아주대학교의료원
Ajou University Medical Center

AJOU TRAUMA

슬기로운 1년차 생활
- 외상편 -

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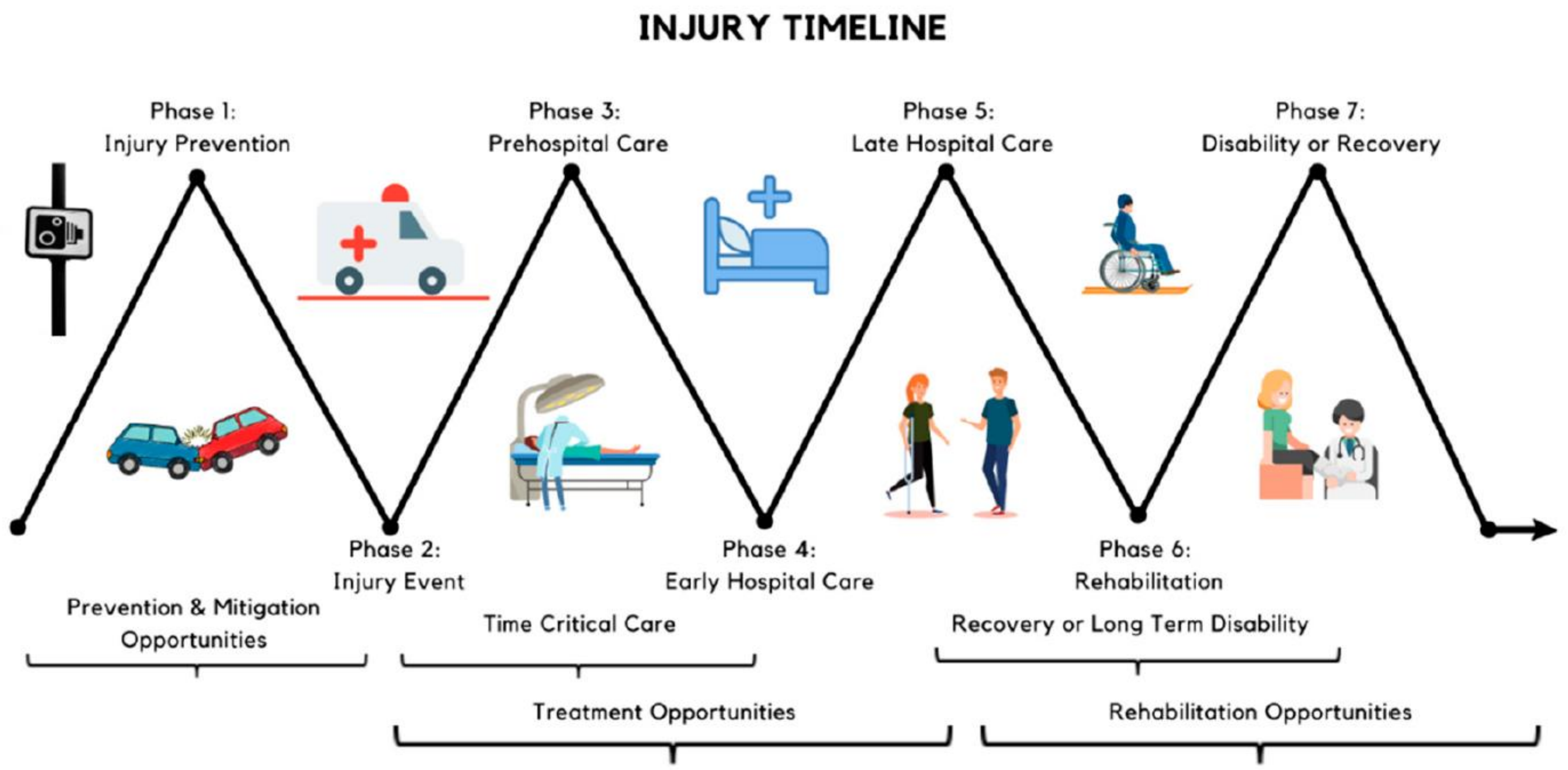
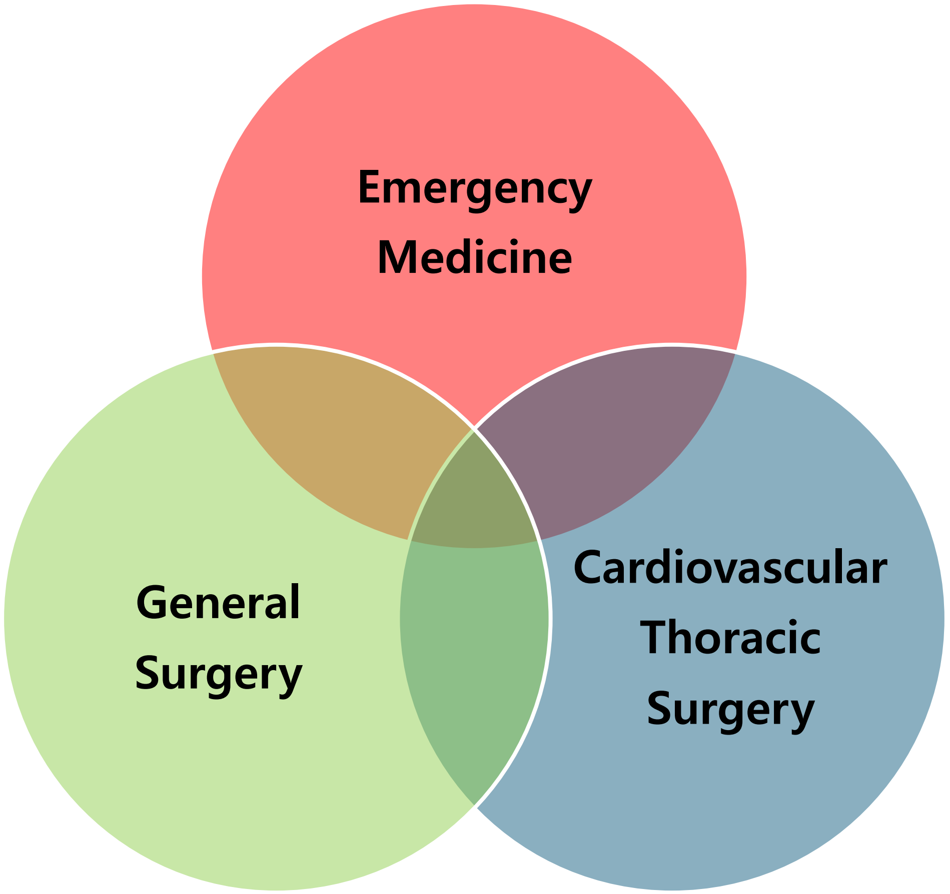

INJURY TIMELINE
Phase 1:
Injury Prevention
Phase 3:
Prehospital Care
Phase 5:
Late Hospital Care
Phase 7:
Disability or Recovery
Phase 2:
Injury Event
Phase 4:
Early Hospital Care
Phase 6:
Rehabilitation
Prevention & Mitigation Opportunities
Time Critical Care
Recovery or Long Term Disability
Treatment Opportunities
Rehabilitation Opportunities

Trauma Sugery

- Pre-hospital care
- Resuscitation
- Surgical treatment
- Non-Surgical treatment
- Critical Care
- Rehabilitation



