Controlled deliberate hypotension: An overview

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The author presents a brief overview of the history, indications, methods, and physiologic considerations of deliberate controlled hypotension. The nurse anesthetist is alerted to basic concepts of the agents, methods, and monitoring techniques to be considered.

The technique of deliberate controlled hypotension is requested by surgeons for a multitude of operative procedures. Harrington rod installation, maxillary osteotomy, and cerebral vascular procedures are common settings in which the technique may be of value.

Reduction of surgical blood loss and operative time, without increasing morbidity, are the goals in the administration of a controlled hypotensive anesthetic.

History

In one form or another deliberate hypotension has been performed for over 40 years. Prior to the administration of volatile agents, the control of blood loss was the burden of the surgeon alone. For example, a rapidly performed amputation on a conscious patient possessing intact sympathetic mechanisms would often result in less bleeding than the same procedure using some early anesthetic techniques. These volatile anesthetics were often accompanied by some degree of respiratory obstruction, vasodilation, and a good deal of straining, all of which contribute to increased bleeding. The explosive nature of the noxious agents (ethers, ethylene oxide, chloroform) also prevented the use of the electrocautery.

"Deep" anesthesia and hemorrhage probably were the earliest forms of the hypotensive technique. The controlled aspect evolved later. Prior to the development of d-tubocurarine, "deep" anesthesia also provided adequate muscle relaxation.

Ganglionic blocking agents

During the research of tubocurarine, the methonium compounds came to light. Initially recommended for the treatment of hypertension, these agents became the first employed to induce controlled operative hypotension. Today trimethaphan (Arfonad®) is the ganglionic blocking agent in most common use. Trimethaphan occupies receptor sites of the ganglionic cholinergic postsynaptic membrane, blocking conduction through the sympathetic chain. Minor direct vasodilating properties have been described. Trimethaphan's rapid metabolism by cholinesterase makes it attractive, although the propensity to release histamine render it somewhat less appealing.

In 1964, Larson also described a technique utilizing spinal or epidural blockade to induce hypotension. Unfortunately this form of hypotension is not always well controlled. The blockade of sympathetic outflow to induce vasodilation and the frequently associated blockade of cardiac ac-
CELERATORS combined with the deleterious effects of hypoventilation and hypoxia made the technique infeasible.

Halogenated agents
Adequate levels of hypotension and control may be achieved in some instances with the more recently developed volatile agents. Halothane, enflurane, and isoflurane each possess dose-dependent hypotensive properties. Halothane exerts its hypotensive effects primarily by myocardial depression and some smooth muscle relaxation. Enflurane and its isomer, isoflurane, exert profound relaxing effects on vascular smooth muscle. A gradual controlled onset and ease of administration are major advantages to inhalation agents.

However, some disadvantages of volatile anesthetic-induced hypotension in some procedures should be noted: (1) difficulty in controlling the degree of hypotension; and (2) predictable rises in intracranial pressure secondary to cerebral vasodilation. The commonly employed "neuro" triad of hyperventilation, steroids, and tranquilizers may aid in the control of unwanted rises in intracranial pressures, but is not recommended in any but the most obvious cases.

Direct acting vascular dilators
The need for an easily controlled, rapidly dissipated hypotensive agent suitable for use in surgery led to the development of a wide range of agents. Direct acting vascular dilating drugs presently enjoy the greatest popularity, in combination with volatile and/or N₂O, narcotic techniques.

Sodium nitroprusside (SNP) and nitroglycerin (NTG) offer potent vasodilation, rapid elimination, and, with the aid of mechanical infusion devices, moment by moment control of blood pressure.

NTG has long been employed to decrease peripheral vascular resistance in patients with heart failure and to control hypertension during coronary artery surgery. Decreases in peripheral resistance are more pronounced in the most peripheral arterioles, where 90% of vascular resistance is controlled. NTG may also enhance coronary blood flow, although that effect is not as predictable. Tachyphylaxis is a commonly seen problem with the drug. The effects of NTG last longer than those of SNP once infusion is discontinued, but recovery can be expected in less than 10 minutes.

