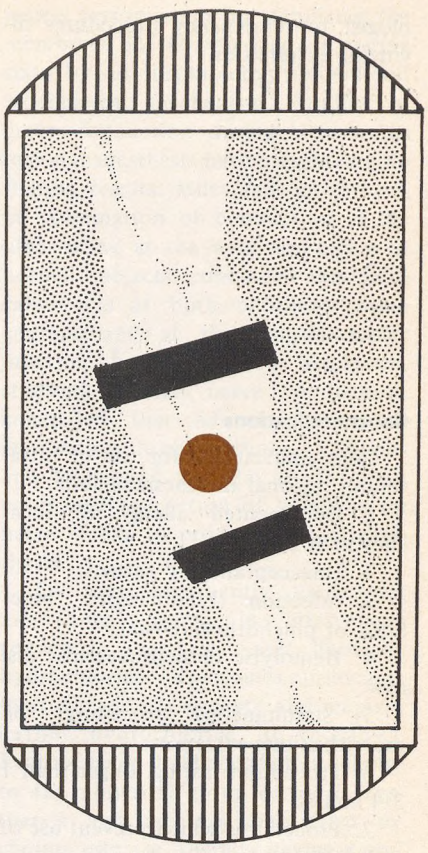
Intravenous Regional Anesthesia



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Intravenous regional anesthesia is a safe, simple, and inexpensive procedure for anesthetization of an extremity that is readily performed successfully by individuals who may be inexperienced in performing block anesthesia. It is particularly useful in many emergency and minor surgical procedures involving the extremities. The advantages, indications, technique, and complications of intravenous regional anesthesia are described. This procedure can be an effective addition to the armamentarium of the family physician in everyday practice.

Intravenous regional anesthesia, a regional block of an extremity distal to a tourniquet involving the intravenous injection of a local anesthetic agent into an exanguinated limb, may be used for a variety of surgical operations or manipulations on the upper or lower extremity. Although this procedure has become better known in recent years, its advantages may not be sufficiently recognized although it should be used more often by family physicians, emergency care physicians, surgeons, and orthopedists.

The history of this procedure is of some interest. Allen reports that Alms, in 1886, first demonstrated that intravascular administration of a local anesthetic agent produced analgesia in the region supplied by the injected vessel.[1] The clinical use of intravenous administration of procaine hydrochloride for producing transient anesthesia of the limb between two tourniquets was first reported by Bier in 1908.[2] He isolated the vein surgically and infused procaine hydrochloride through an indwelling catheter. However, it was not until the report of Holmes[3] in 1963 that the technique of intravenous regional anesthesia became established. Since that time, the clinical value of this technique has been well documented by reports of a number of authors both abroad and in this country.[4-9] In 1966, Mazze and Dunbar demonstrated that the plasma concentration of lidocaine was lower following intravenous regional anesthesia than after lumbar epidural or axillary block.[10]

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Advantages and Indications

Intravenous regional anesthesia has several specific advantages over other techniques utilizing local anesthetic agents, such as the following:

1. It is easily administered by individuals lacking anatomic knowledge required for performance of specific nerve blocks.
2. The needle is not introduced into hematoma at fracture sites with its inherent possibility of introduction of infectious agents.
3. It is rapid in onset and very effective.
4. Lower anesthetic blood levels are achieved by this method than with lumbar epidural or axillary blocks.
5. Pneumothorax, a possible complication of supraclavicular brachial plexus block, does not occur.
6. The recovery time is short.

Intravenous regional anesthesia may be indicated in the following circumstances.

1. Procedures involving the upper and lower extremities lasting less than 1 3/4 hours.
2. General anesthesia is contraindicated (such as by recent ingestion of meal).
3. Lack of availability of anesthesi-

ologist for emergency procedures involving extremities.