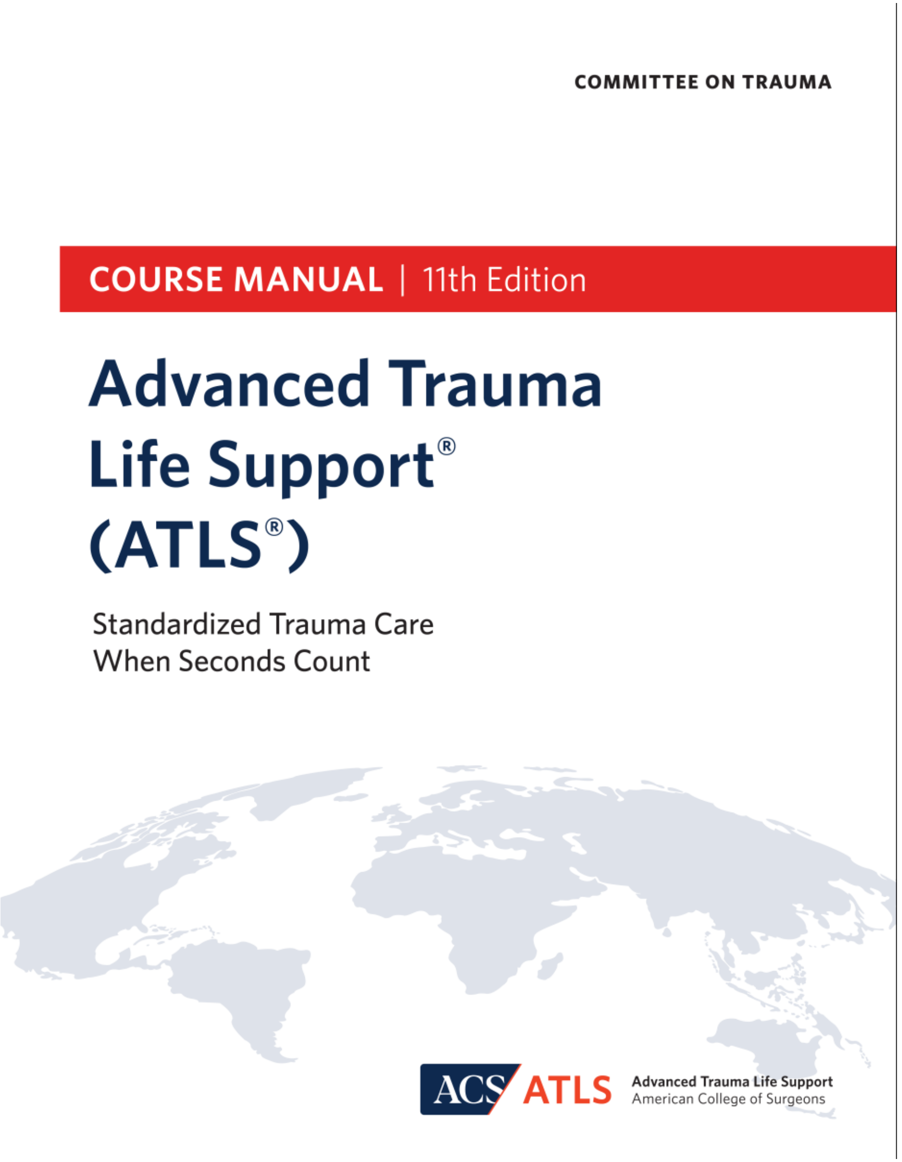
Trauma Surgeon ≠ General Surgery

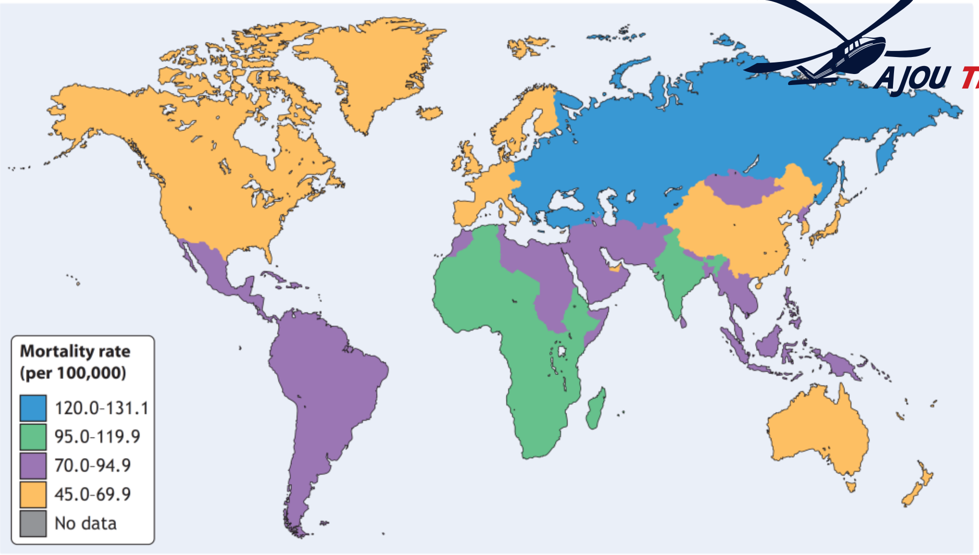
Trauma Surgeon =

General Surgery
+ Cardiovasular Thoracic Surgery
+ Emergency Medicine

Resuscitation

Prehospital care + Early Hospital Care



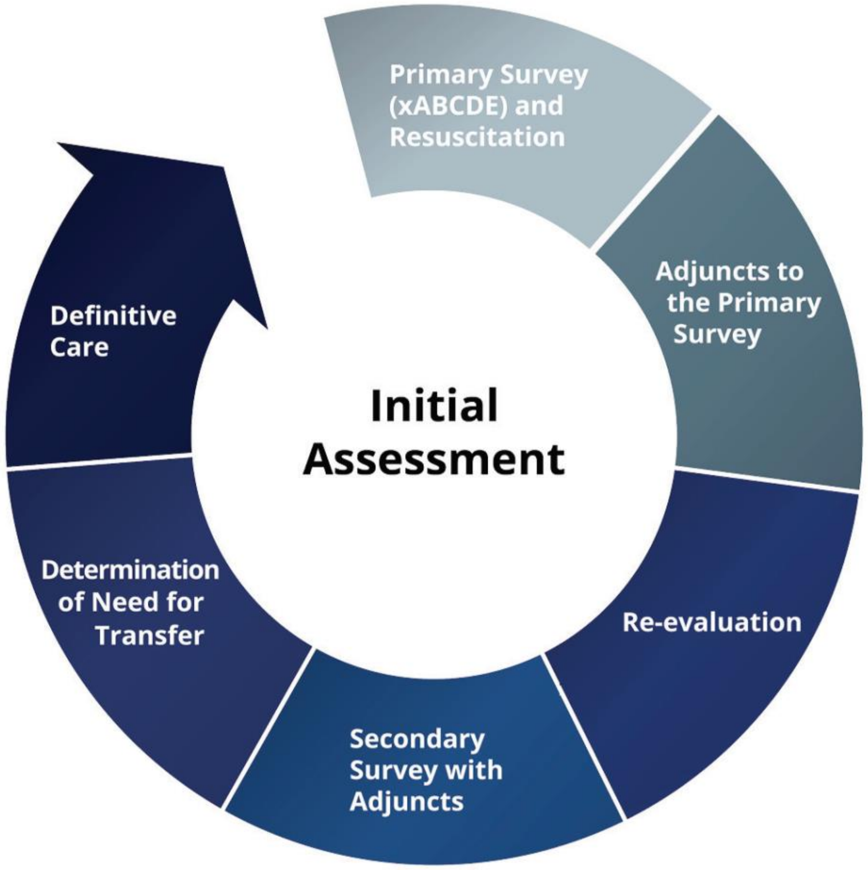


■ FIGURE 1 Global Injury-Related Mortality.

Reproduced with permission from *The Injury Chart Book: a Graphical Overview of the Global Burden of Injuries.* Geneva: World Health Organization Department of Injuries and Violence Prevention. Noncommunicable Diseases and Mental Health Cluster; 2002.

Advanced Trauma Life Support

At the time of publication,
the **78 countries** were actively providing the ATLS course to their trauma providers



- **Primary survey (xABCDE)** with immediate resuscitation of patients with life-threatening injuries

- **Secondary survey** (head-to-toe evaluation and patient history)

Three important concepts greatly enhance the ability to manage injured patients, regardless of the environment where care is provided:

1. **Treat the greatest threat to life first.**

2. **The lack of a definitive diagnosis should not delay the application of urgent treatment.**

3. **An initial, detailed history is not essential to begin the evaluation and treatment of a patient with acute injuries.**

The Primary Survey

& SIMULTANEOUS RESUSCITATION

		Key Causes and Issues
X	e**x**sanguinating e**x**ternal hemorrhage	Massive bleeding from open extremity and other wounds
A	**A**irway	Inability to maintain the airway patency due to direct injury, altered mental status, shock
B	**B**reathing	Compromise of oxygenation and/or ventilation due to direct injury, shock
C	**C**irculation	1. Presence of shock from hemorrhagic, neurogenic, cardiogenic, or other sources 2. Hemorrhage control 3. Restoration and maintenance of end-organ perfusion
D	**D**isability	Injury to the central nervous system • Traumatic brain injury • Spinal cord injury
E	**E**xposure/ **E**nvironment	1. Exposure to prevent missed injuries while maintaining patient dignity 2. Maneuvers to prevent hypothermia

- ATLS provides a defined evaluation order to support global applicability and **guide inexperienced clinicians.**

- **Experienced trauma clinicians** often use steps **as a mnemonic, not a strict sequence**.

✓In trauma care, clinicians must rapidly assess injuries and start life-saving therapy.

✓**Timing is critical → requires a systematic, rapid, and accurate approach.**

✓Life threats should be managed immediately when identified.

PRIORITIZES?

- Airway 가 가장 먼저? A-B-C?
- Circulation 이 가장 먼저? C-A-B?

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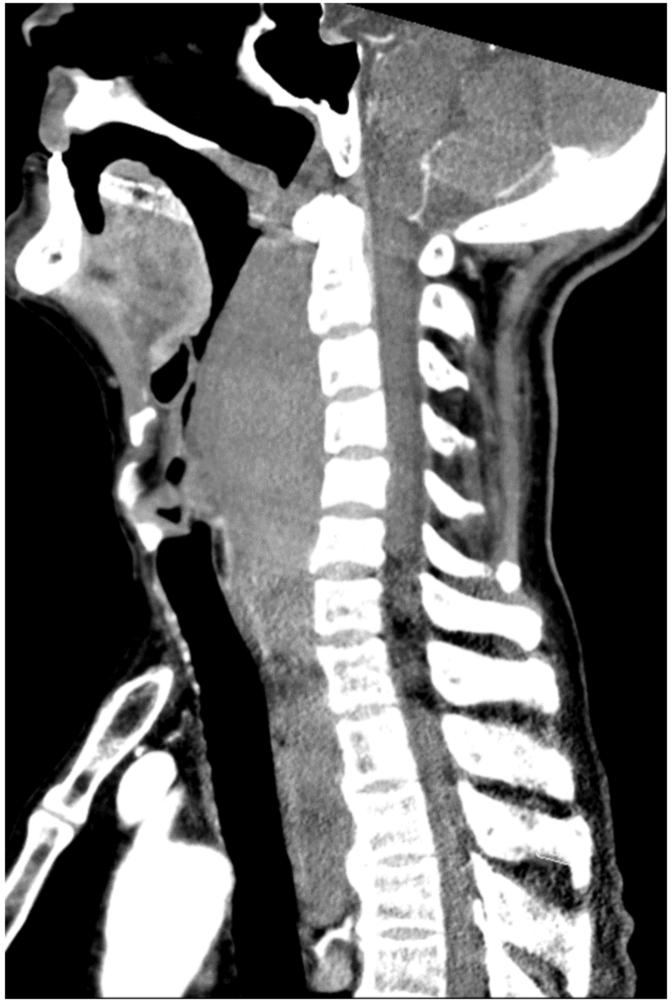
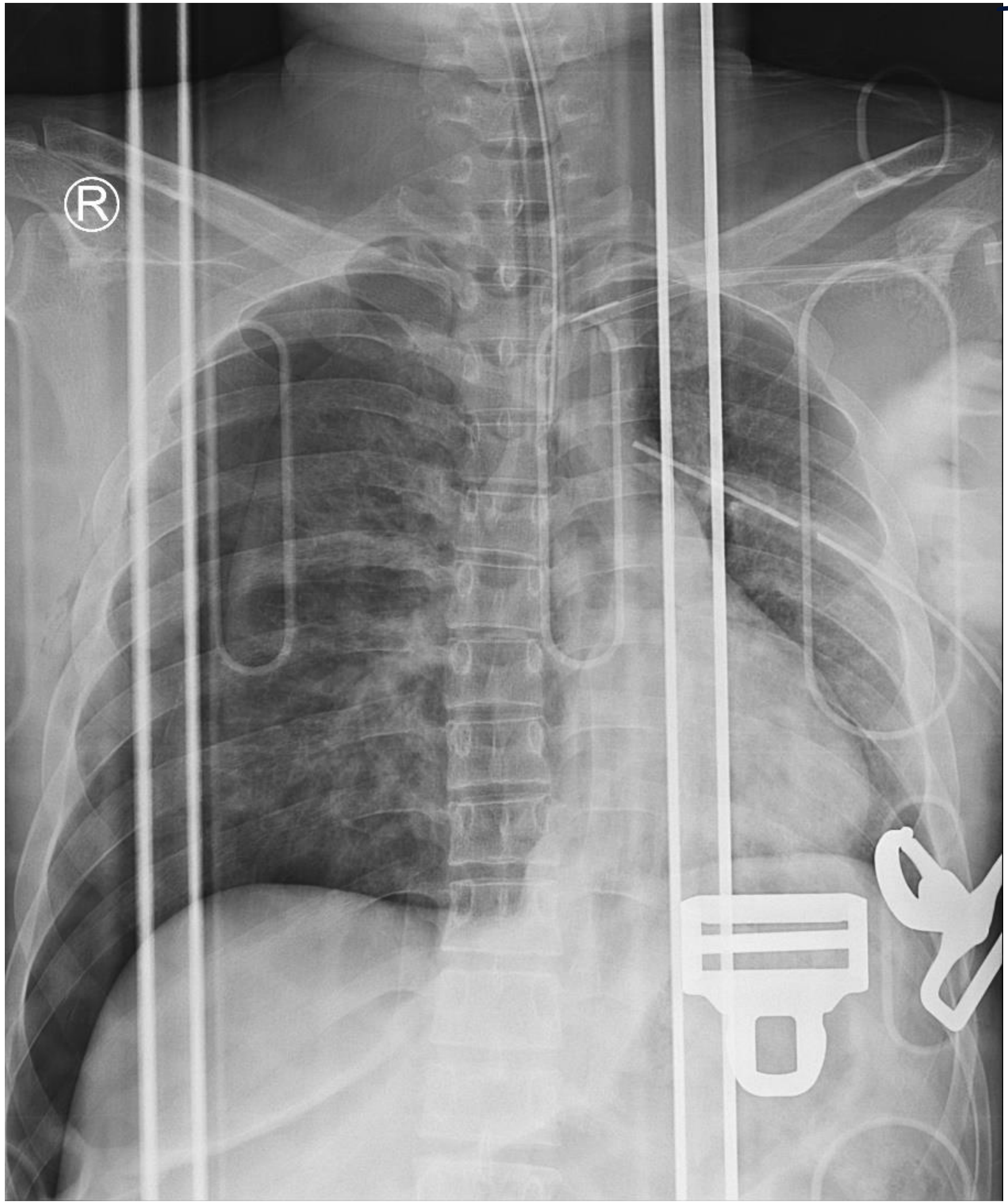
Airway



Breathing



Noncompressible torso bleeding: What are the options?

