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Neonatology

Indian Academy of Pediatrics
NEONATOLOGY CHAPTER

Protocols in Neonatology



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Rhishikesh Thakre
Srinivas Murki

Forewords
Ashok Deorari
Pramod Jog

2nd Edition

JAYPEE

Protocols in Neonatology

Second Edition

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CHAPTER

4

Neonatal Shock

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DEFINITION

Shock is a state of acute circulatory failure resulting in decreased tissue and organ perfusion which leads to depletion of oxygen and substrate in the cells. When this happens, anaerobic metabolism sets in, leading to accumulation of toxic waste products eventually causing cell death.

PHASES OF SHOCK

Shock is a progressive dynamic disorder which evolves over three phases—compensated, uncompensated, and irreversible.

Compensated Shock

In compensated shock, perfusion to vital organs, such as the brain, heart, and adrenal glands, is preserved. Clinical signs include pallor, tachycardia, cool extremities, and delayed capillary refill time (>3 sec) (Table 1).

Uncompensated Shock

During uncompensated shock, delivery of oxygen and nutrients to tissues becomes marginal or insufficient to meet demands. Clinical signs include hypotension, delayed capillary refill time, tachycardia, cold skin, tachypnea, and decreased or absent urine output (Table 1).

Table 1: Phases of shock.

	Compensated	*Decompensated*
Pulse	Tachycardia	Marked tachycardia; can arrest
Skin	White, cool, moist	White, "waxy", cold, marked diaphoresis
BP	Normal	Hypotension
Level of consciousness	Unaltered	Altered, ranging from drowsy to coma

Irreversible Shock

Irreversible shock is a retrospective diagnosis. Despite adequate resuscitation of circulation multiorgan damage sets in and ultimately leads to death.

It may take hours for a compensated shock to become uncompensated shock but it takes few minutes for an uncompensated shock to become irreversible shock.

ROLE OF BLOOD PRESSURE IN SHOCK

There is currently no consensus on the best method to measure blood pressure in all

cases. Invasive blood pressure measurement is widely accepted as the optimum method and its use is restricted to critically ill and those in refractory shock.

Oscillometric method is a noninvasive technique which serves as a surrogate marker. The measurements are taken with the infant in a comfortable position, using an appropriate size and position of cuff and in a restful state. The clinician should evaluate BP measurements within the context of the infant's history and current clinical assessment.

Full assessment of systemic blood flows and an individual baby's hemodynamic status is possible with fECHO for diagnosis and monitoring treatment.

- Hypotension is defined as mean arterial blood pressure less than the 10th centile for gestation/birth weight and postnatal age OR
- Mean arterial blood pressure in millimeters of mercury at or lesser than the mean gestational age in weeks. However, it is worth noting that this is only valid in the first 48 hours of life
- Hypotension is a late sign of shock

The variation in time (trend monitoring) might possibly be more informative than individual, static values. There is no research that has shown either technique for detection and management of BP leads to change in important clinical outcomes.

TYPES OF SHOCK

Many conditions and pathophysiologic disturbances are associated with shock and hypotension. Causes of neonatal shock are shown in Table 2.

EVALUATION OF A NEWBORN WITH SHOCK

Clinical manifestations of shock and hypotension are depicted in Table 3. But none of these alone can be used to diagnose shock. More the parameters affected, more is the likelihood of shock.

Diagnosis: Table 4 depicts certain clues which can help in diagnosing the type of shock and further management.

Table 2: Types of shock and causes of neonatal shock.

Sr. No.	*Types*	*Causes*
1.	Cardiogenic	Perinatal asphyxia, congenital heart disease, cardiomyopathy (IDM), heart failure, arrhythmias, or myocardial ischemia, bacterial toxins
2.	Hypovolemic	Acute blood loss—antepartum hemorrhage, umbilical cord accidents, traumatic birth, twin-to-twin transfusion, perioperative, IVH
3.	Distributive	Sepsis, vasodilators, myocardial depression, or endothelial injury
4.	Obstructive	*Inflow obstructions:* • TAPVR • Acquired inflow obstructions—air or thrombotic embolus • Increased intrathoracic pressure caused by high airway pressures or air-leak syndromes (e.g. pneumothorax) *Outflow obstructions:* • Pulmonary stenosis or atresia/aortic stenosis or atresia • Hypertrophic subaortic stenosis (IDM) • Coarctation of the aorta
5.	Dissociative	Profound anemia or methemoglobinemia

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Table 3: Clinical manifestations of shock and hypotension.