SNP has a major disadvantage in its metabolism and release of cyanide. The cyanide level achieved is dose related and a particular problem when high doses are administered. The total dose at which metabolic acidosis develops varies widely. Tachyphylaxis, metabolic acidosis, and rising mixed venous O₂ content (when a pulmonary-artery catheter is available) should alert the anesthetist to the possibility of increasing cyanide levels. Hypoperfusion and hypovolemia should not be ignored as contributory causes.

Rebound hypertension may also be seen in some cases where abrupt discontinuance of the drug has occurred. This phenomenon is probably the result of increased serum rennin levels induced by renal blood flow effects of SNP. The disparity between the serum half lives of SNP (one to two minutes) and rennin/angiotension activity (30 minutes) suggests the advisability of a gradual weaning of this drug. Additionally, light planes of anesthesia may account for severe hypertension after SNP discontinuance.

Major complications
Almost all serious complications evolving from a controlled hypotensive technique are the result of major organ underperfusion and hypoxia. The brain, heart, kidney, and liver are especially susceptible targets of O₂ deprivation. Cerebral infarct, myocardial infarction, acute tubular necrosis, and hepatic failure may be consequences of a poorly conducted hypotensive technique or its application in a patient with poor preoperative function.

Adequate perfusion of major organs is well preserved at mean arterial pressures (MAP) of 60 torr or higher in the presence of adequate oxygenation. Whereas adequate alveolar oxygenation (Pao₂) is usually attained with inspired concentrations of 30%-40% oxygen (O₂), ventilation/perfusion mismatches are almost inevitable in hypotensive states. Inhalation agents, NTG, and SNP may all increase both shunting and dead space within the lung. Increases in inspired oxygen concentrations (FiO₂) may be needed to maintain Po₂ levels at 100 torr or greater. Minute ventilations, also, may require increases to maintain carbon dioxide partial pressure (Pco₂) measurements of 40 torr or slightly less.

In order for deliberate hypotension to be "controlled," arterial cannulization is necessary to allow serial arterial blood gas determinations, constant MAP reading, and easy access to blood samples for assay. Zeroing of transducers at brain level affords greatest patient safety.

Other considerations
Hypothermia commonly develops rapidly in states of generalized vasodilation. A warming blanket and temperature probe(s) are mandatory.
Warmed humidification of inspired gases, warming lights, elevation of room temperature, and warming of maintenance and replacement fluids all aid in the preservation of body heat.

Since all anesthetic techniques expose the patient to a good number of pharmaceuticals, all drugs and potential interactions should be carefully considered. For example, the hypotensive properties of tranquilizers (droperidol, diazepam), tri-cyclic antidepressants (imipramine), muscle relaxants (d-Tubocurarine), beta blockers (propanolol), and concurrent daily medication for hypertension and/or heart disease should all be judiciously considered in the preoperative planning stage.

Adequate preoperative hydration is imperative and therefore perioperative central venous pressure (CVP) monitoring is advised. A pulmonary-artery catheter is indicated in the unusual case when the technique is applied to a cardiac patient.

Changes of position become of major importance in neurosurgical, orthopedic, and oral surgical procedures where hypotensive anesthesia is utilized. Position (prone, sitting, lateral) must be changed in an especially deliberate and gentle fashion to avert serious cardiovascular consequences. In those situations where profound position changes are anticipated, SNP, and to a lesser extent, NTG, become the drugs of choice because they can be discontinued and/or adjusted so quickly.

Summary

Hypotensive anesthesia provides opportunity for the nurse anesthetist to further expand into the area of special procedures. Proper performance of such techniques requires constant updating of one’s pharmacologic, physiologic, mechanical, and technical finesse.

REFERENCES


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