Contents lists available at ScienceDirect
American Journal of Emergency Medicine
journal homepage: www.elsevier.com/locate/ajem

CAB versus ABC approach for resuscitation of patients following traumatic injury: Toward improving patient safety and survival

Tessa Breeding, B.S[a], Brian Martinez, B.S[a], Joshua Katz, B.S[a], Jason Kim, B.S[a], Will Havron, MD[b,c], Heather Hoops, MD[d], Adel Elkbuli, MD, MPH, MBA[b,c,*]

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- CAB vs ABC
- ABC(삽관 먼저): 사망률↑, 혈압↓
- CAB(수혈 먼저): 생존률↑
- Post Intubation Hypotension (삽관 후 저혈압) → 치명적

Authors	Year	Design	Study Description	Reported Outcomes	Additional Comments
Ferrada	2018	Retrospective	Analysis of 229 hypotensive trauma patients who underwent RSI before blood transfusion (ABC) or blood transfusion before RSI (CAB).	Patients who underwent RSI before blood transfusion (ABC) had a significantly higher mortality rate than those who had blood transfusion initiated first (CAB) (50% vs 78% $p < 0.05$).	RSI resulted in hemodynamic deterioration in 75% of the already hypotensive patients.
Ferrada et al.	2018	Retrospective	Analysis of 440 hypotensive trauma patients, 245 (55.7%) received intravenous blood product resuscitation first (CAB), and 195 (44.3%) were intubated before any resuscitation was started (ABC).	Those intubated prior to receiving transfusion had a lower GCS than those with transfusion initiation prior to intubation (ABC: 4, CAB:9, $p = 0.005$). There was no statistically significant difference in mortality between cohorts (CAB 47% and ABC 50%).	N/A
Petrosoniak and Hicks	2018	Review	Literature review challenges the conventional ABC sequence that can at times inappropriately prioritize less urgent interventions over treatment for more critical injuries.	Authors propose the use of evidence-based methods for shock identification to apply effective trauma resuscitation, placing emphasis on prioritizing circulation in patients without critical hypoxia or dynamic airway injury.	No single indicator can predict both presence and degree of shock in trauma patients reliably
Ferrada et al.	2019	Meta-analysis	Meta-analysis including 2044 trauma and acute patients across four studies that underwent intubation and developed PIH.	Overall mortality rates were higher in trauma patients who developed PIH (mortality, n (%): PIH = 250/753 (33.2%) vs 253/1291 (19.6%), $p < 0.001$).	N/A

Abbreviations: ABC = Airway-Breathing-Circulation, CAB = Circulation-Breathing-Airway, RSI = Rapid Sequence Intubation, GCS = Glasgow Coma Scale, PIH = Post-Intubation Hypotension, NA = Not Applicable.

- Patients are assessed, and **their treatment priorities** are established, based on their injuries, vital signs, and the injury mechanisms.

x: Control of eXsanguinating Hemorrhage

- Massive external hemorrhage represents an immediate threat to life.

- Stopping exsanguinating external bleeding through

✓**direct pressure**,

✓**wound packing**,

✓and/or **tourniquet application**


WOUND PACKING PRINCIPLES
<90 SECS
KEEP PRESSURE
3 MIN
Identify exact source of bleeding and APPLY direct pressure UNTIL dressing or gauze is placed
Pack the wound maintaining CONSTANT direct pressure within 90 SECONDS to be effective
Fill and pack the wound tightly, ensuring dressing or gauze extends 1-2 inches above the skin
HOLD direct pressure for at least 3 MINS (this is necessary, even with the active ingredient in hemostatic dressing)
When packing a large wound, more than one hemostatic gauze and/or additional gauze may be needed
Carefully observe to determine if bleeding has been controlled
Once you are sure the bleeding has stopped, apply a pressure bandage

Tourniquet

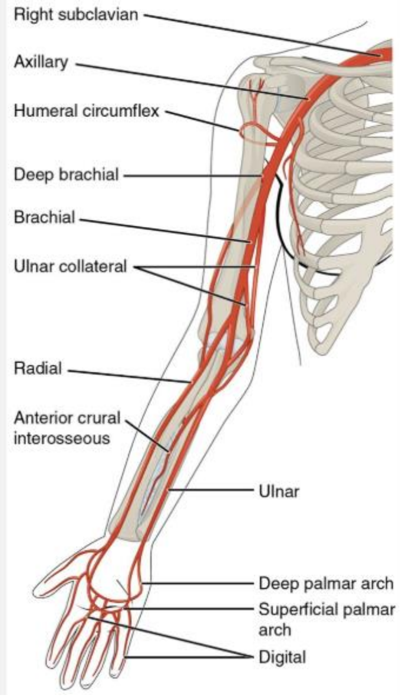
- Mortality ↓
- blood transfusion↓
- Tourniquet application **< 2 hours**

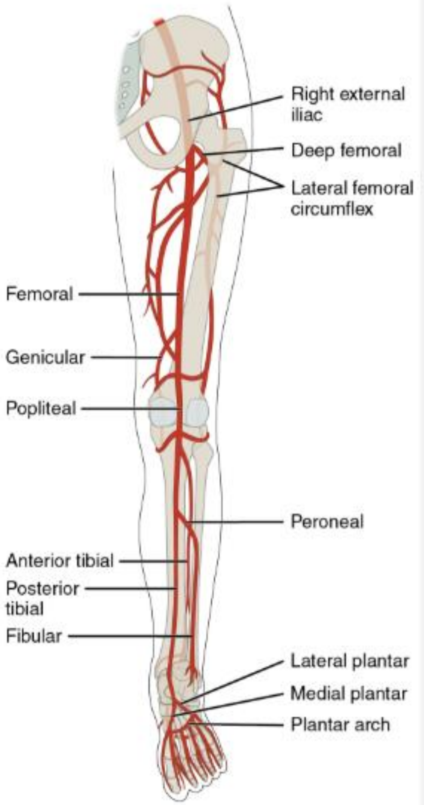
→ Low risk of complications

Tourniquet Application – Key Steps

- Apply **2–3 in (5–8 cm) proximal** to bleeding site, **not over a joint**
- Place **directly on skin**, not over clothing
- Ensure **no distal pulse** and bleeding has stopped
- If bleeding persists → apply a **second tourniquet proximal** to the first(2-3 inches)
- If possible, apply the tourniquet proximally

→ For forearm or lower-leg wounds, place the tourniquet **on the upper arm (humerus) or thigh (femur)** — regions with a single large bone — to maximize effectiveness.





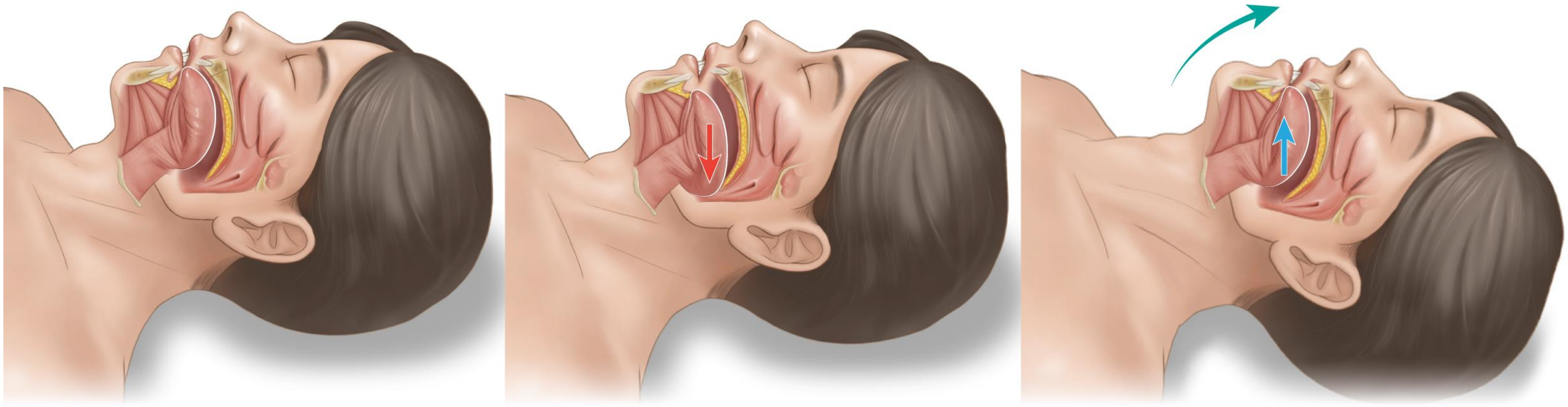
Airway Assessment and Management

■ Table 4-1: Indications for Airway Management During the Primary Survey.

Airway	Partial or complete airway obstruction Anticipated or impending airway obstruction (e.g., direct trauma, hemorrhage, or burns)
Breathing	Severe chest injury with respiratory failure Significant hypoxia (SpO_2 <90%) despite high-flow oxygen, after exclusion of pneumothorax Hypercapnia from hypoventilation, without an immediately reversible cause (e.g. due to neurological or respiratory failure)
Circulation	Altered mental status due to shock
Disability	Severe TBI with GCS score 8 or lower
Exposure	High percentage body surface area burns

SpO_2: Pulse oximety. TBI: Traumatic brain injury. GCS: Glasgow coma scale

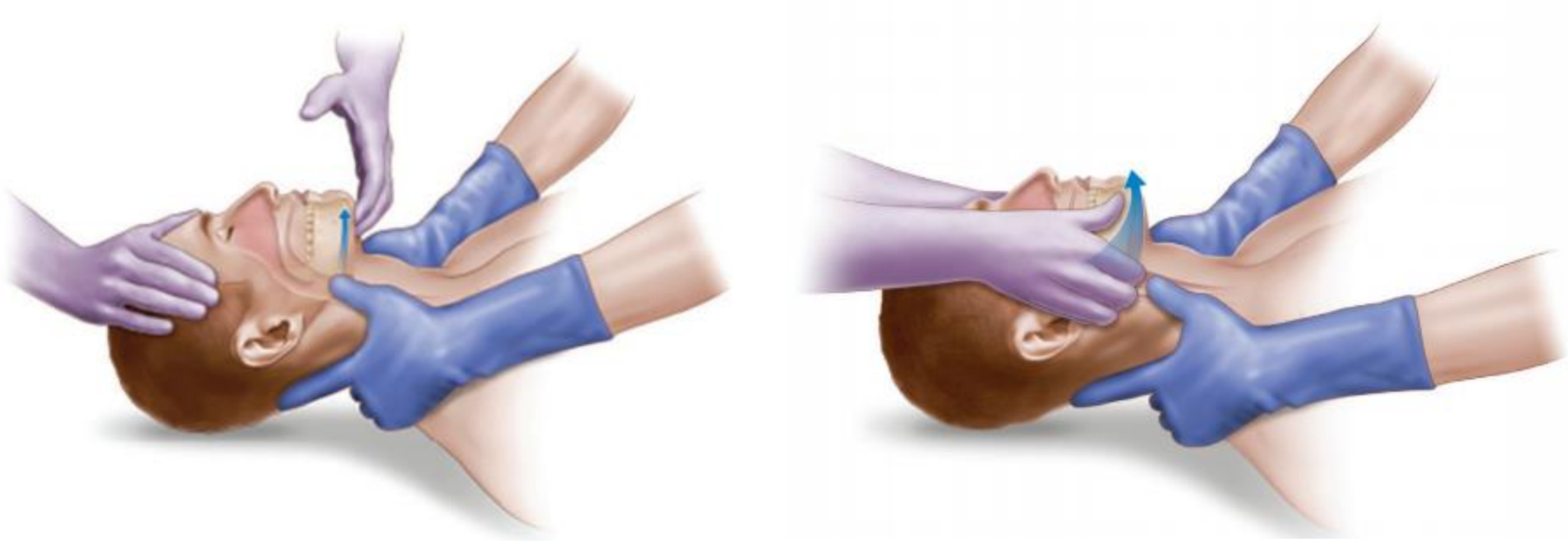
Altered level of consciousness or a GCS <9 The Reason of Airway Maintenance?