Sr. No.	*Parameter*	*Comments*
1	Color	Subjective, influenced by light, skin temperature, race, hemoglobin status
2	Capillary refill time (CRT)	The normal range is <3 sec Subjective, may be delayed if there is hypothermia For most reliable assessment, base of the sternum is preferred
3	Central-peripheral temperature difference	Under normal conditions, core peripheral temperature difference is <2°C. If it is more than 3°C sepsis needs to be ruled out It is influence by body temperature, environmental temperature and the use of vasoactive drugs
4	Blood pressure	Hypotension suggests decompensated shock. It is a late sign BP is determined by cardiac output and systemic vascular resistance
5	Heart rate	Tachycardia may be seen with fever, anemia, pain, agitation, cry, bleeding, drugs, cardiac failure or arrhythmia. It influences the cardiac output and myocardial perfusion
6	Urine output	Denotes renal perfusion. It is a late marker. Oliguria is urine output <1 cc/kg/hr

Table 4: Clues which can help in diagnosing the type of shock and further management.

Hypovolemic shock: Insufficient circulatory blood volume	
Causes	*Clinical clues*
• **Blood Loss:** Perinatal history – APH - Placental abruption/previa. – Uterine rupture – IVH – Pulmonary hemorrhage – DIC	Pallor Bulging fontanelle ETT bleed
• **Plasma Loss** – Low oncotic pressure – Capillary leak	Hydrops Sepsis
• **ECF Loss** – Insensible water loss	Extreme prematurity Gastroschisis Excessive weight loss Epidermolysis bullosa
Cardiogenic shock: Insufficient cardiac output, despite, sufficient blood volume in the ventricles d/t pump failure	
– Myocardial dysfunction – IDM – Sepsis – Arrhythmia – Heart rate more than 220	Perinatal asphyxia ECG rhythm disturbances
• **Obstructive shock:** Obstruction to blood flow – Tension pneumothorax, pneumomediastinum CO_2 retention – Pulm atresia/stenosis – Obstruct TA, MA, TAPVC	Hyper-expanded chest Reduced air entry Hyperoxia test
• **Distributive shock** – Peripheral vasodilatation – Sepsis – Supportive evidence – Drugs and neurogenic	Wide pulse pressure

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Parameters	*Cardiogenic*	*Hypovolemic*	*Early septic (warm)*	*Late septic (cold)*
Blood pressure	Low	Low	Low	Low
CVP	High	Low	Normal	High
Pulse pressure	Decreased	Decreased	Normal	Decreased
Systemic vascular resistance	High	High	Low	High
Cardiac output	Low	Low	High/normal	Low
Core to peripheral skin temperature difference	Increased	Increased	Normal/decreased	Increased

INVESTIGATIONS AND MONITORING

- Continuous vitals monitoring should include heart rate to look for tachycardia and blood pressure for hypotension.
- Monitoring of perfusion and sensorium.
- Invasive intra-arterial blood pressure monitoring is preferred over noninvasive blood pressure, for the need of accuracy.
- Hourly urine output, preferably by placing a urinary catheter is an objective method to evaluate organ specific hypoperfusion.

Investigations:

- Complete blood count to look for anemia
- Total and differential white blood cell (WBC) counts
- C-reactive protein (CRP) and blood culture
- Blood sugar
- Blood grouping and cross matching
- Serum glutamic-pyruvic transaminase (SGPT)
- BUN and creatinine
- Creatine kinase-muscle/brain (CPK-MB)
- Coagulation profile assessment of organ perfusion
- Arterial blood gas (ABG)—assessment of acid-base status
- Serum lactate.
- Echocardiography and Doppler flow velocimetry—assessment of myocardial function and cardiac anatomy
- Inferior vena cava (IVC) collapsibility

Superior vena cava (SVC) flow in newborn infants has been reported to be a novel marker of systemic blood flow. Low SVC flow (<40 mL/kg/min) has been used to diagnose hypotension and to predict long-term outcome.

