The surgeon August Gustav Bier significantly influenced surgery, general medicine and especially anesthesia. Bier was the father of spinal anesthesia (1898) and intravenous regional anesthesia (1908). Both techniques are still valuable and widely applied in everyday anesthesia practices, throughout the world, with a high degree of safety, efficacy, efficiency and satisfaction. The intravenous regional anesthesia technique is especially popular in North and Latin America and Great-Britain. Not only anesthesiologists, but also clinicians working at the accident and emergency department frequently use this method of anesthesia.

History

Two history articles at the occasion of the centennial of intravenous regional anesthesia (IVRA) or Bier’s block have been produced a few years ago (1–2). Bier observed that when local anesthetic was injected i.v. between two tourniquets on a limb, a rapid onset of anesthesia occurred in the area between the tourniquets. The technique became popular in the 1960s when Holmes reintroduced the technique. Today, the technique is slightly modified, using either a single or preferably a double tourniquet at one site and injecting local anesthetic as distal as possible to the cuff. The double tourniquet is used to increase safety and to reduce tourniquet pain in the awake patient, but the downside is that there is a potential for confusion and accidental deflation of the wrong cuff, which may lead to toxic systemic levels of local anesthetics.

IVRA – Technique

The IVRA technique is technically easy, does not require specific anatomical knowledge and results in a high (996%) successful anesthetic with a low incidence of side-effects. IVRA is a reliable, simple and safe method of providing anesthesia for minor surgical procedures to the upper and lower extremities if it is administered by experienced clinicians. Before the procedure the patient should be starved and monitored as usual, while informed consent needs to be obtained. The patient’s blood pressure should be measured. The equipment for IVRA includes the use of a pneumatic tourniquet (checked for leaks and proper function) and a pressure gauge; Esmarch bandage or exsanguinator; local anesthetic solution; and full resuscitation equipment and drugs ready at hand. A 22-G canula is placed i.v. as distal as possible in the arm to be anesthetized (e.g. in the dorsum of the patient’s hand). The smaller gauge i.v. catheter should be used to prevent oozing after the removal of the catheter. The catheter should be firmly taped in place to prevent its dislodgment during the exsanguinations with the Esmarch bandage or the injection procedure. Venous access is established in the opposite arm to allow administration of fluids or drugs if necessary. The double tourniquet (two tourniquets of 6 cm wide) or a single one (14 cm wide) is applied on the arm with
generous layers of padding, ensuring that no wrinkles are formed and the tourniquet edges do not touch the skin. The arm is exsanguinated with an Esmarch or rubber bandage properly applied from distal to proximal (keep the arm above the level of the heart), requiring an assistant. The distal tourniquet is inflated 100 mm Hg higher than the patient’s systolic blood pressure (suggestions are made to use 250 mm Hg for the upper extremity, 300 mm Hg for the lower extremity, and 230 mm Hg in pediatric patients). The proximal tourniquet is inflated to the same level of pressure. After ensuring inflation, the distal cuff is deflated. The Esmarch bandage is then unwrapped and the extremity is checked for color (pale skin) and arterial occlusion (absence of the arterial pulse [radial for arm/dorsal pedis for leg]), before the local anesthetic is injected. A standard volume for injection into the upper limb is 40 ml (max 50 ml in a fit large adult - and 30 ml in a small or frail patient) and should be administered slowly (3 ml/sec). Surgical anesthetic is usually achieved within 15 min. At that time, the distal tourniquet can then be inflated adequately and the proximal one deflated to relieve tourniquet pain (check the function of the distal tourniquet before releasing the proximal tourniquet). After 20 min, 30% of the local anesthetic drug is fixed within the tissues and is unavailable for immediate release into the systemic circulation. Full cuff deflation (preferably not before 30 after the start of IVRA) should be performed in cycles with deflation/inflation times of less than ten seconds until the patient no longer exhibits signs and symptoms of systemic toxicity (tingling lips, tinnitus, drowsiness, bradycardia, hypotension, ECG abnormalities, fitting and loss of consciousness). Maximum blood levels of local anesthetic occur within ten minutes of cuff deflation and all patients should be monitored closely for 20 minutes following tourniquet release. If severe CNS local anesthetic toxicity occurs, appropriate resuscitation guidelines should be followed (oxygen, thiopental/propofol, intralipid), the airway should be protected and if needed endotracheal intubation and ventilation should be instituted. Continue to monitor ECG, blood pressure and pulse oximetry for 20 minutes after deflation of cuff. The release of the tourniquet will result in a rapid resolution of anesthesia/analgesia. Instructions for adequate pain relief should be instituted immediately (e.g. the surgeon can infiltrate local anesthetic before the release of the tourniquet to prevent a sudden, oncoming pain; also other pain relief methods apply). Insufflation times are limited to a maximum of 1.5 to 2 hours. The tourniquet is typically placed on the upper arm. A forearm tourniquet has been proposed to reduce the total dose of local anesthetic and perhaps reduce the tourniquet discomfort, although the upper arm tourniquet remains the most commonly used. IVRA of the lower extremity is basically the same as for the upper extremity but the tourniquet pressure must be higher (300-350 mm Hg) and the dose and volume of local anesthetic has to be increased (e.g. 60 ml). An increase in the occurrence of tourniquet pain can be seen. Tourniquets may be applied to the thigh (two tourniquets about 9 cm wide) or one at the calf (below the fibula head) and one at the thigh.