Loss of respiratory driving due to brain injury

Basic Life Support Airway

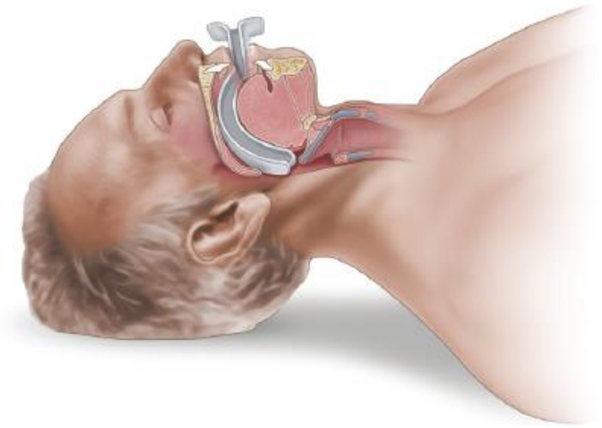
- Chin lift and Jaw thrust



출처 : ATLS 10th, p.31

Basic Life Support Airway

- Oropharyngeal airway
  - Only in unconscious patients
  - Laryngospasm and vomiting



출처 : ATLS 10th, p.31

- Nasopharyngeal airway
  - Oral airway cannot be placed
  - Epistaxis
  - Basilar skull fracture

출처: Emergency Medicine Procedures 2nd, p.43

Basic Life Support Airway

- Bag-valve-mask ventilation (BVM)
  - Poor respiratory effort, more significant respiratory compromise, or apnea
  - **Two** provider : good patient positioning and maintaining a firm seal
  - Gastric insufflation → vomiting

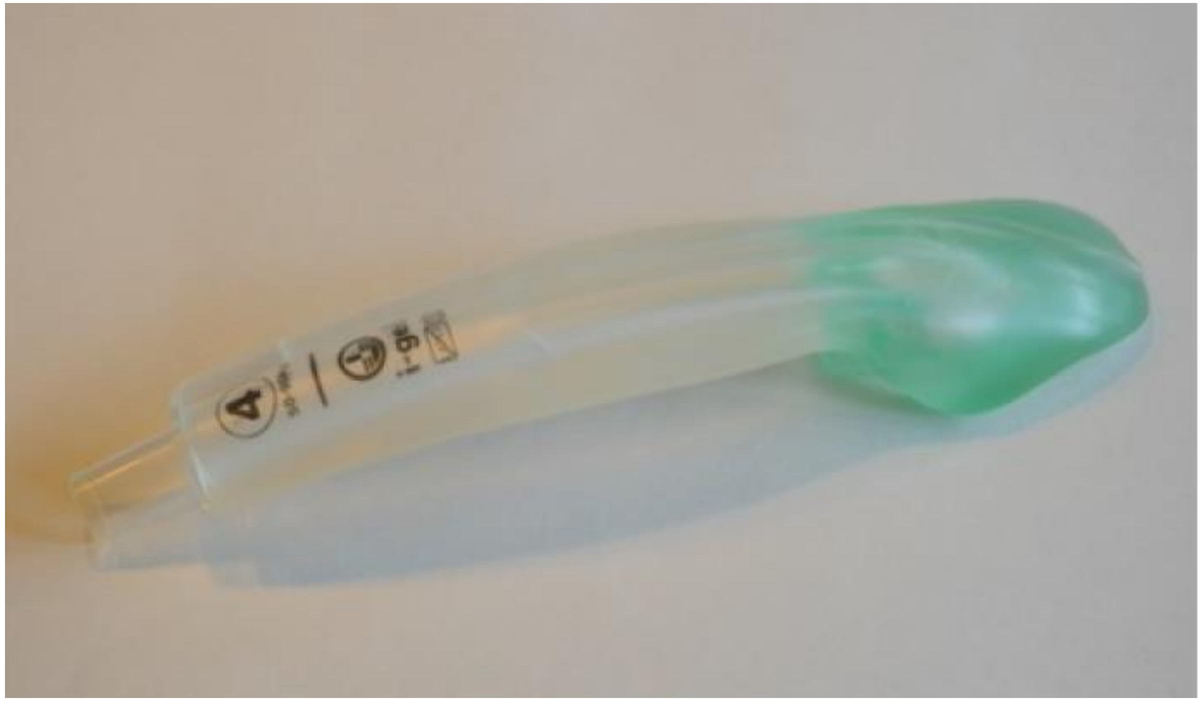
One-handed, one-person mask ventilation technique

Two-handed, two-person mask ventilation technique

출처: Emergency Medicine Procedures 2nd, p.45

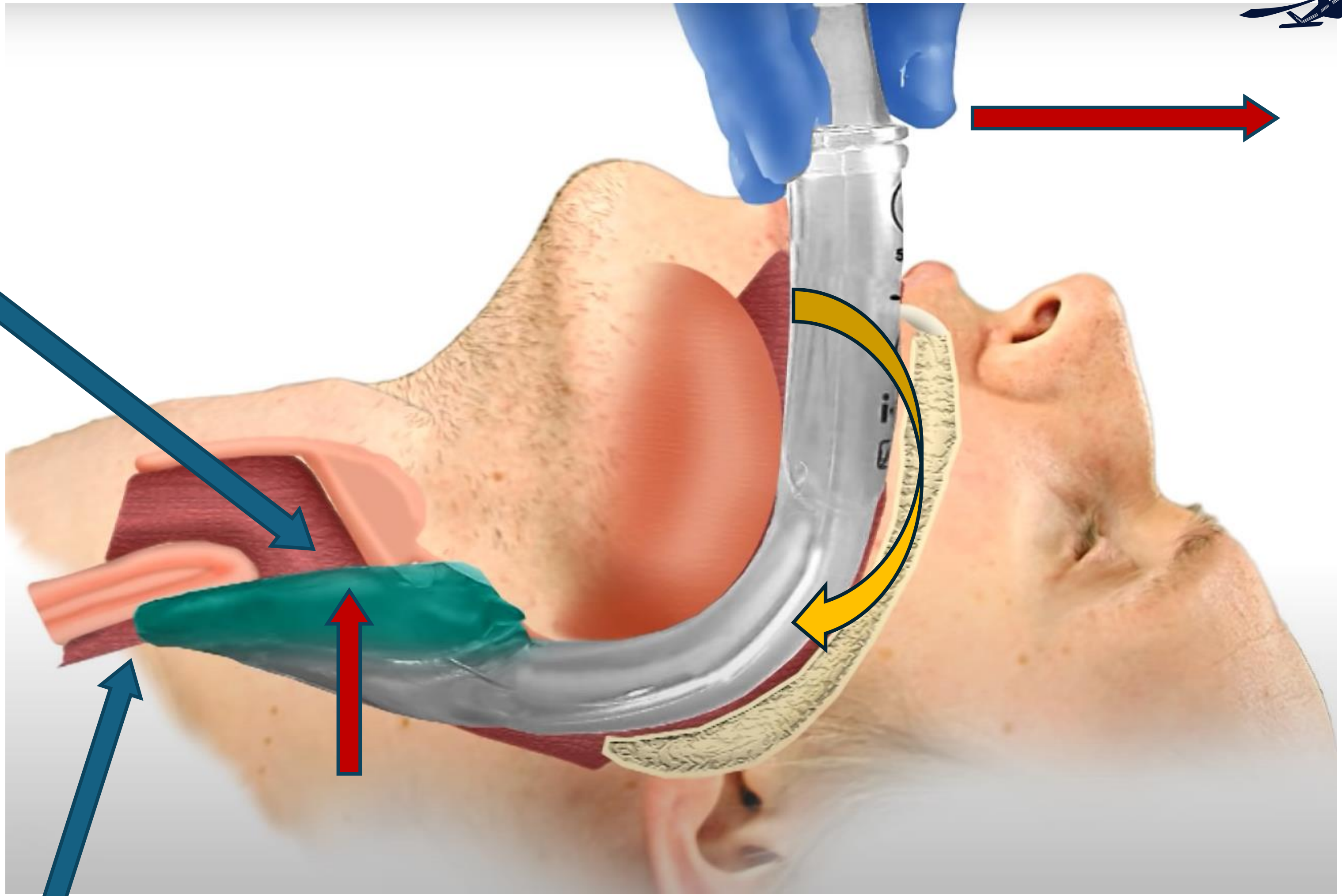
Supra-Glottic Airway : I-gel

- Simple and effective
- Soft, gel-like
- Non inflation cuff ➔ Less time required for placement



출처: Trauma 8th, p.167

Cuff는 기도 상부에 위치

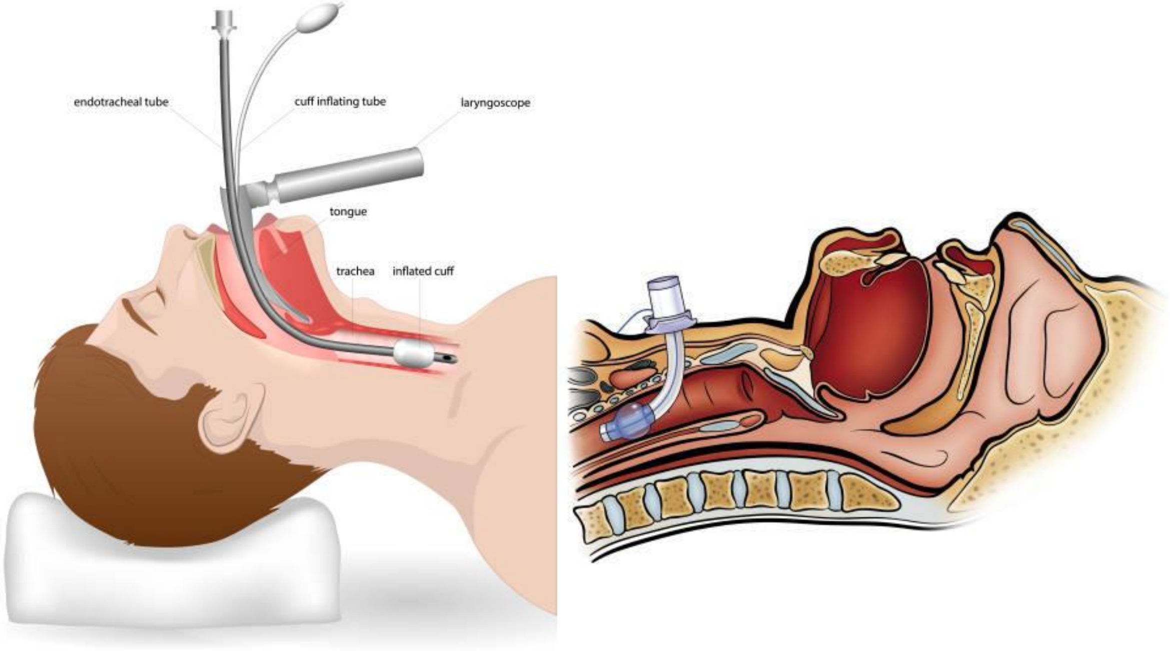


I-gel 의 tip은 식도 상부에 위치

Definitive Airway

An airway device **in the trachea with an inflated cuff distal to the vocal cords** is termed a **definitive airway**.

