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Commonly Used Cardiovascular Formulae

GENERAL HEMODYNAMICS

Mean arterial pressure (mm Hg) = Diastolic blood pressure (BP) + 1/3 (Systolic BP – Diastolic BP)

Stroke volume (mL) = End-diastolic volume – End-systolic volume

Cardiac output (L/min) = Heart rate × Stroke volume

Ohms law $V = IR$

V = Pressure difference across the system

I = Cardiac output or flow

R = Resistance across the system

Systemic vascular resistance (Wood unit) = $\dfrac{\text{Mean arterial pressure} - \text{Central venous pressure}}{\text{Cardiac output}}$

Pulmonary vascular resistance (Wood unit) = $\dfrac{\text{Mean PA pressure} - \text{Mean PCWP}}{\text{Cardiac output}}$

PA, pulmonary artery; PCWP, pulmonary capillary wedge pressure

1 Wood unit = 80 dynes/s/cm^5

Pulmonary vascular resistance (echo) (Wood unit) = $\left(\dfrac{\text{Tricuspid regurgitation velocity}}{\text{RVOT VTI}}\right) \times 10 + 0.16$

RVOT, right ventricular outflow tract; VTI, Velocity Time Integral

Transpulmonary gradient (mm Hg) = Mean PAP – PCWP

PAP, pulmonary artery pressure; PCWP, pulmonary capillary wedge pressure

Fick equation

Cardiac output (L/min) = $\dfrac{\text{V}O_2\ (\text{mL/min})}{1.36\ (\text{mL } O_2/\text{g Hgb}) \times \text{Hgb (g/dL)} \times 10\ (\text{dL/L})\ [\text{Sa}O_2 - \text{Sv}O_2]}$

Vo_2 (oxygen consumption)

Cardiac index (L/min/m^2) = $\dfrac{\text{Cardiac output (L/min)}}{\text{Body surface area } (m^2)}$

Body surface area (m^2) = [Height (cm) + Weight (kg) – 60]/100

Dubois formula for body surface area (m^2) = $\sqrt{\dfrac{\text{Height (cm)} \times \text{Weight (kg)}}{3{,}600}}$

Stroke work (g-m/beat) = Stroke volume × Mean arterial pressure × 0.0144

Stroke work index (g-m/m^2/beat) = $\dfrac{\text{Stroke work}}{\text{Body surface area}}$

Coronary flow reserve = $\dfrac{\text{Peak coronary velocity at maximal hyperemia}}{\text{Peak coronary velocity at baseline}}$

Fractional flow reserve = $\dfrac{\text{Mean distal coronary pressure beyond stenosis}}{\text{Mean aortic pressure}}$

VALVULAR DISEASE AND LEFT VENTRICULAR (LV) FUNCTION

Gorlin equation

Aortic valve area (cm^2) =

$$\frac{\text{Cardiac output (mL/min)}}{44.3 \times \text{Systolic ejection period (s/beat)} \times \text{Heart rate (beats/min)} \times \sqrt{\text{Mean gradient}}}$$

Mitral valve area (cm^2) =

$$\frac{\text{Cardiac output (mL/min)}}{38 \times \text{Diastolic filling period (s/beat)} \times \text{Heart rate (beats/min)} \times \sqrt{\text{Mean gradient}}}$$

Hakki equation

Aortic valve area (cm^2) = $\dfrac{\text{Cardiac output}}{\sqrt{\text{Peak to peak gradient}}}$ or $\dfrac{\text{Cardiac output}}{\sqrt{\text{Mean gradient}}}$

Mitral valve area (cm^2) = $\dfrac{\text{Cardiac output}}{\sqrt{\text{Mean gradient}}}$

Simplified Bernoulli equation

Pressure difference = 4 v^2

If proximal velocity > 1 m/s, then pressure difference = 4 [(distal jet velocity)^2 – (proximal velocity)^2]

Continuity aortic valve area (cm^2) = $\text{Diameter}_{\text{LVOT}}{}^2 \times 0.785 \times \dfrac{\text{VTI}_{\text{LVOT}}}{\text{VTI}_{\text{Aortic valve}}}$

LVOT, left ventricular outflow tract; VTI, velocity time integral

Dimensionless index = $\dfrac{\text{VTI}_{\text{LVOT}}}{\text{VTI}_{\text{Aortic valve}}}$

VTI, velocity time integral; LVOT, left ventricular outflow tract

Stroke volume (mL) = $\text{Diameter}_{\text{LVOT}}{}^2 \times 0.785 \times \text{VTI}_{\text{LVOT}}$