TREATMENT APPROACH

Appropriate supportive measures must be instituted as soon as possible including securing a patent airway, providing supplemental oxygen and positive-pressure ventilation, achieving intravascular or intraosseous access, and infusing 10 mL/kg of colloid or crystalloid (to repeat the same volume if needed).

Use of crystalloid or colloid solutions is appropriate unless the source of hypovolemia is hemorrhage, in which case whole or reconstituted blood is more appropriate.

First dose of broad spectrum antibiotic should be given as early as possible after collecting the blood culture if any infection is suspected.

Correction of negative inotropic factors such as hypoxia, acidosis, hypoglycemia, hypocalcemia, and other metabolic derangements will improve cardiac output.

There are three crucial steps in management of neonatal shock:

1. Optimize preload by volume expanders.
2. Improve cardiac contractility and vascular tone with the use of catecholamines.
3. Consider, case by case, use of steroids.

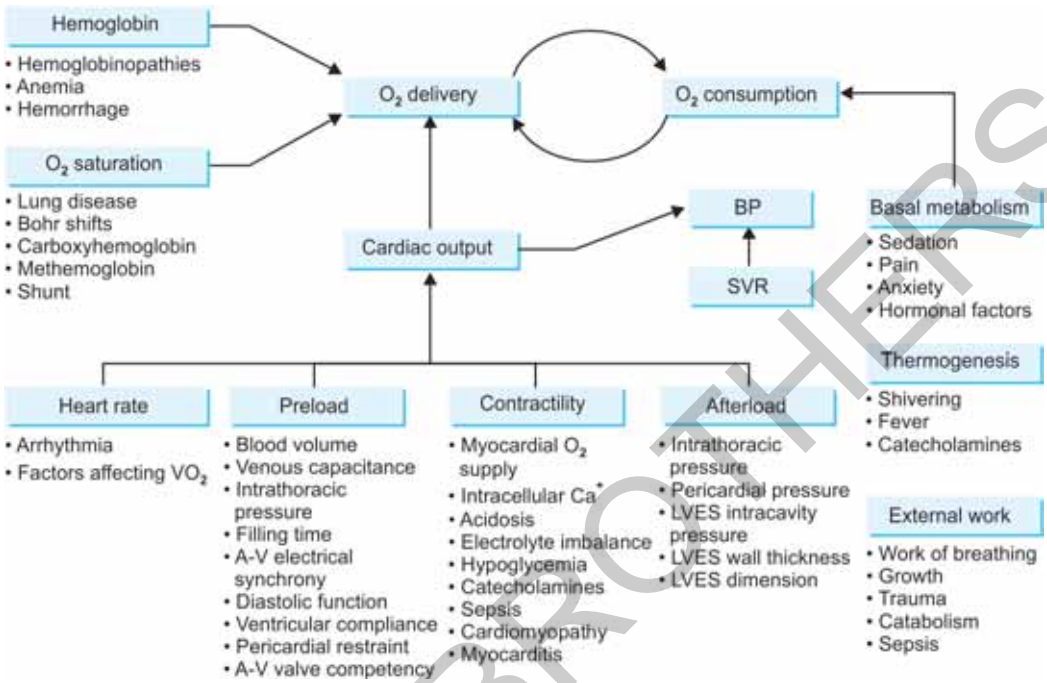
(Flowcharts 1 to 3).

Step 1: Volume Expanders—Practice Points

Fluid boluses are used only when there is evidence of hemorrhage or fluid loss. An

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Flowchart 1: Factors affecting tissue oxygen delivery.



infusion of 10–20 mL/kg isotonic saline solution over 30 minutes is used to treat suspected hypovolemia if hematocrits more than 40% and cardiogenic process unlikely.