- **Endotracheal Intubation**
- **Surgical Airway**
  - ✓ Cricothyroidotomy
  - ✓ Tracheostomy



Rapid Sequence Intubation(RSI)

- 기도 삽관이 힘든 상황에서 **induction과 paralysis** 를 통해 신속한 기관삽관의 환경을 조성하는것
  - **No NPO**
  - **High risk of Aspiration**

Drug-facilitated intubation

Intubation 성공 ↑ , Aspiration risk ↓

Medication	Dose	Comments
Sedative and anesthetic agents		
Ketamine (sedation)	0.5 mg/kg, repeat if necessary	May induce airway/respiratory collapse
Ketamine (RSI)	0.5-2 mg/kg	Can cause or exacerbate hypotension and shock–dose reduction in shock
Etomidate (RSI)	0.2-0.3 mg/kg	
Propofol (RSI)	Dose determined by an experienced clinician	Can cause or exacerbate hypotension and shock–dose reductions in shock, sometimes up to 90%
Thiopentone (RSI)		
Midazolam (RSI)		
Fentanyl (sedation RSI)	0.5 - 1 mcg/kg	

Medication	Dose	Comments
Neuromuscular blocking drugs		
Rocuronium	0.6-1.2 mg/kg	Will prevent patient from maintaining spontaneous, unassisted open airway
Suxamethonium (succinylcholine)	1 mg/kg	

Etomidate

- Rapid onset (15-45 seconds) & Rapid recovery (3-12 mins)
- Intraocular pressure(IOP) & Intracerebral pressure(ICP) ↓
- **Superior hemodynamic stability compared with other induction agents.**

✓ BP, CVP, PAP, PCWP => minimal change (<10%)

✓ SV, CI, PVR, SVR => minimal change (<10%)

- Effect on ventilation => minimal

- Myoclonus => cortical seizure acitivity X
- Absence of any analgesic effect
- **Adrenocortical suppression <24hr**

✓ Septic shock -> refractory hypotension ↑

✓ No continuous infusion or repeated injection

Ketamine

- Onset time (45-60 sec) & Duration of action (10-20 min)
- **Sympathetic tone ↑ (BP, HR, CO ↑)**
- **Bronchodilatory effect**
- Maintains airway reflexes and respiratory drive
- **Profound analgesic properties**
- Intramuscular (IM) injection is feasible for children(oral or rectal administration is possible)
- Sympathetic tone ↑ =>myocardial oxygen demand ↑
- Pulmonary hypertension or Rt. Heart failure => aggravation
- cerebral metabolic rate of oxygen, ICP, CBF ↑

Succinylcholine

- depolarizing agent
- Onset : 40 to 60 sec
- Duration : 6 to 10 mins
- 1.5 mg/kg intravenous (IV) dose
- Bradycardia, Hyperkalemia

Contra-indications

- Malignant hyperthermia history (personal or family)
- Neuromuscular disease involving denervation
- Muscular dystrophy
- Stroke over 72 hours old
- Rhabdomyolysis
- Burn over 72 hours old
- Significant hyperkalemia (eg, suggested by characteristic changes on an electrocardiogram)

Rocuronium

- Non-depolarizing agent
- Onset : 45-60 sec
- Duration : 45 min
- 1 to 1.2 mg/kg

RISKS OF RSI

- All agents have the potential to produce significant hypotension.

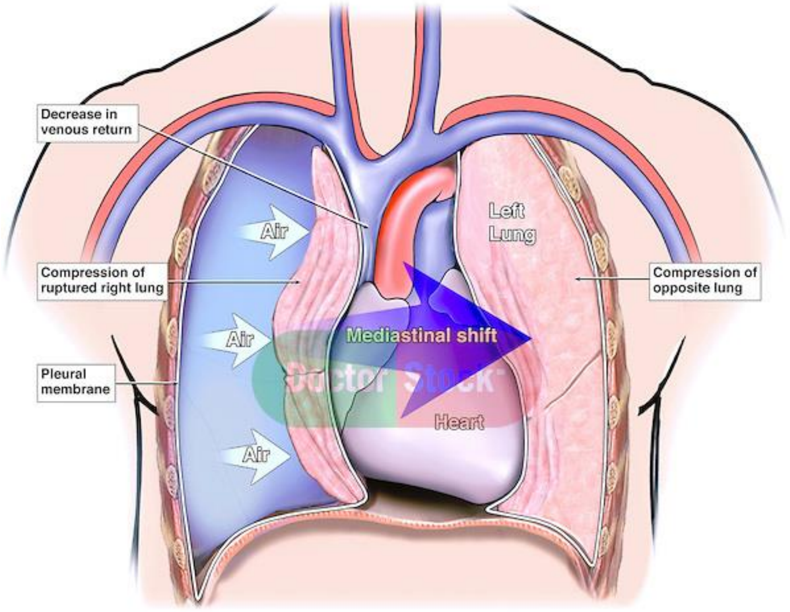
- **Post-Intubation Hypotension(PIH)**

✓Hypovolemia
✓Sedation drug
✓Increased intrathoracic pressure
✓Myocardial depression

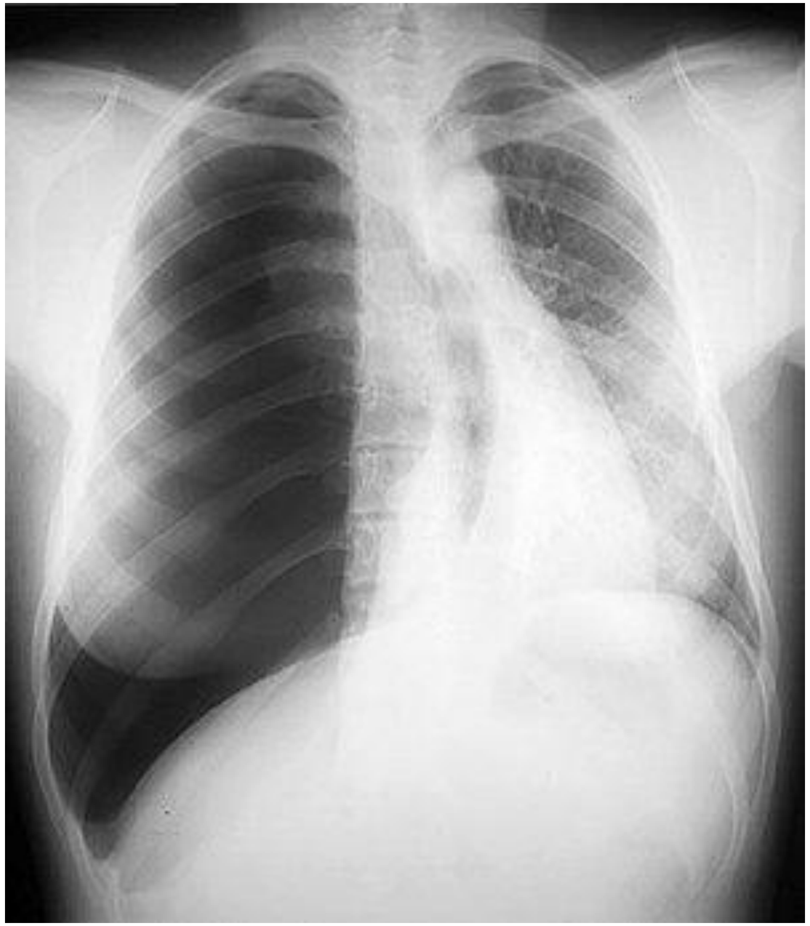
Factors toward *immediate* RSI	Factors toward *delaying or deferring* RSI
Inability to oxygenate via mask or supraglottic airway (absolute indication), or difficulty maintaining ventilation with these methods	Well-functioning upper airway device or patient maintaining airway spontaneously
Appropriate resuscitation and adequate hemodynamic status	Hypotension or hemodynamic abnormality
Inability to maintain airway patency due to airway bleeding, regurgitation, or emesis	Inadequate intubation experience
Lack of or prolonged delay until availability of airway specialist	Potential or suspected difficult airway and anticipated rapid arrival of expert assistance
Definitive airway indicated for safe transfer	More urgent clinical priorities
	Inadequate staff available to assist
	Rapid availability of airway specialist
	Multi-casualty scenario

Breathing and Ventilation Assessment and Management

Tension Pneumothorax



In a tension pneumothorax, air from a ruptured lung enters the pleural cavity without a means of escape. As air pressure builds up, the affected lung is compressed and all of the mediastinal tissues are displaced to the opposite side of the chest.



Needle Decompression

■ FIGURE 4-2 **Needle Decompression.** Tension pneumothorax may be managed initially by rapidly inserting a large-caliber needle into the second intercostal space in the midclavicular line of the affected hemithorax.

chest wall thickness

needle kinking

Due to the **variable thickness of the chest wall, kinking of the catheter, and other technical or anatomic complications**, needle decompression may not be successful.

