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Trauma Facts and Formulas

Trauma results in a number of emergency department presentations and intensive care unit admissions around the world and a number of formulas, scores, and indices are available for the assessment and management of these patients.

1. HEMORRHAGE

In order to assess the intravascular volume resuscitation needed in a trauma patient, *normal blood volumes* according to age need to be known (see Table 16.1):

Severity of Hemorrhage
The *severity of hemorrhage* in a trauma patient can be classified as shown in Table 16.2:

Table 16.1 Normal blood volumes according to age

Normal blood volumes by age	
Newborn	85 mL/kg
Infant	80 mL/kg
Child	75 mL/kg
Adult	70 mL/kg

J. Varon and R.E. Fromm Jr., *Acute and Critical Care Formulas and Laboratory Values*, DOI 10.1007/978-1-4614-7510-1_16,

Table 16.2 Severity of hemorrhage classification trauma patients

Severity of hemorrhage	*BP (mmHg)*	*Blood loss (mL)*	*Blood loss (%)*	*HR*	*Pulse pressure*	*RR*	*Urine output (mL/h)*	*CNS/mental status*	*Fluid replacement*
Class I	Normal	>750	>15	<100	Normal or decreased	14–20	>30	Slightly anxious	Crystalloid
Class II	Normal	750–1,500	15–30	>100	Decreased	20–30	20–30	Mildly anxious	Crystalloid
Class III	Decreased	150–2,000	30–40	>120	Decreased	30–40	5–15	Anxious confused	Crystalloid and blood
Class IV	Decreased	>2,000	>40	>140	Decreased	>35	Negligible	Confused lethargic	Crystalloid and blood

BP blood pressure, *HR* heart rate, and *RR* respiratory rate

The following formula can be utilized to estimate how much whole blood or packed red blood cells (PRBCs) must be administered to change the hematocrit percentage to the desired amount in a trauma patient:

$$\textbf{Transfusion required (mL)} = \text{Desired change in Hct} \times \text{kg} \times \text{factor}$$

where

Hct = hematocrit
factor = varies with the volume of blood per body weight (adults and children >2 years, a factor of 1 will achieve a Hct of 70 % using PRBC and 1.75 to achieve a Hct of 40 % using whole blood)

2. BURNS

Please refer also to Chap. 3.

There are several formulas that guide the initial fluid resuscitation after burn injuries. Below are the most common formulas used in clinical practice. In all these formulas, 50 % of calculated volume is given during the first 8 h, 25 % of calculated volume is given during the second 8 h, and 25 % of calculated volume is given during the third 8 h.

Fluids used for fluid management in major buns.

Parkland Formula

The *Parkland formula* can be calculated as:

$$\textbf{< 24 h} = \text{Ringer's lactated (RL) solution 4 mL/kg/\% burn for adults and 3 mL/kg/\% burn for children}$$

RL solution is added for maintenance for children:

- 4 mL/kg/h for children 0–10 kg
- 40 mL/h + 2 mL/h for children of 10–20 kg
- 60 mL/h + 1 mL/kg/h for children of ≥20 kg

This formula recommends no colloid in the initial 24 h.

$$\textbf{> 24 h} = \text{Colloids given as 20-60 \% of calculated plasma volume}$$

No crystalloids. Glucose in water is added in amounts required to maintain a urinary output of 0.5–1 mL/h in adults and 1 mL/h in children.

Modified formula:

$$\textbf{< 24 h} = \text{RL 4 mL / kg / \% burn (adults)}$$

$$\textbf{> 24 h} = \text{Begin colloid infusion of 5\% albumin 0.3-1 mL / kg / \% burn / 16 / h}$$

Evans Formula
The *Evans formula* can be calculated as:

< 24 h = Crystalloids 1 mL / kg / % burn plus colloids at 1 mL / kg / % burn plus 2,000 mL glucose in H_2O

> 24 h = Crystalloids at 0.5 mL / kg / % burn, colloids at 0.5 mL / kg / % burn, and the same amount of glucose in water as in the first 24 h

Brooke Formula and the Modified Brooke Formula
The *Brooke formula* and the *modified Brooke formula* are calculated as:

< 24 h = RL solution 1.5 mL / kg / % burn plus colloids 0.5 mL / kg / % burn plus 2,000 mL glucose in water

> 24 h = RL 0.5 mL / kg / % burn, colloids 0.25 mL / kg / % burn, and the same amount of glucose in water as in the first 24 h

Modified formula = 2 mL Ringer's lactate/kg/% burn/24 h:

< 24 h = No colloids

RL solution 2 mL/kg/% burn in adults and 3 mL/kg/% burn in children.

