Vasopressors are a potent class of medications that produce vasoconstriction to increase both systolic blood pressure (SBP) and diastolic blood pressure, an average being the mean arterial blood pressure (MAP). Much of the data for vasopressor use is derived from expert opinion, animal studies, and surrogate end points, because clinical comparisons are lacking. Vasopressors are used for hypotension, defined as a decrease in SBP > 30 mm Hg or < 60 mm Hg, with evidence of hypoperfusion. These agents should be initiated after adequate fluid resuscitation with colloids or crystalloids.1

Vasopressors are adrenergic agonists acting at different receptors. The main receptors of activity include the alpha-1, beta-1, beta-2, and dopaminergic receptors. The alpha-1 receptors are located on vascular walls and the heart, allowing increased vasoconstriction and duration of cardiac contraction without effects on heart rate. The beta-1 receptors, located on the heart and vasculature, allow inotropy (increased contractility of the heart muscle), chronotropy (increased heart rate), and vasoconstriction. Contrarily, beta-2 and dopamine receptor stimulation cause vasodilation whether on the blood vessels, or the renal, splanchic, and coronary vascular beds.

Shock is defined as impaired oxygen supply, and is usually accompanied by hypotension.2 A vasopressor should be chosen based on the etiology of the shock, and then titrated up to the minimal dose necessary to maintain adequate perfusion. Cardiogenic, hypovolemic, and obstructive shock are primary defects of poor cardiac output, while septic shock is due to pathologic vasodilation, hypovolemia, and maldistribution. Without oxygen and essential nutrients there may be vasoconstrictor dysfunction, and ultimately organ damage. Clinically, there is a reliance on cool skin, mental status, capillary refill, blood pressure (BP), and urinary output to determine necessity of therapy. Surrogate markers of efficacy include MAP, blood measurements of base excess and lactic acid, and many other laboratory values to assess regional hyperperfusion (eg, liver function tests, blood urea nitrogen, and creatinine). Adequate fluid resuscitation will increase volume, which increases preload and stroke volume, and must be achieved before vasopressor-mediated vasoconstriction occurs. Initial response sought is an increase in BP. When maximum doses fail to achieve an appropriate therapeutic response, second or even third agents should be considered.

This review will discuss vasopressors that are currently available: norepinephrine, phenylephrine, epinephrine, dopamine, and vasopressin (Table 1). Dobutamine and isoproteranol are classified as inotropes and are beyond the scope of this review. Dobutamine stimulates beta-1 receptors causing a greater inotropic than chronotropic effect due to less beta-2 activity. Isoproteranol stimulates beta-1 and beta-2 causing more chronotropic and less inotropic effects, and some vasodilation possibly leading to a decreased MAP.

Abstract: Vasopressors are a heterogeneous potent class of medications designed to increase blood pressure in emergent hypotensive situations. The goal of therapy is to increase blood pressure and maintain adequate perfusion, allowing nutrient and oxygen delivery to vital organs. Norepinephrine, phenylephrine, dopamine, epinephrine, and vasopressin are five vasopressors available in the United States. All vasopressors, with the exception of vasopressin, are titratable and dosed on a continuum according to clinical effect. With their different clinical features, adverse effects, and range of potency, the clinical situation usually guides therapy. Outcome data comparing different vasopressors have not demonstrated a clear mortality benefit of any one vasopressor over another, and physician preference also guides therapy. Norepinephrine, nonetheless, remains one of the preferred choices for a variety of hypotensive states, including cardiogenic and septic shock.

Key Words: vasopressors, norepinephrine, phenylephrine, epinephrine, dopamine, vasopressin, sepsis, shock, mean arterial pressure

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NOREPINEPHRINE (LEVOPHED)
Norepinephrinebitartrateschemicallyknownasa-(aminomethyl)-3,4-dihydroxybenzyl alcohol which is a (1:1) tartrate salt form (Figure 1) It is a sympathomimetic amine that has both alpha-1 and beta-1 adrenergic activity. Beta activity specifically increases atrial and ventricular contractility, stimulates the sinoatrial node, and enhances ventricular conduction. It is approved by the Food and Drug Administration to treat acute hypotensive states (eg, drug reactions, septicemia, sympathectomy, myocardial infarction, and others) and hypotension after cardiac arrest in adults. Following intravenous (IV) administration, norepinephrine raises BP.