In this case, **finger thoracostomy** is an alternative approach

Contents lists available at ScienceDirect

Injury

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journal homepage: www.elsevier.com/locate/injury

Chest wall thickness and decompression failure: A systematic review and meta-analysis comparing anatomic locations in needle thoracostomy☆

Danuel V. Laan[a], Trang Diem N. Vu[e], Cornelius A. Thiels[a], T.K. Pandian[a], Henry J. Schiller[b], M. Hassan Murad[c,1], Johnathon M. Aho[a,d,*,1]

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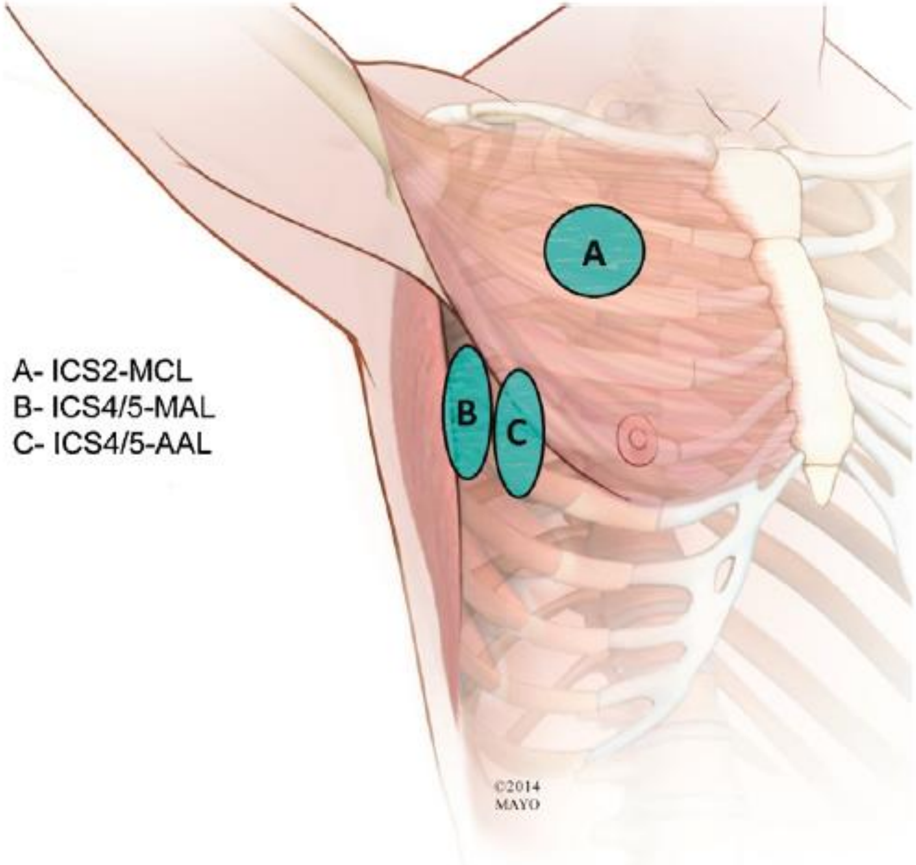

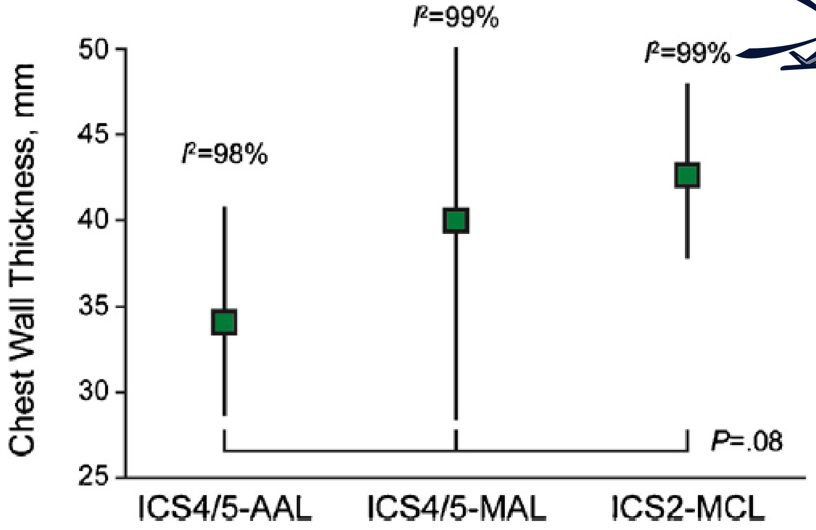

Fig. 3. Chest wall thickness by recommended anatomic location and alternative anatomic locations. Shown are the fourth and fifth intercostal spaces-anterior axillary line (ICS4/5-AAL), the fourth and fifth intercostal spaces-midaxillary line (ICS4/5-MAL), and the second intercostal space-midclavicular line (ICS2-MCL).

NT failure rate with 5-cm angiocatheter

Mean (95% CI) NT failure rate was 38% (24–54%) at ICS2-MCL, 31% (10–64%) at ICS4/5-MAL, and 13% (8–22%) at ICS4/5-AAL (P = .01). The I^2 values, representing heterogeneity of the included studies, were high (Fig. 4).

Optimal Positioning for Emergent Needle Thoracostomy: A Cadaver-Based Study

Kenji Inaba, MD, FRCSC, FACS, Bernardino C. Branco, MD, Marc Eckstein, MD, David V. Shatz, MD, Matthew J. Martin, MD, Donald J. Green, MD, Thomas T. Noguchi, MD, and Demetrios Demetriades, MD, PhD

Figure 1. Photograph of a standard 14-gauge (5-cm long) angiocatheter used for needle thoracostomy as recommended by ATLS guidelines.

TABLE 1. Summary of the Outcomes

	Fifth Intercostal Space		Second Intercostal Space	
	Entered the Chest (Y/N)	Wall (cm)	Entered the Chest (Y/N)	Wall (cm)
Right hemithorax	100.0% (20/20)*	3.6 ± 1.0; (3.5), (2.1, 4.9)*	60.0% (12/20)	4.5 ± 1.1; (4.7), (3.1, 6.2)
Left hemithorax	100.0% (20/20)*	3.5 ± 0.9; (3.3), (2.1, 4.8)*	55.0% (11/20)	4.4 ± 1.1; (4.4), (2.8, 6.1)
Overall	100.0% (40/40)*	3.5 ± 0.9; (3.4), (2.1, 4.9)*	57.5% (23/40)	4.5 ± 1.1; (4.5), (2.8, 6.2)

* p-values are significantly different ($p < 0.05$).

Continuous variables were reported as mean ± SD; (median), (range). Values were reported in centimeters. The p-values for categorical variables were derived from Fisher's exact test; p-values for continuous variables were derived from Mann-Whitney U test.

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JAMA Surgery | Original Investigation

Association of Prehospital Needle Decompression With Mortality Among Injured Patients Requiring Emergency Chest Decompression

Daniel Muchnok, NRP; Allison Vargo, BS; Andrew-Paul Deeb, MD, MSc; Francis X. Guyette, MD, MPH; Joshua B. Brown, MD, MSc

IMPORTANCE Prehospital needle decompression (PHND) is a rare but potentially life-saving procedure. Prior studies on chest decompression in trauma patients have been small, limited to single institutions or emergency medical services (EMS) agencies, and lacked appropriate comparator groups, making the effectiveness of this intervention uncertain.

OBJECTIVE To determine the association of PHND with early mortality in patients requiring emergent chest decompression.

DESIGN, SETTING, AND PARTICIPANTS This was a retrospective cohort study conducted from January 1, 2000, to March 18, 2020, using the Pennsylvania Trauma Outcomes Study database. Patients older than 15 years who were transported from the scene of injury were included in the analysis. Data were analyzed between April 28, 2021, and September 18, 2021.

EXPOSURES Patients without PHND but undergoing tube thoracostomy within 15 minutes of arrival at the trauma center were the comparison group that may have benefited from PHND.

MAIN OUTCOMES AND MEASURES Mixed-effect logistic regression was used to determine the variability in PHND between patient and EMS agency factors, as well as the association between risk-adjusted 24-hour mortality and PHND, accounting for clustering by center and year. Propensity score matching, instrumental variable analysis using EMS agency-level PHND proportion, and several sensitivity analyses were performed to address potential bias.

RESULTS A total of 8469 patients were included in this study; 1337 patients (11%) had PHND (median [IQR] age, 37 [25-52] years; 1096 male patients [82.0%]), and 7132 patients (84.2%) had emergent tube thoracostomy (median [IQR] age, 32 [23-48] years; 6083 male patients [85.3%]). PHND rates were stable over the study period between 0.2% and 0.5%. Patient factors accounted for 43% of the variation in PHND rates, whereas EMS agency accounted for 57% of the variation. PHND was associated with a 25% decrease in odds of 24-hour mortality (odds ratio [OR], 0.75; 95% CI, 0.61-0.94; P = .01). Similar results were found in patients who survived their ED stay (OR, 0.68; 95% CI, 0.52-0.89; P < .01), excluding severe traumatic brain injury (OR, 0.65; 95% CI, 0.45-0.95; P = .03), and restricted to patients with severe chest injury (OR, 0.72; 95% CI, 0.55-0.93; P = .01). PHND was also associated with lower odds of 24-hour mortality after propensity matching (OR, 0.79; 95% CI, 0.62-0.98; P = .04) when restricting matches to the same EMS agency (OR, 0.74; 95% CI, 0.56-0.99; P = .04) and in instrumental variable probit regression (coefficient, −0.60; 95% CI, −1.04 to −0.16; P < .01).

CONCLUSIONS AND RELEVANCE In this cohort study, PHND was associated with lower 24-hour mortality compared with emergent trauma center chest tube placement in trauma patients. Although performed rarely, PHND can be a life-saving intervention and should be reinforced in EMS education for appropriately selected trauma patients.

Table 2. Adjusted Odds Ratio (OR) of 24-Hour Mortality for Prehospital Needle Decompression Compared With Tube Thoracostomy Within 15 Minutes of Arrival at the Trauma Center

Characteristic	aOR (95%CI)	P value
Primary analysis	0.75 (0.61-0.94)	.01
Propensity matched cohort	0.79 (0.62-0.98)	.04
Propensity matched cohort within EMS agency	0.74 (0.56-0.99)	.04
Survived ED stay	0.68 (0.52-0.89)	<.01
Excluded severe head injury	0.65 (0.45-0.95)	.03
Severe chest injury	0.72 (0.55-0.93)	.01
Documented pneumothorax	0.68 (0.49-0.95)	.02
Including patients DOA (n = 8725)	0.67 (0.45-0.98)	.04
Helicopter transport	0.67 (0.52-0.86)	<.01
Ground transport	0.77 (0.60-0.98)	.03

Abbreviations: aOR, adjusted odds ratio; DOA, dead on arrival; ED, emergency department; EMS, emergency medical services.

Circulation Assessment and Volume Resuscitation

- **Hemorrhage** is the predominant cause of preventable deaths after injury.

- Once tension pneumothorax has been excluded as **a cause of shock**, consider that hypotension following injury is **due to blood loss until proven otherwise**.

- Blood Volume and Cardiac Output
  - Level of consciousness
  - Skin color
  - Pulse

  ✓to be palpable – SBP
    - Carotid pulse – 60mmHg
    - Femoral pulse – 70mmHg
    - Radial pulse – 80mmHg
    - Pedal pulse – 100mmHg

- Bleeding

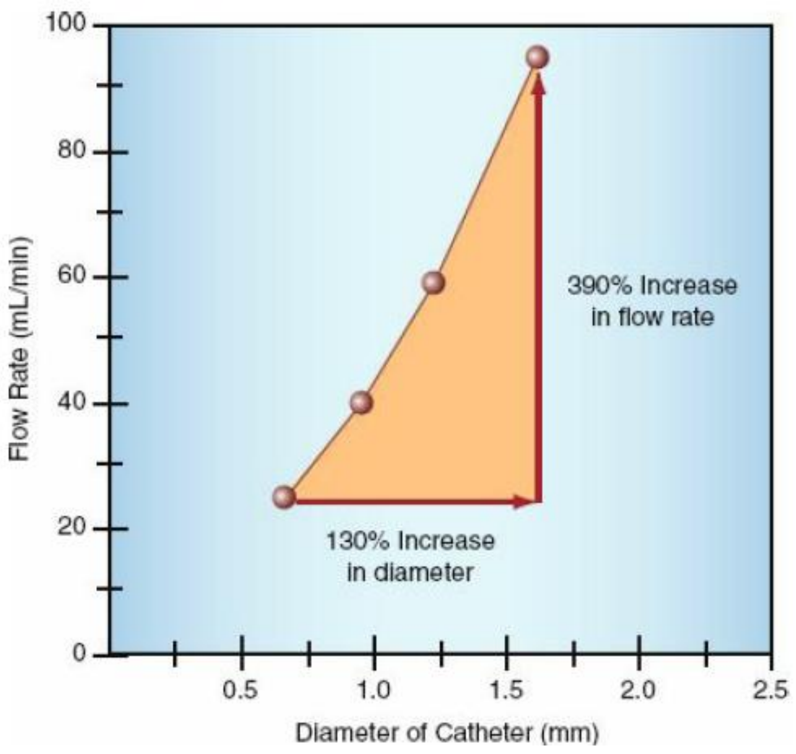
  External hemorrhage is identified and controlled during the primary survey.