> 24 h = Colloids at 0.3-0.5 mL / kg / % burn and no crystalloids are given

Glucose in water is added in the amounts required to maintain good urinary output.

In addition to these formulas, the evaporative water losses in patients with burns need to be calculated and replaced.

Evaporative Water Loss
Evaporative water loss (EWL) is calculated as:

$$\textbf{EWL (mL / h)} = (25 + \%\ \text{BSA burned}) \times \text{BSA}$$

3. TRAUMA SCORING SYSTEMS

Out of the many used injury scoring systems, the abbreviated injury scale (AIS) is the most commonly used (see Table 16.3):

Table 16.3 The abbreviated injury scale

AIS score	*Injury severity*
1	Minor
2	Moderate
3	Serious
4	Severe
5	Critical
6	Unsurvivable

Trauma Score

The *trauma score* (TS) is another commonly utilized system and is depicted in Table 16.4:

Table 16.4 The trauma score

Variable	*Measurements*	*Score*
Respiratory rate (bpm)	10–24	4
	25–35	3
	> 35	2
	0–9	1
Respiratory effort	Normal	1
	Shallow, retractive	0
Systolic blood pressure (mm Hg)	>90	4
	70–90	3
	50–69	2
	<50	1
	No carotid pulse	0
Capillary refill	Normal	2
	Delayed	1
	Absent	0
Glasgow coma scale	14–15	5
	11–13	4
	8–10	3
	5–7	2
	3–4	1

Revised Trauma Score
The *revised trauma score* (RTS) eliminates the assessment of capillary refill and respiratory effort and is calculated as:

$$\mathbf{RTS} = 0.9368\,\text{GCS} + 0.7326\,\text{SBP} + 0.2908\,\text{RR coded values} \times \text{Revised score coefficient}$$

where

GCS = Glasgow coma scale
SBP = systolic blood pressure
RR = the respiratory rate

For children and infants, the *pediatric trauma score* is utilized (see Table 16.5):

Table 16.5 The pediatric trauma score

Variable	*+2*	*+1*	*−1*
Weight (kg)	>20	10–20	<10
Airway	Normal	Maintained	Non-maintained
Systolic BP (mm Hg)	> 90	50–90	<50
CNS function	Awake	Obtunded/loss of consciousness	Coma/decerebrate
Open wound	None	Minor	Major
Skeletal trauma	None	Closed	Open or multiple

■ 4. NEUROLOGICAL TRAUMA

AVPU Method
Within the primary survey, an early neurological trauma evaluation can be accomplished using the *AVPU method*:

A = *a*lert
V = responds to *v*erbal stimulation
P = responds to *p*ainful stimulation
U = *u*nresponsive

Glasgow Coma Scale
The *Glasgow coma scale* (Table 16.6) is another frequently utilized method of assessment of the neurological status of the trauma patient:

Table 16.6 Glasgow coma scale

Variable	*Score*
Eye opening	
Spontaneous	4
To verbal command	3
To pain	2
None	1
Best motor response	
Obeys verbal commands	6
Localizes painful stimuli	5
Flexion-withdrawal from painful stimuli	4
Decorticate (flexion) response to painful stimulation	3
Decerebrate (extension) response to painful stimulation	2
None	1
Best verbal response	
Oriented conversation	5
Disoriented conversation	4
Inappropriate words	3
Incomprehensible sounds	2
None	1

Cerebral Perfusion Pressure
In those patients with severe head injuries and intracranial pressure monitoring, *cerebral perfusion pressure* (CPP) is commonly utilized in management and is calculated as:

$$\mathbf{CPP} = \mathrm{MAP} - \mathrm{ICP}$$

where

MAP = mean arterial blood pressure
ICP = intracranial pressure

Pressure–Volume Index

Another useful formula in neurological trauma is that of the calculation of the *pressure–volume index* (PVI), which is defined as the volume (in mL) necessary to raise the cerebrospinal fluid (CSF) pressure by a factor of 10:

$$\mathbf{PVI} = \frac{\Delta V}{\log 10(P_{\mathrm{p}} / P_0)}$$

where

ΔV = volume change in the lateral ventricle using a ventricular cannula
P_0 = initial ICP
P_{p} = peak ICP