Pharmacokinetics/Dynamics
Norepinephrine has a very rapid onset of action documented to be well within 1–2 min when given by IV. Subcutaneous (SQ) absorption is very poor, and oral drug is inactivated in the gastrointestinal tract. It is then metabolized by catechol-o-methyltransferase (COMT) and monamine oxidase (MAO). Eighty-four to ninety-four percent of the drug is excreted in the urine as inactive metabolites.4 Physiologically, norepinephrine has direct and reflex actions. Direct actions of beta-1 stimulation may increase heart rate. Alpha-1 stimulation causes vasoconstriction and may decrease heart rate as a reflex leading to an overall neutral effect on heart rate.

Indications/Dosage/Administration
Norepinephrine is indicated for acute hypotension, subsequent to cardiac arrest or other hypotensive states. The initial doses of norepinephrine should be 8–12 μg/mL (0.1–0.5 μg/kg/min) IV followed by adjustments up to 35 μg/min to maintain a low-normal SBP of 80–100 mm Hg or MAP > 60 mm Hg.2 Doses ranging from 0.001 to 3 μg/kg/min have been documented to be efficacious in septic shock.5 The dose must be diluted before infusion and never directly injected into a vein. It should only be mixed with dextrose-containing solutions, which prevents excessive oxidation and subsequent potency loss. Concentrations should be 16–64 μg/mL, which is made by mixing 4–16 mg in 250 mL D5W. Administration through large central veins is preferred so as to avoid extravasation.

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TABLE 1. Vasopressor Clinical Comparison

<table>
<thead>
<tr>
<th>TabDrug Name</th>
<th>Preferred in</th>
<th>Dose</th>
<th>α</th>
<th>β1</th>
<th>β2</th>
<th>Dopamine Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dopamine</td>
<td>Not recommended</td>
<td>1–3 mg/kg/min</td>
<td>+/−</td>
<td>+</td>
<td>+/−</td>
<td>+++</td>
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<tr>
<td>Norepinephrine</td>
<td>Septic shock</td>
<td>3–10 mg/kg/min</td>
<td>++</td>
<td>+++</td>
<td>+/−</td>
<td>++</td>
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<tr>
<td></td>
<td>Cardiogenic shock</td>
<td>0.01–1 mg/kg/min</td>
<td>+++</td>
<td>+++</td>
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<td>0</td>
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<tr>
<td>Epinephrine</td>
<td>Anaphylactic shock</td>
<td>0.01–1 mg/kg/min</td>
<td>+++</td>
<td>+++</td>
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<td>0</td>
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<tr>
<td></td>
<td>Secondary choice for refractory shock</td>
<td>2–10 mg/min</td>
<td>+++</td>
<td>+++</td>
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<tr>
<td>Phenylephrine</td>
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<td>0.5–8 mg/kg/min</td>
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<td>0</td>
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</tr>
<tr>
<td></td>
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<td>MAX: (10 mg/min)</td>
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<tr>
<td></td>
<td></td>
<td>50–180 mg/min</td>
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<td>Vasopressin</td>
<td>Adjunct for physiologic replacement only</td>
<td>0.01–0.04 units/min</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

This table represents data from multiple sources. See references section.

SVR, systemic vascular resistance; BP, blood pressure.

Norepinephrine should not be used in a patient with a history of hypersensitivity reactions to norepinephrine or any of its components. No vasopressor should be used for hypovolemic shock, except in an emergency until volume can be adequately replaced.5

Adverse Effects

Ischemic injury and tissue hypoxia can occur with any vasoconstrictor, and may lead to gangrene of extremities on rare occasions. Brady- or tachyarrhythmias, anxiety, transient headaches, dyspnea, nausea/vomiting, and extreme hypertension may occur. Extravasation necrosis at the injection site is a serious complication that can be minimized by dilution and administration through a large vein.

Drug Interactions

Norepinephrine interacts with tricyclic antidepressants (eg, amitriptyline, clomipramine, and imipramine), selective serotonin reuptake inhibitors (eg, fluoxetine, paroxetine, and sertraline), and MAO inhibitors with clinical increases in alpha-adrenergic effects. Inhaled anesthetics (eg, halothane) increase cardiac autonomic irritability, thus increasing the risk of ventricular tachycardia or fibrillation. Carbonic anhydrase inhibitors (acetazolamide) can decrease the excretion of alpha/beta adrenergic agonists. Spironolactone may decrease the vasoconstriction of alpha/beta adrenergic agonists.6 Norepinephrine may enhance the toxic effects of bromocriptine including ventricular arrhythmia and seizure, and of lurasidone including hypotension. Cannabinoids may enhance the tachycardic effects of sympathomimetics.