**IVRA - Choice of Local Anesthetic Solution**

The drug of choice is preservative free 0.5% prilocaine, 3-6 mg/kg, because it has less systemic toxicity and is partially taken up in the lungs before reaching the systemic circulation. Prilocaine is the least toxic local anesthetic and has the largest therapeutic index. The usual dose of prilocaine is 200 mg (20 ml) without epinephrine. However one often uses prilocaine 1% as it is often the only
solution available and stability is not guaranteed if diluted. In countries where prilocaine is not available, 0.5% lidocaine at a dose of 3 mg/kg is used for IVRA of the arms and 0.2-0.25% lidocaine for IVRA of the legs. The maximum recommended dose is 250 mg lidocaine (50 ml 0.5% solution). If prilocaine is used for IVRA of the legs, a larger volume must be injected (e.g. 60 ml), keeping in mind that the maximum recommended dose is 400 mg (e.g. 80 ml 0.5% prilocaine) in adults. Other local anesthetics have been used for IVRA, but they do not provide superior analgesia or more rapid onset of block. Severe toxic reactions and death have been reported with bupivacaine and its use is contraindicated. 0.2% ropivacaine has been used intraoperatively and was as effective as 0.5% prilocaine, but with prolonged postoperative analgesia. Several additives to local anesthetics were tried out (pethidine 1 mg/kg; muscle relaxants, ketamine, clonidine 150 Kg; NSAIDS), resulting in improved analgesia and prolonged postoperative analgesia, but may show side effects. The addition of epinephrine should be avoided and plain local anesthetics should be used. Prilocaine can cause methemoglobinemia. Usually it goes clinically unnoticed, unless prilocaine doses in excess of 600 mg are used.

**IVRA - Mechanism of Action**

Although the exact mechanism of action for IVRA is not clearly understood, there appears to be multiple and complimentary mechanisms for producing analgesia and anesthesia. Ischemia, asphyxia, hypothermia and acidosis play an important role. Peripheral nerve endings of the upper and lower extremities are nourished by small blood vessels. The injected local anesthetic diffuses into the small veins surrounding the nerves, followed by the vasa nervorum and capillary plexus of the nerves, leading to a core to mantle conduction block in the nerves of the area. The local anesthetic diffuses into the small nerves in the skin, blocking conduction. This holds true for as long as the concentration of the local anesthetic in the venous system remains relatively high. The tourniquet itself also produces ischemia, and contributes to the analgesic action of the local anesthetic by blocking nerve conduction and motor endplate function. Analgesia to pinprick can be obtained after 20-min tourniquet alone (without injecting local anesthetic), although the speed of onset and the density of anesthesia are much better with the injection of a local anesthetic.

**IVRA - Indications**

IVRA for surgical interventions on the hand, forearm or elbow not exceeding one hour is a well accepted technique by patients and surgeons. The operations include manipulation of forearm fractures, excision of ganglia and palmar fasciotomy. It is particular useful for tendon grafting as it allows the surgeon to observe movement and tension of the grafted tendon (after deflating the tourniquet) before closing the wound. IVRA for surgical interventions on the foot ankle, or lower leg is also possible.

**IVRA - Contraindications**

Most contraindications are related to the use of the tourniquet. Absolute contraindications include (homozygous) sickle cell disease, Raynaud’s disease, sclerodermia, crush injuries, allergy to local
anesthetics, patient refusal and young children. Relative contraindications include severe hypertensive and peripheral vascular disease, local infection and skeletal muscle disorder or Paget’s disease.

**IVRA - Side Effects**

Tourniquet discomfort (see above) and rapid return of sensation after tourniquet release, resulting in subsequent pain may occur. If the operation is prolonged, the patient may complain of pain due to pressure from the tourniquet. Subcutaneous infiltration of a few ml of local anesthetic above the tourniquet may help. Toxic reactions from malfunctioning or deflating the tourniquet prior to 20-25 min are possible. Double check tourniquet leaks and sufficient pressures during the procedure are imperative. Label each cuff appropriately. Exsanguinating and tightly wrapping the arm/leg may cause pain to the patient (e.g. if the limb is fractured). Simply elevate the arm for 30 seconds whilst applying firm digital pressure on the brachial/femoral artery, will allow venous blood to drain from the limb whilst preventing further arterial blood entering the limb. Hematoma formation at the insertion area of the i.v. canula may be seen and need adequate padding.

**Conclusion**

IVRA is an excellent regional anesthesia technique for surgery of the extremities, and can also be successfully used in pain therapy, such as in reflex sympathetic dystrophy (CRPS). It is widely recommended and applied in patients undergoing ambulatory procedures, for both urgent as well as scheduled surgery, with a high degree of safety, effectiveness and efficiency. IVRA still deserves it place in regional blocks of the extremities, despite progress made in upper and lower extremity blocks using ultrasound and nerve stimulation techniques.

**References**