VTI, velocity time integral; LVOT, left ventricular outflow tract

Aortic regurgitant fraction (%) = $\dfrac{\text{Aortic regurgitant volume}}{\text{LVOT stroke volume}} \times 100$

LVOT, left ventricular outflow tract

Mitral valve area (mitral stenosis) (cm^2) = $\dfrac{220}{\text{Pressure half time}}$

Tricuspid valve area (tricuspid stenosis) (cm^2) = $\dfrac{190}{\text{Pressure half time}}$

Pressure half time (ms) = 0.29 × Deceleration time

Proximal isovelocity surface area (PISA) method in mitral regurgitation

$$\text{Regurgitant orifice area (cm}^2) = \frac{6.28\, r^2 \times \text{Aliasing velocity}}{\text{Mitral regurgitation velocity}}$$

r, radius of PISA

Simplified PISA when aliasing velocity ~40 cm/s and peak continuous wave mitral regurgitation velocity ~5 m/s

$$\text{Regurgitant orifice area (cm}^2) = \frac{r^2}{2}$$

r, radius of PISA

Mitral regurgitant volume (mL) = $1.9r^2 \times$ Aliasing velocity

r, radius of PISA

Mitral regurgitant fraction $(\%) = \dfrac{\text{Mitral regurgitant volume}}{\text{Mitral valve flow}} \times 100$

Fractional shortening $(\%) = \dfrac{\text{LVED dimension} - \text{LVES dimension}}{\text{LVED dimension}} \times 100$

LVED, left ventricular end diastole; LVES, left ventricular end systole

Ejection fraction $(\%) = \dfrac{\text{End diastolic volume} - \text{End systolic volume}}{\text{End diastolic volume}} \times 100$

Estimated pulmonary artery systolic pressure (mm Hg) =
RA pressure + 4 × (Peak tricuspid regurgitation velocity)^2

RA, right atrium

Estimated pulmonary artery end-diastolic pressure (mm Hg) =
RA pressure + 4 × (Pulmonary regurgitation end-diastolic velocity)^2

RA, right atrium

Assessment of right atrial (RA) pressure (by echo)

IVC diameter (cm)	IVC collapse	Estimated RA pressure (mm Hg)
≤ 2.1	> 50%	3 (range 0–5)
≤ 2.1	< 50%	8 (range 5–10)
> 2.1	> 50%	8 (range 5–10)
> 2.1	< 50%	15 (range 10–20)

IVC, inferior vena cava

Left atrial (LA) pressure (mm Hg) =
Systolic blood pressure − 4 × (Mitral regurgitation velocity)^2

LV mass (area length) = $1.05\{[5/6\ \text{A1}(a + d + t)] - [5/6\ \text{A2}\ (a + d)]\}$

A1 = area of LV short axis using epicardial perimeter

A2 = area of LV short axis using endocardial perimeter

t = myocardial thickness

a = long axis length from widest minor axis radius to apex

b = short axis radius

d = truncated long axis from widest short axis diameter to mitral annulus plane

D*p*/d*t* $= \dfrac{32{,}000 \text{ mm Hg}}{dt \text{ (in seconds)}}$

Dt, time it takes velocity to go from 1 to 3 m/s

Tei index (myocardial performance index) =

$$\frac{\text{Isovolumic contraction time} + \text{Isovolumic relaxation time}}{\text{Ejection time}}$$

SHUNTS

Shunt fraction (Q_p/Q_s) $= \dfrac{(SaO_2 - SvO_2)}{(PvO_2 - PaO_2)}$

SaO_2, systemic arterial oxygen saturation

SvO_2, systemic venous oxygen saturation

PvO_2, pulmonary venous oxygen saturation

PaO_2, pulmonary arterial oxygen saturation

MvO_2 (%) $= \dfrac{3 \times (\text{SVCsat}) + (\text{IVCsat})}{4}$

MvO_2, mixed venous saturation

SVC, superior vena cava

IVC, inferior vena cava

Q_p/Q_s (echo) $= \dfrac{\text{RVOT Cross-sectional area} \times \text{RVOT TVI}}{\text{LVOT Cross-sectional area} \times \text{LVOT VTI}}$