Routine use of volume expanders is not warranted as it may cause more harm than benefit.

Crystalloids are preferred over colloids in management of shock (compared in terms of cost, availability, safety, and effective therapeutic outcome).

Step 2: Use of Catecholamine

Despite adequate volume restoration, myocardial contractility and vascular tone may still be compromised due to the prior poor myocardial perfusion. In this scenario, inotropic agents and intensive monitoring may need to be continued. Knowledge about action and effects of inotropes helps in judicious use in appropriate situations (Table 5).

Dopamine, norepinephrine, and vasopressin are used to improve the systemic vascular resistance while dobutamine and milrinone are used to improve myocardial function.

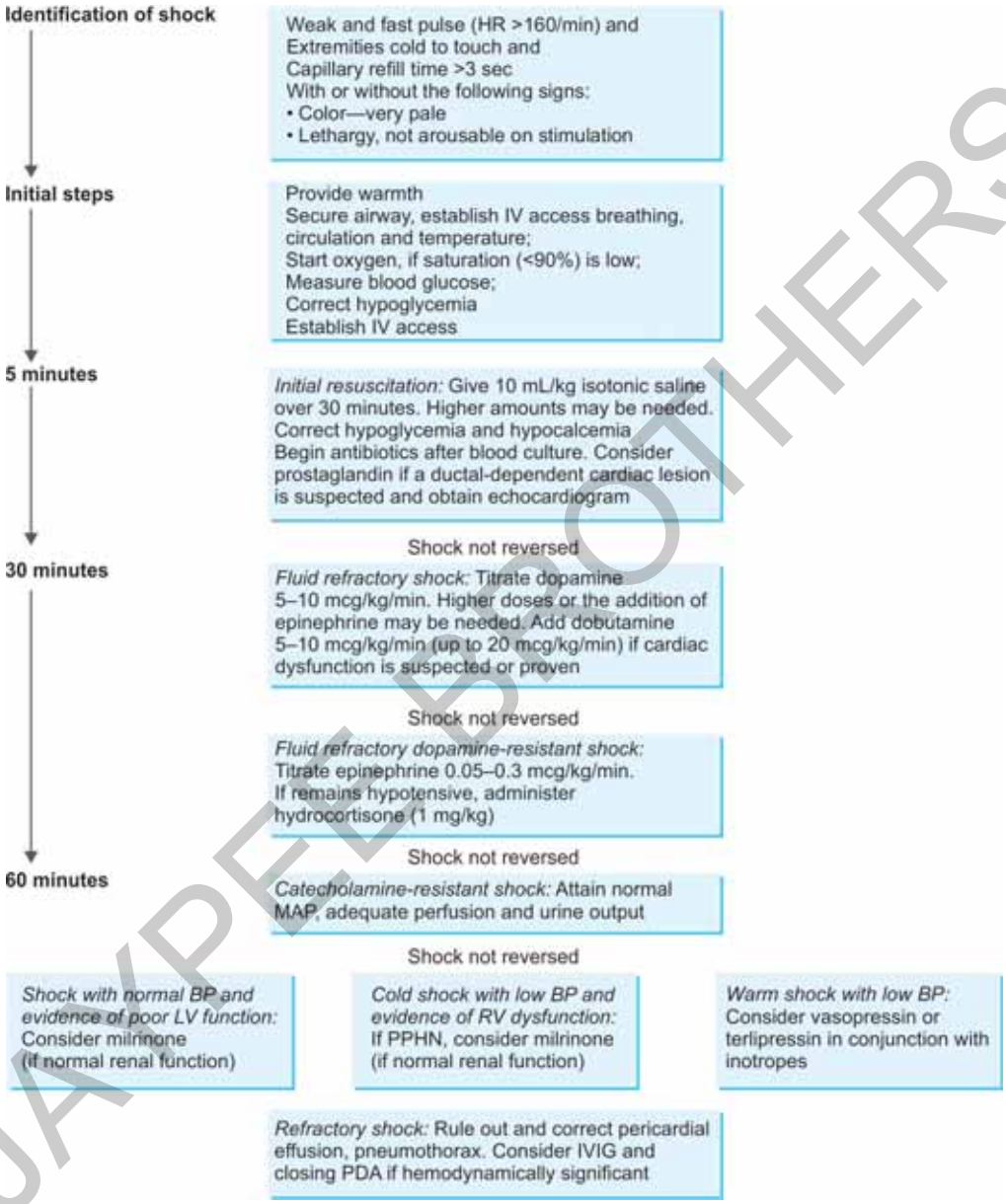
In premature infants younger than 30 weeks' gestation, poor cardiac contractility is most common and they benefit from early institution of dobutamine.