Availability

Norepinephrine is available as 1 mg base/mL in 4 mL vials.7

PHENYLEPHRINE (NEOSYNEPHRINE)

Phenylephrine is chemically known as 3-hydroxy-alpha-[(methylamino)methyl] benzyl alcohol available as a (1:1) hydrochloride salt (Figure 1). It is a sympathomimetic amine that has primarily alpha-adrenergic activity causing peripheral vasoconstriction and little beta-adrenergic activity. Vasoconstriction lasts longer with phenylephrine than it does with epinephrine, documented to be 20 min after IV administration and 50 min after SQ administration.8 It is a potent vasoconstrictor; however, venous constriction is not marked. It may cause reflex bradycardia, which may decrease cardiac output with no chronotropic or inotropic effect.

Pharmacokinetics/Dynamics

Phenylephrine is a pure alpha-adrenergic agonist and leads to vasoconstriction without chronotropic or inotropic effects.9 Phenylephrine is poorly absorbed orally (<38%), but can be efficacious via the SQ or intramuscular (IM) route. The onset of action depends on the route of administration, with SQ and IM administration being 10–15 min, while IV administration is immediate. The volume of distribution (Vd) can range from 184 to 543 L, and metabolism is extensive. Hepatic metabolism involves 50% deamination, but there is also a degree of sulfation and glucuronidation before the metabolites are excreted in the urine. The alpha half-life is about 5 min, but the terminal half-life is about 2–3 hours. The duration of action is about 1–2 hours if given IM, 50 min if given SQ, and 15–20 min if given IV.7

Indications/Dosage/Administration

Phenylephrine may be used to maintain adequate BP during anesthesia use, shock, or shock-like states. It may also be used to...
overcome paroxysmal supraventricular tachycardia from prolonged spinal anesthesia and as a vasoconstrictor in regional anesthesia. Phenylephrine can be given as a 100–500 μg bolus dose every 10–15 min, if needed. IV infusions should start at a dose of 100–180 μg/min (or 0.5 μg/kg/min) and be titrated to maintain a low-normal SBP of 80–100 mm Hg or MAP >60 mm Hg.4 Concentrations of phenylephrine should range from 0.04 to 0.2 mg/mL, and can be mixed with dextrose, saline, or lactated Ringer’s solutions.7

Topical phenylephrine has a number of indications, which will not be discussed in this review.

Adverse Effects
Adverse reactions include reflex bradycardia, hypertension, metabolic acidosis, and gastric irritation and nausea. Phenylephrine use may lead to anxiety, headache, parasthesias, tremors, and weakness. Extravasation, similar to norepinephrine, may also occur.

Drug Interactions
Phenylephrine interacts with tricyclic antidepressants (eg, amitriptyline, clomipramine, and imipramine), atomoxetine, and MAO inhibitors with clinical increases in alpha-adrenergic effects.

Availability
Phenylephrine is available in 10 mg/mL vials of 1 and 5 mL.7

Figure 1. Chemical structures of vasopressors used in the United States.

DOPAMINE
Dopamine is a natural catecholamine formed by decarboxylation of 3,4-dihydroxyphenylalanine (Figure 1). Dopamine has a variable dose-dependent response, resulting in many different clinical effects that may or may not overlap. At doses of 1–5 μg/kg/min, dopamine stimulates dopamine receptors on the renal, splanchnic/mesenteric, and coronary vasculature and causes vasodilation. Low-dose dopamine is thought to have primarily renal effects increasing renal blood flow and urine output. At doses of 5–15 μg/kg/min, dopamine stimulates dopamine and beta-1 receptors, and may stimulate norepinephrine release from nerve terminals. Doses >15 μg/kg/min stimulate alpha-1 receptors, and the corresponding vasoconstriction occurs.