RVOT, right ventricular outflow tract

VTI, velocity time integral

LVOT, left ventricular outflow tract

ELECTROPHYSIOLOGY/ECG

QT_c (ms) $= \dfrac{QT}{\sqrt{\text{RR interval (seconds)}}}$

Heart rate (beats/min) $= \dfrac{60{,}000}{\text{Cycle length (ms)}}$

Left ventricular hypertrophy

Limb lead criteria

(1) R wave in lead I + S wave in lead III > 2.5 mV

(2) R wave in aVL > 1.1 mV

(3) R wave in aVF > 2.0 mV

(4) S wave in aVR > 1.4 mV

Precordial lead criteria

(1) R wave in V_5 or $V_6 > 2.6$ mV

(2) R wave in V_6 + S wave in $V_1 > 3.5$ mV

(3) Largest R wave + largest S wave in precordial leads > 4.5 mV

Cornell criteria

R wave in aVL + S wave in $V_3 > 2.0$ mV for females and 2.8 mV for males

Duke treadmill score (DTS)

DTS = Exercise time (minutes) – (5 × Maximal ST deviation) – (4 × Angina score)

0 = no angina

1 = nonlimiting angina

2 = angina limiting further testing

DTS ≤ −11 = high risk

DTS – 10 to 4 = moderate risk

DTS ≥ 5 = low risk

Age-predicted maximal heart rate (beats/min) = 220 – Age

PHARMACODYNAMICS

Volume of distribution (L) $= \dfrac{\text{Amount of drug in body}}{\text{Plasma drug concentration}}$

Loading dose (mg) $= \dfrac{(\text{Volume of distribution}) \times (\text{Plasma drug concentration})}{(\text{Fraction of dose that is active}) \times (\text{Bioavailability of drug})}$

Clearance (L/h) $= \dfrac{\text{Rate of drug administration}}{\text{Steady-state plasma drug concentration}}$

Half-life (h) $= \dfrac{0.693 \times \text{Volume of distribution}}{\text{Clearance (L/h)}}$

MISCELLANEOUS

Cockcroft-Gault

Glomerular filtration rate (mL/min) $= \dfrac{[(140 - \text{Age}) \times \text{Weight (kg)}]}{72 \times \text{Creatinine}}$

If female, multiply by 0.85

Ankle-Brachial index $= \dfrac{\text{Pedal pressure}}{\text{Brachial pressure (higher of two sides)}}$

Law of Laplace

Wall tension $= \dfrac{\text{Pressure} \times \text{Radius}}{\text{Wall thickness}}$

Central perfusion pressure = Mean arterial pressure – Intracranial pressure

Assessment of appropriateness of ascending aorta size to height

Aortic index $= \dfrac{\text{Maximal cross-sectional area of ascending aorta (cm}^2\text{)}}{\text{Height (m)}}$

If ratio > 10, consider repair of aorta

Cholesterol mg/dL to mmol/L

1 mg/dL = 0.02586 mmol/L; 1 mmol/L = 38.7 mg/dL

Thus, 130 mg/dL = 3.45 mmol/L

Total cholesterol = LDL cholesterol + HDL cholesterol + 0.20 (Triglyceride level)

HDL, high-density lipoprotein; LDL, low-density lipoprotein

STATISTICS

	Disease present	Disease absent
Test result positive	a (True positive)	b (False positive)
Tests result negative	c (False negative)	d (True negative)

Sensitivity $= \dfrac{a}{a + c}$

Specificity $= \dfrac{d}{b + d}$

Positive predictive value $= \dfrac{a}{a + b}$

Negative predictive value $= \dfrac{d}{c + d}$

Likelihood ratio for a positive test $= \dfrac{\text{Sensitivity}}{1 - \text{Specificity}} = \dfrac{a/a + c}{b/b + d}$

Likelihood ratio for a negative test $= \dfrac{1 - \text{Sensitivity}}{\text{Specificity}} = \dfrac{c/a + c}{d/b + d}$

	Outcome positive	Outcome negative
Treated group	a	b
Control group	c	d

Relative risk $= \dfrac{\text{Risk of outcome in treated group}}{\text{Risk of outcome in control group}} = \dfrac{a/a + b}{c/c + d}$

Relative risk reduction = (1 − Relative risk) × 100%

Absolute risk reduction = Difference in risk of outcome between control group and treated group

Absolute risk reduction = c/c + d − a/a + b

Number needed to treat $= \dfrac{1}{\text{Absolute risk reduction}}$

Odds ratio $= \dfrac{\text{Number of outcome events/Number of subjects}}{1 - \text{(Number of outcome events/Number of subjects)}}$