Patients with septic shock benefit from dopamine as first-line management; it has been found to be more effective than dobutamine in correcting blood pressure for short-term treatment in these situations; however, the effect of these drugs on long-term outcome is unknown. Although adrenaline is used for cardiovascular compromise, its effect on mortality and morbidity has not yet been evaluated.

Evidence suggests that milrinone is not beneficial particularly in prevention of low systemic blood flow in ill, very-preterm

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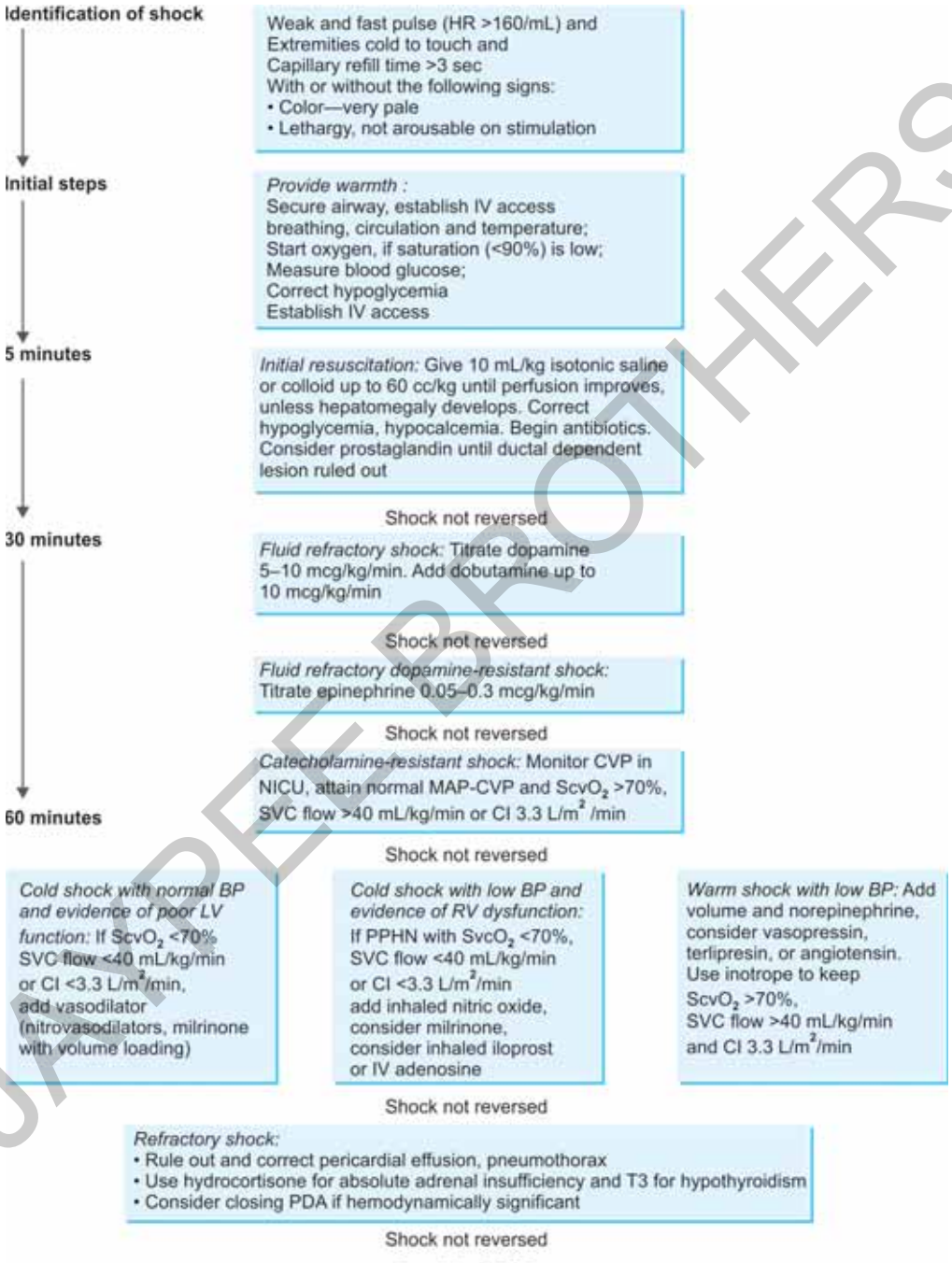
Flowchart 2: Suggested treatment algorithm for preterm.