Contraindications

Contraindications for use of intravenous regional anesthesia include:

1. Documented allergy to local anesthetic agents.
2. Unacceptance by patient.
3. Infection (lymphangitis, phlebitis, or phlebothrombosis).
4. Hemolytic or neurovascular disease.
5. Simultaneous procedures on more than one extremity.
6. Procedures lasting longer than 1 3/4 hours.
7. Procedures which prevent use of an inflated tourniquet.
8. Procedures which require intermittent deflation of the tourniquet.

Materials Required

Although the materials required for performance of intravenous regional anesthesia are simple, the block never should be performed in the absence of resuscitation equipment and drugs in the event that a rare complication develops. In addition to those materials required for resuscitation, the following items are required for proper performance of intravenous regional anesthesia.

1. A 250 ml, 500 ml, or 1,000 ml bottle of intravenous fluid with an appropriate administration set and needles.
2. An additional 21 gauge needle or scalp vein butterfly needle with an intravenous extension tubing attached or a 20 gauge plastic intravenous cannula with proper obturator through which the local anesthetic agent will be administered.
3. Some sheet wadding.
4. Two pneumatic tourniquets or a single tourniquet with two pneumatic bladders which are known to be in perfect working condition.
5. An Esmarch's or elastic bandage.
6. A syringe, preferably a 50 cc size.
7. An anesthetic agent without a preservative or epinephrine.
8. Sterile sodium chloride as a diluent for the anesthetic agent.

Any of the following anesthetic agents may be used in the concentrations and maximum doses listed:

1. Lidocaine hydrochloride (Xylocaine) in a 0.5 or 0.6 percent solution in a dose not to exceed 3 mg/kg body weight.
2. Prilocaine hydrochloride (Citanest) in a 0.5 percent solution not to exceed 3 mg/kg body weight.
3. Mepivacaine hydrochloride (Carbocaine) 0.6 percent solution not to exceed 4.3 mg/kg for use in the arm or 8.6 mg/kg for use in the leg.

Technique

Premedication is at the physician's option for patients receiving an intravenous regional anesthetic. After sterile preparation of the skin, an intravenous route is established in one hand or arm which is not being anesthetized. This intravenous infusion will serve as a means for administration of drugs in the rare event that an untoward reaction occurs.

Sheet wadding to protect the limb is wrapped around the involved extremity in the region in which the tourniquet will be applied. The two pneumatic tourniquets are applied adjacent to one another or a single tourniquet equipped with two pneumatic bladders is applied proximally to the extremity and attached to a pneumatic source so that the two bladders or cuffs may be individually inflated or deflated. The pneumatic source is set to a pressure above systolic blood pressure (250 mm Hg for compression of the arm and 500 mm Hg for use on the leg). These pressures are reduced in children to 180 to 240 mm Hg for the arm and 350 to 500 mm Hg for the leg depending upon the size of the child. The pneumatic tourniquets are inflated in turn to test functional condition and then immediately deflated.

The desired anesthetic agent is diluted to the appropriate concentration and the required volume is drawn into a syringe. Dosage varies with the size of the extremity. Carrel and Eyring recommend the following dosages for lidocaine hydrochloride:[7]

adult

arm 40 ml (0.5%) leg 100 ml (0.25%)

10-year-old

arm 30 ml (0.5%) leg 80 ml (0.25%)

5-year-old

arm 20 ml (0.5%) leg 70 ml (0.25%)

Infant

Arm 10 ml (0.5%) leg 60 ml (0.25%)

After sterile preparation of the skin, an intravenous route is established and carefully stabilized in the limb to be anesthetized. A peripheral vein in which a venipuncture can easily be accomplished is usually chosen. Anesthetic onset is quicker if the injected vein is in close proximity to the surgical site but it is not essential that it be near the surgical field. Needles used for this purpose include

short small gauge needles fitted with a 12 to 18 inch extension tube or scalp vein butterfly needles 21 or 23 gauge size. The syringe containing the anesthetic agent is attached to the extension tube. If a plastic intravenous cannula is used, which is not as easily dislodged during exanguination, an obturator of appropriate size may be inserted to prevent blood loss during mechanical exanguination.