Pharmacokinetics/Dynamics
Dopamine should only be given by IV. It and distributes extensively with a $V_d = 1.8–2.45 \text{ L/kg}$. Dopamine does not cross the blood-brain barrier in adults. The liver, kidney, and plasma metabolize 75% dopamine by the MAO and COMT to homovanillic acid. Twenty-five percent of dopamine is metabolized to norepinephrine.4 The metabolites are then excreted by the kidneys. The half-life elimination is about 1.8 min. The duration of action is 10 min after a single dose.10
Indications/Dosage/Administration

Dopamine should be initiated at doses of 2–5 μg/kg/min and titrated up by increments of 5–10 μg/kg until at a dose of 20–50 μg/kg/min or adequate response. Doses >25 μg/kg/min are not recommended, and a more direct-acting vasopressor may be of benefit. Doses >50 μg/kg/min may have deleterious effects on the kidney.10 Dopamine should not be used in patients with a history of hypersensitivity to any of the product components and in patients with pheochromocytoma or tachyarrhythmias.

Adverse Effects

Cardiac dysrhythmia, extravastation, nonadjacent limb gangrene, diabetes insipidus, hypoprolactinemia, nausea/vomiting, mydriasis, dysuria, polyuria, nephrotoxicity, and psychotic hallucinations have been reported with dopamine use.18 Dopamine may also decrease the release of hormones, especially prolactin.11

Drug Interactions

Atomoxetine may enhance the hypertensive effects, and cannabinoïds enhance the tachycardic effects of all sympathomimetics. Inhaled anesthetics enhance the arrhythmogenic potential of dopamine. Dopamine may enhance the hypertensive effects of lurasidone.

Availability

Dopamine is available as 40 mg/mL ampules of 5 mL; vials of 5, 10, and 20 mL; and syringes of 5 and 10 mL. It is also available as 80 mg/mL ampules of 5 mL, vials of 20 mL, and syringes of 10 mL. Dopamine is available in premixed bags of D5W 0.8 mg/mL in 250 and 500 mL, 1.6 mg/mL in 250 and 500 mL, and 3.2 mg/mL in 250 mL.7 Dopamine solutions are light sensitive and not stable in alkaline solutions.

EPINEPHRINE

Epinephrine is chemically known as 3,4-dihydroxy-α-(methylamino)methyl benzyl alcohol available as a (1:1) hydrochloride salt (Figure 1). It is a sympathomimetic amine which is the same as endogenous epinephrine secreted by the adrenal medulla, and has both alpha-1 activity causing peripheral vasoconstriction and beta-1 activity causing inotropic stimulation of the heart. It is the most potent alpha-receptor activator.9 It also has beta-2 activity, relaxes smooth muscle of the bronchi and iris, is a histamine antagonist, and increases glycogenolysis in the liver to increase blood sugar.

Pharmacokinetics/Dynamics

Epinephrine is not absorbed orally due to gastrointestinal inactivation. SQ suspensions are partially absorbed, but have limited clinical utility due to delays in therapeutic effects. When used for asthma, SQ epinephrine has an onset of 5–10 min and a peak of 20 min.8 IM epinephrine into the thigh (vastus lateralis muscle) is the most potent alpha-receptor activator.12 It also has beta-2 activity, decreases systemic absorption and increase duration of action.

Nonetheless, there are many unlabeled and widely accepted uses. These include Advanced Cardiovascular Life Support (ACLS) protocols, hypotension and shock unresponsive to volume resuscitation, bradycardia unresponsive to atropine or pacing, and inotropic support.

During ACLS protocols for asystole, pulseless arrest, ventricular tachycardia, or ventricular fibrillation, epinephrine 1 mg may be given IV or IO every 3–5 min. If neither access is available, 2–2.5 mg can be given IT every 3–5 min. Epinephrine IM is preferred for hypersensitivity reactions at a dose of 0.2–0.5 mg every 5–10 min, although there are no outcome data preventing the use of SQ.13 IV administration can be used for either or all indications. Continuous IV can be used for Bradycardia or Hypotension/shock at a dose of 0.1–0.5 μg/kg/min (7–35 μg/min in a 70-kg adult). Epinephrine as a continuous infusion should be diluted in dextrose, dextran, saline, and lactated Ringer’s solution. Epinephrine is incompatible in alkaline solutions such as sodium bicarbonate. Acceptable concentrations range from 2 to 4 mg in 250 mL solution.

There are no absolute contraindications to epinephrine IM for anaphylaxis. Epinephrine should not be used in patients with narrow angle glaucoma, organic brain injury, local anesthesia of the digits, heart failure, or coronary insufficiency, unless the benefits outweigh the risks.