(HR: heart rate; BP: blood pressure; MAP: mean arterial pressure; LV: left ventricle; RV: right ventricle; PPHN: persistent pulmonary hypertension of the newborn; IVIg: intravenous immunoglobulin; PDA: patent ductus arteriosus; IV: intravenous; ECMO: extracorporeal membrane oxygenation).

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Flowchart 3: Treatment algorithm for term newborns.



(CVP: central venous pressure; MAP: mean arterial pressure; $ScvO_2$: central venous oxygen saturation; SVC: superior vena cava; CI: cardiac index; VLBW: very low birth weight; PDA: patent ductus arteriosus; PPHN: persistent pulmonary hypertension of the newborn; ECMO: extracorporeal membrane oxygenation.

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Table 5: Drugs in neonatal shock.

Sr. No.	*Inotrope*	*Receptor*	*Dose*
1.	Dopamine	Low dose: D1 D2 Intermediate dose: β1 β2 High dose: α1 α2	3–20 mcg/kg/min
2.	Dobutamine	β1 β2	3–20 mcg/kg/min
3.	Epinephrine	α1 α2β1 β2	0.05–0.1 mcg/kg/min
4.	Norepinephrine	α1 α2 β1 β2	0.05–0.1 mcg/kg/min
5.	Milrinone	Phosphodiesterase III inhibitors	0.25–1 mcg/kg/min

neonates during the first postnatal day. However, use of milrinone in post-cardiac surgery as lusitropic agent is well-documented.

Tip:
- Dopamine should be the first choice inotrope if short-term improvement in blood pressure is the goal.
- Dobutamine could be considered as a first line if there is documented myocardial dysfunction.

There is paucity of evidence that clinically important outcomes are improved by the use of any of these catecholamine pressor agents. The clinical risk/benefit ratio and the long-term consequences of use of inotropes are uncertain.

Step 3: Steroids in Shock

Use of steroids should be limited to catecholamine resistant shock states. The dose of hydrocortisone for refractory hypotension is 1–2 mg/kg/dose. If efficacy is noted, the dose can be repeated every 8–12 hours for 2–3 days, especially if low serum cortisol levels are documented before hydrocortisone treatment. There is no consensus on the choice, dose, and duration of steroid use.

THERAPEUTIC TARGETS IN THE MANAGEMENT OF NEONATAL SHOCK

- Normal sensorium, alertness
- Normal HR
- Capillary refill time <2 sec
- Warm extremities
- Normal CVP
  8–12 cm and ventilated 12–15 cm
- Normal blood pressure (age and sex)
- Urine output >1 mL/kg/hr
- Serum lactate (<1.2 mmol/L)
- Normal base deficit
- $ScvO_2$ (central venous O_2 saturation) >70 (usually not measured in neonates)

OUTCOMES

The outcome of shock in the newborns is guarded. The various factors associated with poor outcome are refractory shock, acute renal failure, neutropenia, deranged coagulation profile, and metabolic acidosis.

SUGGESTED READING

1. ACCCM consensus guidelines for treatment of shock in term infants and suggested modifications for preterm infants.

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