The limb is mechanically exanguinated by wrapping an Esmarch's bandage snugly about the limb starting at the distal end and wrapping in a proximal direction until the limb underlying the proximal (upper) tourniquet has had the blood expelled from it. The upper tourniquet is inflated and the Esmarch's bandage is removed. The Esmarch's bandage is not used in the presence of a localized infection which is to be drained nor is it used in the presence of a fracture which would be painful during bandage application. In the presence of a fracture, exanguination has been accomplished with an inflatable arm splint as reported by Winnie and Ramamurthy.[11] Although intravenous regional anesthesia works best in an exanguinated limb, gravity drainage by elevation of the limb above the level of the heart with digital compression of the artery supplying it for three minutes is adequate in those situations in which use of an Esmarch's bandage is contraindicated.

After removal of the Esmarch's bandage or inflation of the upper tourniquet following gravity drainage of the limb, the anesthetic agent is introduced into the the drained vascular space. The first 5 ml (30 mg) is introduced slowly as a test dose; if no adverse reaction occurs, the remainder of the solution is administered rapidly. Immediate blanching and mottling of the skin is seen and indicates that the drug has been introduced into the vascular compartment. Onset of anesthesia occurs within minutes and sensory anesthesia is complete in 7 to 15 minutes, finger flexion is reduced in 7 to 20 minutes, and all of the muscles in the forearm are paralyzed within 10 to 25 minutes.

During development of anesthesia, surgical preparation can be done if required. Patients will usually complain of tourniquet discomfort 10 to 15 minutes after the proximal tourniquet has been inflated. The distal (lower) tourniquet is therefore inflated at this time and the proximal tourniquet is deflated. Discomfort will disappear rapidly; inasmuch as the lower tourniquet is located in an anesthetized area, it is well tolerated for the duration of the procedure. It is for this reason that two tourniquets or bladders are used.

At completion of the procedure (maximum 1 3/4 hours), the distal tourniquet is deflated allowing reentrance of blood into the limb washing the anesthetic agent into the central vascular compartment. Anesthesia recovery time is usually complete in five to ten minutes with an absence of postoperative analgesia. After procedures less than 15 minutes, the distal tourniquet should be deflated for five seconds and then reinflated, and this sequence repeated three times.

Postoperative follow-up in the majority of cases is short and simple. Upon release of the tourniquet, the anesthetic agent is flushed into the vascular space and transported to the liver where metabolic degradation occurs. The dose of drug released is ordinarily below toxic levels and few symptoms occur, and total recovery is accomplished within 30 minutes. If no symptoms occur within five to ten minutes, it is unlikely that symptoms will occur. For minor procedures, patients may usually be discharged after a 30-minute observation period. It should be realized that there is no postoperative analgesic and an analgesic may be required for the patient's comfort.

Mechanism and Duration of Action

Local anesthetic agents prevent neural transmission by stabilizing the membrane in its polarized or resting state by an incompletely understood biochemical mechanism. Studies of nerve conduction during intravenous regional anesthesia have presented conflicting results. Miles and co-workers, in examination of conduction in the ulnar nerve at the wrist and elbow in normal subjects, concluded that lidocaine acts at both periphery nerve endings and at the neuromuscular junction.[12] Adams and associates, studying median nerve conduction, concluded that lidocaine decreased conduction in nerve trunks.[13] Shanks and McLeod[14] and Raj et al[15] have confirmed the action of lidocaine on nerve trunks to produce clinical anesthesia.

The most frequently used local anesthetic agents in intravenous regional anesthesia are lidocaine hydrochloride (Xylocaine), prilocaine hydrochloride (Citanest), and mepivocaine hydrochloride (Carbocaine). Each of these local anesthetics belongs to the non-ester group of local anesthetics and are not detoxified by choline esterase, thereby having a prolonged intravascular effect. Since there is no one ideal agent, the agent used depends upon personal preference. It is better to use one agent and become thoroughly acquainted with its action and toxicity than to alternate agents. Although prilocaine hydrochloride has a lower central nervous system toxicity as compared to lidocaine hydrochloride, a significant methemoglobinemia may occur with use of prilocaine hydrochloride which does not occur with use of the other two agents. Mepivocaine hydrochloride has the advantage of longer duration than lidocaine hydrochloride when topically applied to a nerve, but this characteristic is not seen in intravenous regional anesthesia where the duration of action depends on duration of vascular occlusion.