	HEMORRHAGE SEVERITY →			
PARAMETER	**MINOR**		**MODERATE**	**MAJOR**
Heart Rate (beats/min)	Unchanged	Unchanged to Increased	Increased (>100)	Markedly Increased (>120)
Systolic Pressure (mm Hg)	Unchanged	Unchanged	Unchanged to Decreased	Markedly Decreased (<90)
Pulse Pressure	Unchanged	Decreased	Decreased	Decreased
Respiratory Rate	Unchanged	Unchanged to Increased	Increased	Increased
Level of Consciousness	Unchanged	Unchanged	Decreased	Markedly Decreased
Base Deficit (meq/L)	0 to -2	-2 to -6	-6 to -10	-10 and less
Blood Products	Unlikely	Possibly	Likely	Massive Transfusion Protocol
Response to Resuscitation	Rapid and Sustained	Fairly Rapid and Sustained	Transient	Minimal to None
Operative Hemorrhage Control	Unlikely	Possibly	Likely	Extremely Likely

Hypovolemic shock

- Central line insertion???
- Crystalloid? Colloid?
- Transfusion?

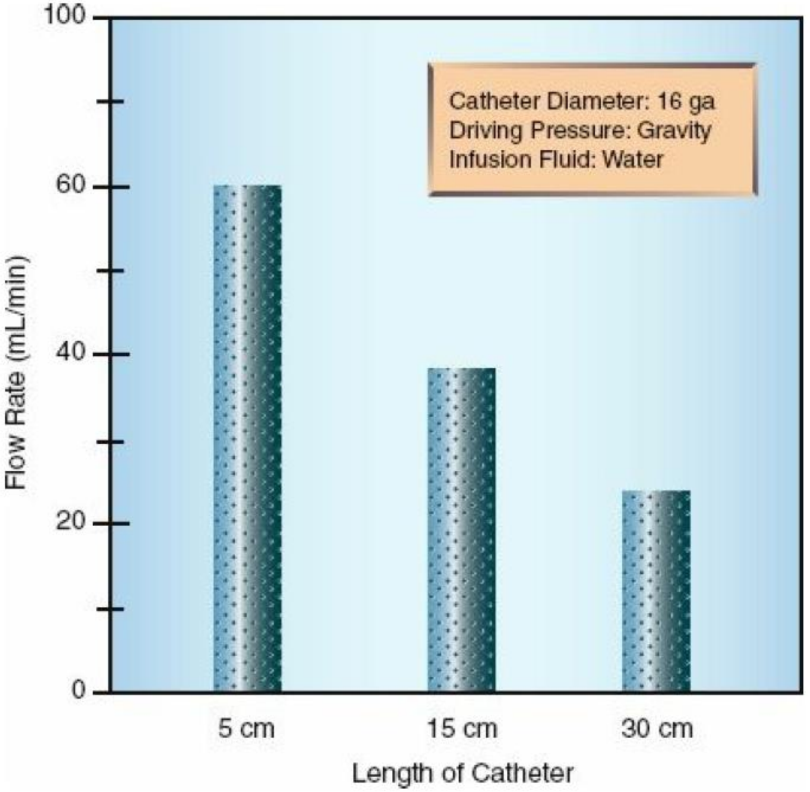
Gauge	Range of Actual OD (mm)	Nominal OD (mm)
24	0.65 – 0.749	0.7
22	0.75 – 0.949	0.8, 0.9
20	0.95 – 1.149	1.0, 1.1
18	1.15 – 1.349	1.2, 1.3
16	1.55 – 1.849	1.6, 1.7, 1.8
14	1.85 – 2.249	1.9, 2.0, 2.1, 2.2



$$Q = \Delta P \times (\pi r^4 / 8\mu L) \quad (1.2)$$

This equation states that the steady flow rate (Q) in a rigid tube is directly related to the fourth power of the inner radius of the tube (r^4), and is inversely related to the length of the tube (L) and the viscosity of the fluid (μ). The term enclosed in parentheses ($\neq r^4/8\mu L$) is equivalent to the reciprocal of resistance (1/R, as in equation 1.1), so the resistance to flow can be expressed as $R = 8\mu L/\neq r^4$.

Since the Hagen-Poiseuille equation applies to flow through rigid tubes, it can be used to describe flow through vascular catheters, and how the dimensions of a catheter can influence the flow rate (see next).



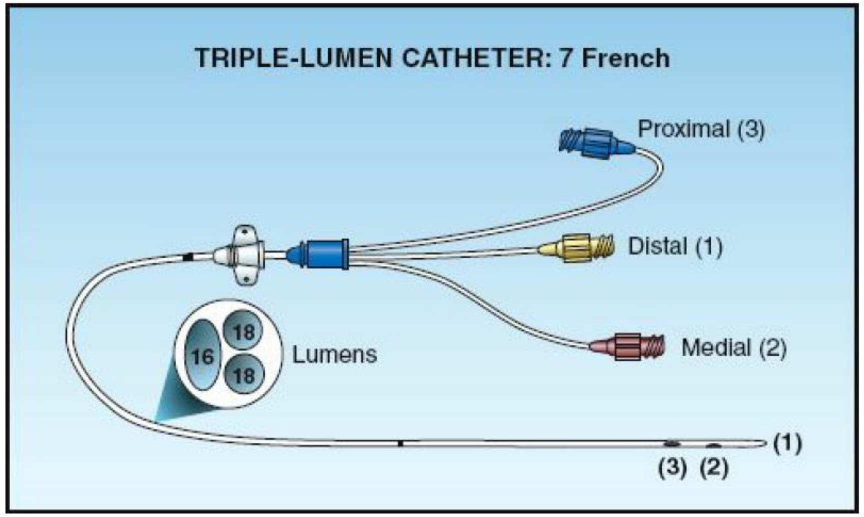


Table 1.2 Flow Characteristics in Peripheral Vascular Catheters

Gauge Size	Length	Flow Rate mL/min	Flow Rate L/hr
16	30 mm (1.2 in)	220	13.2
18	30 mm (1.2 in)	105	6.0
	50 mm (2 in)	60	3.6
20	30 mm (1.2 in)	60	3.6

Table 1.3 Selected Features of Triple-Lumen Central Venous Catheters

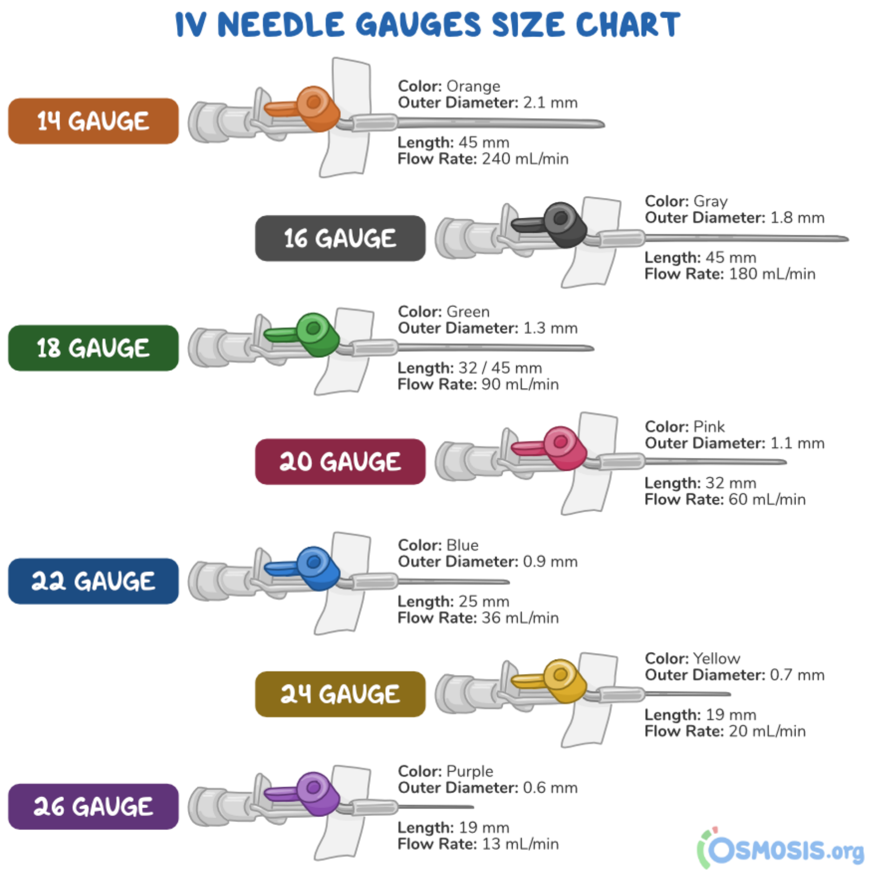
Size	Length	Lumens	Lumen Size	Flow Rate (L/hr)†
7 Fr	16 cm (6 in)	Distal	16 ga	3.4
		Medial	18 ga	1.8
		Proximal	18 ga	1.9
7 Fr	20 cm (8 in)	Distal	16 ga	3.1
		Medial	18 ga	1.5
		Proximal	18 ga	1.6
7 Fr	30 cm (12 in)	Distal	16 ga	2.3
		Medial	18 ga	1.0
		Proximal	18 ga	1.1

†All flow rates are for gravity-driven flow of isotonic saline from a height of 40 inches above the catheters. Fr = French size; ga = gauge size.
From Arrow International (www.arrowintl.com); accessed 8/1/2011.

