g IV bolus over 10 min followed by 1g IV infusion over 8 hours

Results: early administration (within 3 hrs) reduced head injury-related death

Health Technol Assess. 2013 Mar;17(10):1-79.
Trials. 2012 Jun 21;13:87.
Arch Surg. 2012 Feb;147(2):113-9.

Calcium Supplementation During MTP

- Citrate is an anticoagulant used as a preservative in donated blood
- Hepatically metabolized
- Citrate chelates calcium → hypocalcemia
- 1-2 g calcium chloride for every 2-4 units pRBCs

Primary Survey

- [x] Airway
- [x] Breathing
- [x] Circulation
- [x] Disability
- [x] Exposure

Secondary Survey

- [x] Analgesia
- [x] Antibiotics
- [x] Tetanus vaccination
- [x] Disease-specific medications (i.e., traumatic brain injury, hemostatic agents, reversal medication(s), etc.)

Commonly Used Medications in Trauma Resuscitation

Intubation

- Pretreatment
- Induction
- Paralysis
- Post-Intubation Sedation/ Analgesia

Circulation

- Fluids
- Vasopressors

Disease-Specific

- Mannitol/ Hypertonic Saline
- Seizure prophylaxis
- Anticoagulation reversal agents
- Antibiotics
- Vaccinations
- Calcium

Pain Management

- Opioids
- Non-Opioid

Summary

01 There are numerous different medication needs that must be considered during the management of an acutely injured patient

02 During the primary and secondary survey, one must consider each of the different medications that may be required

03 An ED pharmacist can help assist with the patient-specific medication needs in the trauma bay

04 Always familiarize yourself with the appropriate trauma treatment protocols and formulary of your specific organization/agency

References

1. Atropine. *Lexi-Drugs*. UpToDate Lexidrug Inc. http://online.lexi.com. Accessed May 20, 2025.
2. Lidocaine. *Lexi-Drugs*. UpToDate Lexidrug Inc. http://online.lexi.com. Accessed May 20, 2025.
3. Fentanyl. *Lexi-Drugs*. UpToDate Lexidrug Inc. http://online.lexi.com. Accessed May 20, 2025.
4. Etomidate. *Lexi-Drugs*. UpToDate Lexidrug Inc. http://online.lexi.com. Accessed May 20, 2025.
5. Midazolam. *Lexi-Drugs*. UpToDate Lexidrug Inc. http://online.lexi.com. Accessed May 20, 2025.
6. Ketamine. *Lexi-Drugs*. UpToDate Lexidrug Inc. http://online.lexi.com. Accessed May 20, 2025.
7. Propofol. *Lexi-Drugs*. UpToDate Lexidrug Inc. http://online.lexi.com. Accessed May 20, 2025.
8. Succinylcholine. *Lexi-Drugs*. UpToDate Lexidrug Inc. http://online.lexi.com. Accessed May 20, 2025.
9. Rocuronium. *Lexi-Drugs*. UpToDate Lexidrug Inc. http://online.lexi.com. Accessed May 20, 2025.
10. Vecuronium. *Lexi-Drugs*. UpToDate Lexidrug Inc. http://online.lexi.com. Accessed May 20, 2025.
11. Patanwala AE, Erstad BL, *et al.* Succinylcholine is associated with increased mortality when used for rapid sequence intubation of severely brain injured patients in the emergency department. *Pharmacotherapy*. 2016 Jan;36(1):57-63. doi: 10.1002/phar.1683.
12. Amini A, Faucett EA, et al. Effect of a pharmacist on timing of postintubation sedative and analgesic use in trauma resuscitations. *Am J Health Syst Pharm*. 2013 Sept;1;70(17):1513-7. doi: 10.2146/ajhp120673.
13. Devlin JW, Skrobik Y, *et al.* Clinical Practice Guidelines for the prevention and management of pain, agitation/sedation, delirium, immobility, and sleep disruption in adult patients in the ICU. *Crit Care Med. 2018 Sep;46(9):e825-e873.* doi: 10.1097/CCM.0000000000003299.
14. Dexmeditomidine. *Lexi-Drugs*. UpToDate Lexidrug Inc. http://online.lexi.com. Accessed May 20, 2025.
15. Lorazepam. *Lexi-Drugs*. UpToDate Lexidrug Inc. http://online.lexi.com. Accessed May 20, 2025.
16. Hébert PC, Wells G, *et al*. A multicenter, randomized, controlled clinical trial of transfusion requirements in critical care. Transfusion Requirements in Critical Care Investigators, Canadian Critical Care Trials Group. *N Engl J Med.* 1999 Feb 11;340(6):409-17. Erratum in: N Engl J Med 1999 Apr 1;340(13):1056.
17. Semler MW, Self WH, *et al*. Balanced crystalloids versus saline in critically ill adults. *N Engl J Med*. 2018 Feb 27; 378:829-839.
18. Guilabert P, Usua G, *et al*. Fluid resuscitation management in patients with burns: update. *Brit J Anesth* 2016; 117(3): 284-96.
19. Dopamine. *Lexi-Drugs*. UpToDate Lexidrug Inc. http://online.lexi.com. Accessed May 20, 2025.
20. Epinephrine. *Lexi-Drugs*. UpToDate Lexidrug Inc. http://online.lexi.com. Accessed May 20, 2025.
21. Norepinephrine. *Lexi-Drugs*. UpToDate Lexidrug Inc. http://online.lexi.com. Accessed May 20, 2025.
22. Phenylephrine. *Lexi-Drugs*. UpToDate Lexidrug Inc. http://online.lexi.com. Accessed May 20, 2025.
23. Vasopressin. *Lexi-Drugs*. UpToDate Lexidrug Inc. http://online.lexi.com. Accessed May 20, 2025.
24. Scarponcini TR, Edwards CJ, *et al*. The role of the emergency pharmacist in trauma resuscitation. *J Pharm Pract* 2011; 24(2): 146-159.
25. Van Veelen MJ and Maeder MB. Hypothermia in trauma. *Int J Environ Res Public Heath* 2021; 18: 8719.
26. Nebraska Medicine Antibiotic prophylaxis in open fractures protocol. https://www.unmc.edu/intmed/_documents/id/asp/surgical-antibiotic-prophylaxis-in-open-fractures-guideline.pdf. [Accessed May 22, 2025.]
27. Mehran R, Rao SV, *et al.* Standardized bleeding definitions for cardiovascular clinical trials: a consensus report from the bleeding academic research consortium. *Circulation* Jun 2011; 123(23): 2736-2747.
28. Connolly SJ, Sharma M, *et al.* Andexanet for factor Xa inhibitor – associated with acute intracranial bleeding. *N Eng J Med* 2024 May 16; 390(19): 1745-55.
29. Roberts I, Shakur H, *et al*. The CRASH-2 trial: a randomised controlled trial and economic evaluation of the effects of tranexamic acid on death, vascular occlusive events and transfusion requirement in bleeding trauma patients. *Health Technol Assess*. 2013 Mar;17(10):1-79.
30. Dewan Y, Komolafe EO, *et al.* CRASH-3 Collaborators. CRASH-3 - tranexamic acid for the treatment of significant traumatic brain injury: study protocol for an international randomized, double-blind, placebo-controlled trial. *Trials*. 2012 Jun 21;13:87.
31. Morrison JJ, Dubose JJ, *et al*. Military Application of Tranexamic Acid in Trauma Emergency Resuscitation (MATTERs) Study. *Arch Surg*. 2012 Feb;147(2):113-9.

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