Reports of the maximum plasma concentration of local anesthetic agents following release of the tourniquet have produced inconsistent data. Mazze and Dunbar[10] report that following release of the tourniquet, the maximum plasma concentration of local anesthetic agents was not correlated to the duration of the tourniquet inflation. In general, the longer the tourniquet time, the

greater was the maximum plasma-lidocaine concentration. However, more recent observations by Tucker and Boas show a correlation of peak plasma levels of local anesthetic agents to tourniquet time in that peak levels were inversely proportional to tourniquet time.[16] Levels also tended to be lower when the same total dose was administered as a 0.5 percent solution as compared to a 1.0 percent solution. The release of drug was shown to be biphasic with an initial rapid release of 30 percent of the administered dose followed by a gradual washout of the remainder. According to their calculations, 50 percent still remained in the arm 30 minutes after tourniquet deflation. To re-establish anesthesia within 10 to 30 minutes after initial cuff release, they recommend injection of only one-half of the original dose. High plasma concentrations of anesthetic drugs after prolonged tourniquet inflation probably result from increase washout resulting from the vasodilation produced by hypoxia and hypercarbia occurring locally during the ischemic period. Because of the inverse relationship between observed plasma peak levels of the anesthetic agent and tourniquet inflation time, it is recommended that, following completion of procedures lasting 15 minutes or less, the tourniquet be deflated by cycled deflation for five seconds and reinflation for 45 seconds. This sequence is repeated three times after which the tourniquet is deflated permanently.

Management of Complications

If meticulous attention is given to details, complications are extremely rare. Those which occur result primarily from the toxic effects of an overdose of the anesthetic agent entering the central vascular system. This can result from use of an incompetent tourniquet, use of an initial overdose of the anesthetic agent (most frequently from use of a one percent solution), or too abrupt release of the tourniquet after a short inflation time. The possibility of release of toxic doses of the anesthetic agent is greater in instances where the tourniquet time is less than 15 minutes or when the lower extremity (and a larger anesthetic dose) is involved. Toxic manifestations of the local anesthetic agents involve the central nervous system and the cardiovascular system.

Local anesthetic drugs in toxic doses initially stimulate the central nervous system, then depress it. Symptoms of a toxic reaction depend upon the degree of toxicity varying from a mild reaction of increased anxiety and nervousness to a severe reaction as manifested in a frank grand mal seizure. Therapy will depend upon the severity of the reaction. Mild reactions require no therapy whereas grand mal seizures require immediate intravenous treatment with a short acting barbiturate such as sodium thiopental (Pentothal). If significant depression occurs from the combined effect of the depression phase of the biphasic toxic reactions and depression from administered barbiturates, the patient may become apneic and require assisted or controlled artificial ventilation.

Cardiovascular effects of a toxic dose of local anesthetic agents consist of hypotension and myocardial depression. Hypotension results from vasodilation produced by the direct action of the anesthetic agent on muscle cells in vascular walls and a reduced cardiac output resulting from both decreased venous return as a result of peripheral vasodilation and decreased contractility of the myocardium which is depressed by the local anesthetic agents. Local anesthetic drugs also decrease conduction and spontaneous electrical activity within the heart and arrhythmias including asystole may occur. Therapy consists of symptomatic treatment of the hypotension with a vasopressor. Cardiac arrest requires cardiopulmonary resuscitation.

Allergic reactions to the local anesthetic agents are rare but such reactions have been reported. Treatment is the same as an allergic reaction produced by any other allergen.

It should be stressed that strict adherance to the protocol as described provides an easy and safe form of anesthesia for surgical procedures on the extremities of less than 1 3/4 hours.

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