Initial Management of Hemorrhagic Shock

Vascular Access Lines

✓ This is best done by inserting
two large- caliber (minimum of 16-gauge)
peripheral intravenous catheters
before placing a central venous line is consider



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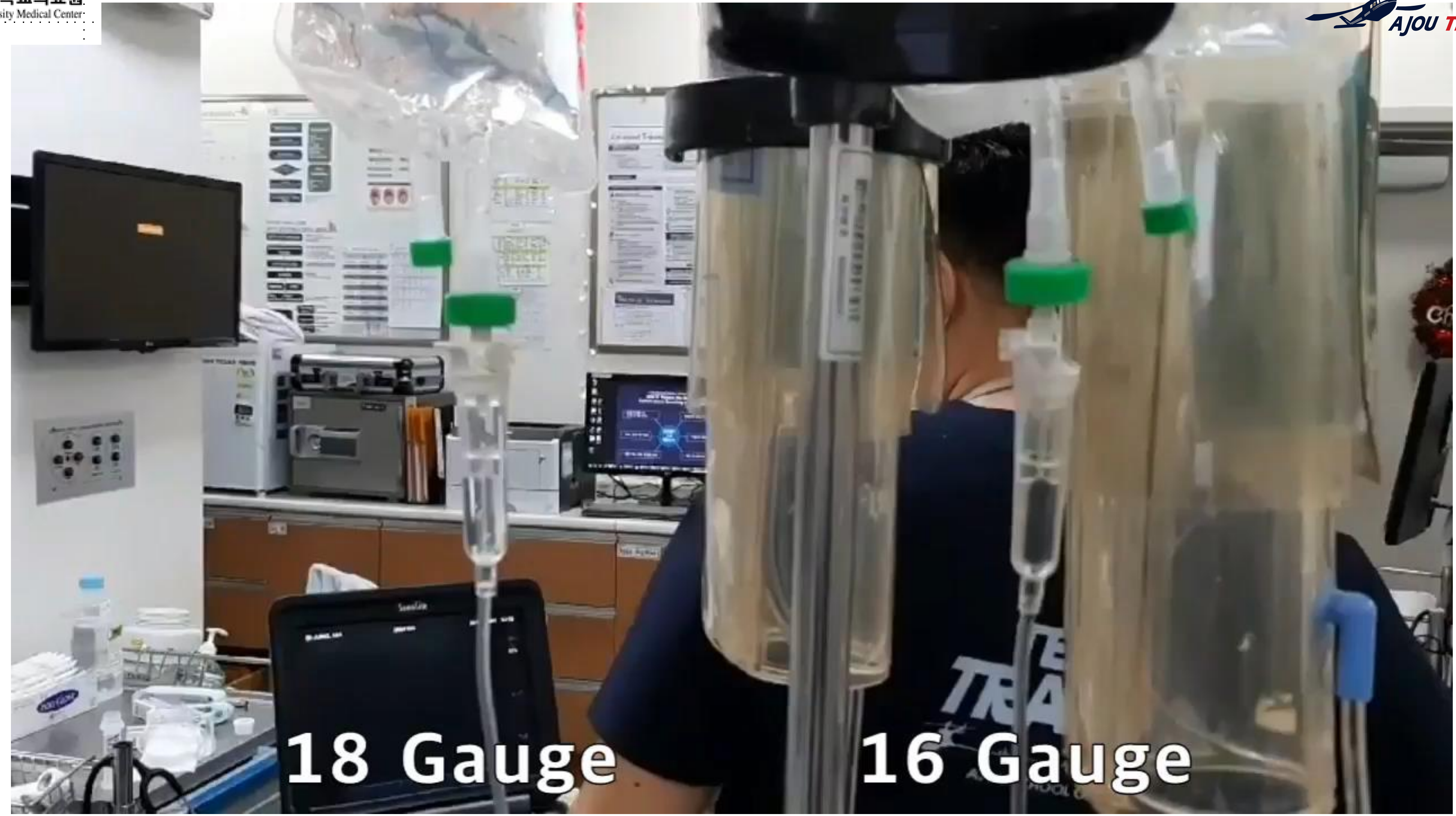
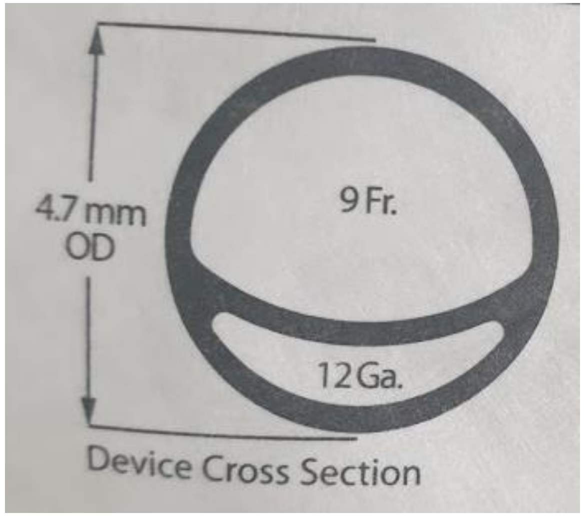


Antecubital/ Wrist / ankle 16G

In patients with injuries below the diaphragm, at least one intravenous (IV) line should be placed in a tributary of the superior vena cava, as there may be vascular disruption or obstruction of the inferior vena cava.

<MAC catheter>



Lumen	Priming Volume* (mL)	Flow Rate† (mL/hr)
Distal (9 Fr.) no catheter	1.65	33,000
Distal (9 Fr.) with 8 Fr. catheter	0.90	10,500
Proximal (12 Ga.) no catheter	0.60	13,000

* Priming volumes are approximate and are done without the injection cap. Injection cap priming volume is 0.17 mL.

† Flow rates are done with normal saline, room temperature, 100 cm head height and represent approximate flow capabilities.

What Fluid?

- Lactated Ringer's

- calcium, serum lactate level elevation in patient with hepatic failure

- Normal saline

- Hyperchloremic metabolic acidosis

- Plasmalyte

- Hypertonic saline

- Colloid

- ARF, coagulopathy, plasma oncotic pressure effect? due to damaged EGL(endothelial gycocalyx layer), expensive..

Fluid	mEq/L						pH	Osmolality (mOsm/L)
	Na	CL	K	Ca§	Mg	Buffers		
Plasma	140	103	4	4	2	HCO_3^-(25)	7.4	290
0.9% NaCL	154	154	–	–	–	–	5.7	308
7.5% NaCL†	1283	1283	–	–	–	–	5.7	2567
Ringer's Injection	147	156	4	4	–	–	5.8	309
Ringer's Lactate	130	109	4	3	–	Lactate (28)	6.5	273
Ringer's Acetate	131	109	4	3	–	Acetate (28)	6.7	275
Normosol Plasma-Lyte A	140	98	5	–	3	Acetate (27) Gluconate (23)	7.4	295

Initial Fluid Therapy

- Warmed (39℃) isotonic crystalloid

- lactated Ringer's
- normal saline
- plasma solution
- as rapidly as possible.

- The usual dose
  - For **adults** : 1 L
  - For **pediatric patients** : 20mL/kg
- **Pumping devices**
- **Transfusion !!**

ORIGINAL ARTICLE

ONLINE FIRST

The Prospective, Observational, Multicenter, Major Trauma Transfusion (PROMMTT) Study

Comparative Effectiveness of a Time-Varying Treatment With Competing Risks

Objective: To relate in-hospital mortality to early transfusion of plasma and/or platelets and to time-varying plasma:red blood cell (RBC) and platelet:RBC ratios.

Design: Prospective cohort study documenting the timing of transfusions during active resuscitation and patient outcomes. Data were analyzed using time-dependent proportional hazards models.

Setting: Ten US level I trauma centers.

Patients: Adult trauma patients surviving for 30 minutes after admission who received a transfusion of at least 1 unit of RBCs within 6 hours of admission (n=1245, the original study group) and at least 3 total units (of RBCs, plasma, or platelets) within 24 hours (n=905, the analysis group).

Main Outcome Measure: In-hospital mortality.

Results: Plasma:RBC and platelet:RBC ratios were not constant during the first 24 hours ($P < .001$ for both). In a multivariable time-dependent Cox model, increased ratios of plasma:RBCs (adjusted hazard ratio=0.31; 95% CI, 0.16-0.58) and platelets:RBCs (adjusted hazard ratio=0.55; 95% CI, 0.31-0.98) were independently associated with decreased 6-hour mortality, when hemorrhagic death predominated. In the first 6 hours, patients with ratios less than 1:2 were 3 to 4 times more likely to die than patients with ratios of 1:1 or higher. After 24 hours, plasma and platelet ratios were unassociated with mortality, when competing risks from nonhemorrhagic causes prevailed.

Conclusions: Higher plasma and platelet ratios early in resuscitation were associated with decreased mortality in patients who received transfusions of at least 3 units of blood products during the first 24 hours after admission. Among survivors at 24 hours, the subsequent risk of death by day 30 was not associated with plasma or platelet ratios.

JAMA Surg. 2013;148(2):127-136. Published online October 15, 2012. doi:10.1001/2013.jamasurg.387

Research

Original Investigation

Transfusion of Plasma, Platelets, and Red Blood Cells in a 1:1:1 vs a 1:1:2 Ratio and Mortality in Patients With Severe Trauma
The PROPPR Randomized Clinical Trial

John B. Holcomb, MD; Barbara C. Tilley, PhD; Sarah Baraniuk, PhD; Erin E. Fox, PhD; Charles E. Wade, PhD; Jeanette M. Podbielski, RN; Deborah J. del Junco, PhD; Karen J. Brasel, MD, MPH; Eileen M. Bulger, MD; Rachael A. Callcut, MD, MSPH; Mitchell Jay Cohen, MD; Bryan A. Cotton, MD, MPH; Timothy C. Fabian, MD; Kenji Inaba, MD; Jeffrey D. Kerby, MD, PhD; Peter Muskat, MD; Terence O'Keeffe, MBChB, MSPH; Sandro Rizoli, MD, PhD; Bryce R. H. Robinson, MD; Thomas M. Scalea, MD; Martin A. Schreiber, MS; Deborah M. Stein, MD; Jordan A. Weinberg, MD; Jeannie L. Callum, MD; John R. Hess, MD, MPH; Nena Matijevic, PhD; Christopher N. Miller, MD; Jean-Francois Pittet, MD; David B. Hoyt, MD; Gail D. Pearson, MD, ScD; Brian Leroux, PhD; Gerald van Belle, PhD; for the PROPPR Study Group

	1:1:1	1:1:2	
Mortality at 24 hours	12.7%	17%	P=0.12
Mortality at 30 days	22.4%	26.1%	P=.26
Exsanguination	9.2%	14.6%	P=0.03*
Hemostasis achieved	86%	78%	p=0.006*

Vasopressors are contraindicated as a first-line treatment of hemorrhagic shock because they worsen tissue perfusion.

Definitive bleeding control is essential, along with appropriate replacement of intravascular volume.

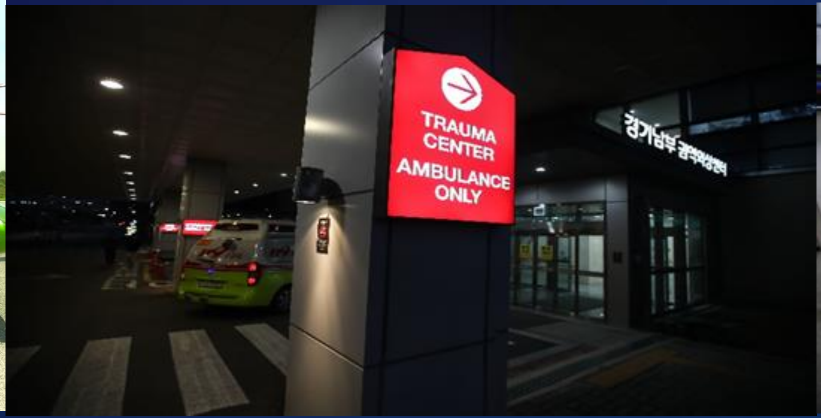
Aggressive and continued volume resuscitation is not a substitute for definitive control of hemorrhage.

Find Bleeding Focus!

- **CHEST**
  - **Physical Examination**
  - Massive Hemothorax
- **ABDOMEN**
  - **Physical Examination**
  - FAST, f/u
- **PELVIS**
  - **Physical Examination**
  - Pelvic X-ray /pelvic binder /Pre-Peritoneal Packing
- **LONG BONES**
  - **Physical Examination**
  - Splinting / traction
- **EXTERNAL**
  - **Physical Examination**
  - Direct compression/Tourniquet

blood is lost into the site of injury, particularly in cases of major fractures

- ✓ **Tibia** or **Humerus** fracture = loss of **750mL** of blood
- ✓ **Femur** fracture = up to **1500mL**
- ✓ **Pelvic** fracture = **Several liters** of blood



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Thank you for your attention