Adverse Effects

Splanchnic vasoconstriction has been demonstrated to be more significant with epinephrine than equipotent dose of norepinephrine and dopamine.14 Angina, cardiac arrhythmias, flushing, palpitation, ventricular ectopy, anxiety, headache, and dizziness have been reported with its use. Dry throat, nausea/vomiting, xerostomia, urinary retention in patients with outflow obstruction, dyspnea, pulmonary edema, and diaphoresis have also been reported. Epinephrine may decrease certain hormone production. Ischemic injury and tissue hypoxia can occur with any vasoconstrictor, and may lead to gangrene of extremities on rare occasion. Extravasation necrosis at the injection site is a serious complication that can be minimized by dilution and administration through a large vein.

Drug Interactions

Epinephrine interacts with tricyclic antidepressants (eg, amitriptyline, clomipramine, and imipramine), serotoninnorepinephrine reuptake inhibitors (eg, venlafaxine), and MAO inhibitors with clinical increases in alpha-adrenergic effects. Inhaled anesthetics (eg, halothane) increase cardiac autonomic irritability, thus increasing the risk of ventricular tachycardia or fibrillation. Carbonic anhydrase inhibitors (acetazolamide) can decrease the excretion of alpha/beta adrenergic agonists. Spironolactone may decrease the vasoconstriction of alpha/beta adrenergic agonists.6 Epinephrine may enhance the toxic effects of bromocriptine including ventricular arrhythmia and seizure, and of lurasidone including hypotension. Beta-blockers may enhance the vasopressor effect of alpha/beta agonists, by leaving alpha effects unopposed. Cannabinoids may enhance the tachycardic effects of sympathomimetics.

Availability

Epinephrine is available in 1 mg/mL (1:1000) ampules of 1 mL and vials of 30 mL mostly for IM administration. There are also some topical preparations available in this same 1:1000 ratio. Epinephrine 1:10,000 is used IV (1 mg/10 mL) and in syringes.7

VASOPRESSIN (PITRESSIN)

Vasopressin is chemically known as 8-arginine vasopressin, which is a synthetic vasopressin of the posterior pituitary gland (Figure 1). Naturally, vasopressin acts at the many receptor subtypes (ie, V1A, V1B, and V2), and the location determines the ultimate activity of the chemical/receptor interaction. For example, action at the V2 receptor
on the renal tubules allows for aquaporin insertion and an increase in water reabsorption. However, action on the V1A/V1B receptor allows for contraction of the smooth muscle of the gastrointestinal tract and vascular bed. In the vascular bed, capillaries, arterioles, and venules contract, leading to overt vasoconstriction and hypertensive effects.

**Pharmacokinetics/Pharmacodynamics**

Vasopressin can be used SQ or IM for diuresis, with variable effects lasting 2–8 hours. Metabolism by the liver and kidney create an effective half-life of about 10–20 min.

**Indications/Dosage/Administration**

Vasopressin is indicated for the prevention and treatment of postoperative abdominal distention, in abdominal roentography to dispel interfering gas shadows in diabetes insipidus.

Vasopressin can be considered for patients with refractory hypotension/vasodilatory shock or septic shock despite adequate fluid resuscitation and high-dose conventional vasopressors. Although not approved by the Food and Drug Administration, vasopressin is used in ACLS for pulseless arrest as 40 units IV or IO once to replace the first or second dose of epinephrine. IT administration has also been used in patients with success. It has also been used for vasodilatory or septic shock as a second-line agent dosed at 0.01–0.04 units/min. This dose represents a fixed, nontitratable dose. Vasopressin should be diluted to a concentration ranging from 0.1 to 1 unit/mL. This is accomplished by mixing 100 units in 100 mL of D5W or NS.

Vasopressin should not be used in patients with a history of hypersensitivity or anaphylaxis to any of the product components.

**Adverse Effects**

Arrhythmia, chest pain, myocardial infarction, asystole, and decreased cardiac output have been reported especially with doses >0.04 units/min. Headache, fever, vertigo, ischemic skin lesions, abdominal cramps, mesenteric ischemia, nausea/vomiting, uterine contraction, bronchial constriction, and diaphoresis may also occur. Extravasation necrosis at the injection site is a serious complication that can be minimized by dilution and administration through a large vein. Water intoxication may also occur due to antidiuretic effects at the V2 receptors in the collecting ducts of the kidney.

**Drug Interactions**

Carbamazepine, chlorpropamide, clofibrate, fludrocortisone, and tricyclic antidepressants may potentiate the antidiuretic effects of vasopressin. Demeclocycline, norepinephrine, lithium, heparin, and alcohol may decrease the antidiuretic effects. All interactions occur simply due to the stimulation or inhibition of synthetic and naturally occurring vasopressin.

**Availability**

Vasopressin is available in 20 pressor units/mL vials of 0.5, 1, and 10 mL.

**SUMMARY**

Hypotension is not synonymous with shock, but is very common. It usually leads to poor oxygen and nutrient delivery, a catabolic state of anaerobic metabolism, loss of ion pumps and electrical gradients, poor mitochondrial function, and cell death. Cell death leads to tissue injury, and ultimately organ failure. Vasopressors are life-saving medications in the armamentarium against shock, because one of the primary goals in the treatment of shock is to maintain BP and restore tissue perfusion. The initiation of vasopressors should be considered when a patient has received adequate fluid resuscitation. Rivers et al. contend that early goal-directed therapy decreases in-hospital and 28-day mortality, in addition to the length of stay. Using 500 mL boluses of crystalloid or colloids with vasopressors to achieve a central venous pressure of 8–12 mm Hg within the first 6 hours of resuscitation is key. Newer animal studies suggest that early use of norepinephrine improves MAP, sustains aortic and mesenteric blood flow, and allows better tissue oxygenation compared with fluid resuscitation alone. Thus, advocating the use of norepinephrine in the septic shock model even before adequate fluid resuscitation is achieved. Beale et al. also advocate that vasopressors may be required to sustain and maintain perfusion, even when hypovolemia has not been resolved. With minimal data on the exact threshold for BP maintenance, many studies begin when systolic falls to <90 mm Hg or MAP <60–65 mm Hg.

Norepinephrine, phenylephrine, dopamine, epinephrine, and vasopressin have all been used effectively in septic shock. Doses should be titrated to maintain MAP >65 mm Hg in most patients, unless previously hypertensive, because that has been shown to maintain tissue perfusion. Dopamine and epinephrine may exacerbate tachycardia more than norepinephrine and phenylephrine due to greater beta-1 stimulation. Norepinephrine may as well, but this effect is not seen clinically. Both dopamine and norepinephrine raise cardiac index, which is a measure of cardiac output per body surface area, due to the beta-1 stimulation. Dopamine raises stroke volume; however, it may interfere with the hypothalamic pituitary axis by decreasing concentrations of all anterior pituitary hormones except cortisol, which may also decrease its benefit clinically. Phenylephrine is a pure alpha-1 agonist and may cause reflex bradycardia, in turn decreasing in cardiac output, which may not be an ideal initial choice for septic shock. Epinephrine may cause severe vasoconstriction, which may in turn compromise splanchnic and peripheral blood supply.

With the heterogeneity of this class, clinician preference plays a major role in treatment, based on comorbidities and confounding factors. The most commonly used vasopressor was norepinephrine, as per a study of 1981 intensive care units in Europe. The Surviving Sepsis guideline also recommends norepinephrine and dopamine as first choice in treatment of septic shock. Septic shock is formally defined as acute circulatory failure characterized by persistent arterial hypotension unexplained by other causes. The neuroendocrine pathology in septic shock is further complicated by a depletion of neurohypophysial stores of vasopressin and impaired release due to lack of stimulation at the baroreceptor. Replacement of vasopressin at a low constant dose allows significant rises in MAP with decreased doses of traditional vasopressors. Higher doses, >0.04 unit/min, may increase risks of splanchnic and coronary artery ischemia. In conclusion, vasopressors are a diverse class of medications with immediate hemodynamic effects. All have different recommendations, different hemodynamic effects, and adverse effects, with little difference in outcome. A larger Cochrane review included all randomized controlled trials of vasopressors for the treatment of shock. All trials with acutely and critically ill adults and pediatric patients were included. Nonrandomized trials, crossover trials, and animal studies were excluded. Twenty-three studies were assessed as having low to moderate risk of bias. All five vasopressors discussed, in addition to terlipressin, which is a synthetic vasopressin available in Europe, were the main interventions. Norepinephrine compared to dopamine, epinephrine, terlipressin, vasopressin, phenylephrine, and norepinephrine plus vasopressin was not associated with any significant differences in mortality. There was no difference in intensive care unit length of stay, vasopressor-free days, or hospital length of stay. There was no difference in rates of renal failure. However, there were more tachyarrhythmias with dopamine versus norepinephrine in two of the included studies, which was a significant finding. Vasopressors remain a unique class of medications used in emergency situations, making clinical end points the major determinant for selection and use of therapy.
REFERENCES


