INTRAVENOUS REGIONAL ANAESTHESIA*

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In 1908 August Bier, who was associated with the discovery of spinal anaesthesia, described a method of intravenous regional anaesthesia^{1 2} He injected a dilute procaine solution intravenously between two tourniquets which were inflated above arterial pressure The resulting intense anaesthesia was adequate for all surgical procedures that could be carried out on the extremity either between or distal to the tourniquets

Modern texts on local anaesthesia either do not mention this technique or have only quoted Bier's original work A brief description is given by Lee³ Recently the interest in this technique has been revived and Holmes⁴ and Bell *et al*⁵ have described modifications of the technique and reported their clinical experience. Holmes' method, with modification of equipment, has been used in the 47 cases reported here

EQUIPMENT AND MATERIALS REQUIRED

- 1 A supply of suitable local anaesthetic solutions (without the addition of vasoconstrictors)
- 2 A sterile 50 c c syringe
- 3 Scalp vein needle
- 4 One or two reliable tourniquets
- 5 A broad rubber bandage (Esmarch)

TECHNIQUE

The tourniquet is applied to the limb and a venipuncture with a scalp vein needle is performed in the usual manner using a vein which is fairly close to the site of the operation The needle is firmly taped and a 50 c c syringe loaded with the local anaesthetic solution is attached The limb is then exsanguinated by compression with the broad rubber bandage In painful and infected lesions sufficient exsanguination is produced by elevating the limb for 3 to 5 minutes The tourniquet is then inflated to above arterial pressure and the local anaesthetic solution is injected fairly rapidly, but avoiding painful distension of the veins Where possible, to avoid the discomfort of the tourniquet, a second one is placed lower down the limb during the time of onset of anaesthesia (a period of 7 to 10 minutes), and inflated when anaesthesia is complete The first tourniquet is then released After the operation has been completed, the remaining tourniquet is released intermittently and sensation returns very quickly

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The following is a step-by-step presentation of the technique and the results of its use in 47 patients

Preparation of Patient

It is advisable to explain the anaesthetic procedure to the patient, the need for premedication can readily be assessed during this conversation. Of the 47 patients, 20 were premedicated. Three very nervous patients were given a sleep dose of thiopentone for the preparation. They awoke during the early part of the surgical procedure and were quite content. For out-patients the rapid recovery is a distinct advantage which should not be offset by heavy premedication.

Selection of the Needle and Venipuncture Site

The scalp vein needle (Baxter or Abbott) was used in 30 cases and the plastic Rochester needle in 16 cases. A cutdown procedure was done on one occasion. The scalp vein needle, particularly one with a shoulder (Abbott), is small and convenient but during the manipulation of the limb there is the possibility of piercing the venous wall. This is minimized by selection of a well-supported vein and careful handling while "stripping" with the rubber bandage.

The Rochester needle is more secure. It is ideal if, during the operation, it can be left *in situ* closed with a matching stilette. However, when removed after the injection of the anaesthetic agent it leaves a large hole in the vein and the subsequent haematoma can be a source of annoyance to the patient.

Exsanguination by Esmarch Bandage or Elevating the Limb

The impression is that the more efficient the emptying of the veins the more profound the anaesthesia.^{3 5} However, a satisfactory anaesthetic can be obtained by elevation of the limb only. This method is preferable when manipulation of the limb is painful. Of the 47 patients, exsanguination of the limb was done by bandage in 42 and by limb elevation in 5 patients.

Tourniquet

In 37 patients a two-tourniquet technique was used, 10 were managed with one tourniquet only.

In short cases one tourniquet may suffice and many patients will tolerate the feeling of heavy pressure. The discomfort of the tourniquet can be reduced by subcutaneous infiltration of the area with the same local anaesthetic solution.^{3 4} This was not tried in our cases.

It is probably better to apply a second tourniquet distal to the first one. This manoeuvre causes no delay because the second tourniquet is placed in position during the onset of analgesia and is inflated when anaesthesia is complete. The upper, proximal tourniquet is then released and the patient is more comfortable because the pressure of the distal tourniquet is not felt. Also the likelihood of toxic effects is lessened by reducing the amount of local anaesthetic solution to be released at the end of the operation. Although the aim is to anaesthetize as little as possible of the limb, allowance must be made for surgical requirements. The Kidde Robbins pneumatic tourniquet is preferred as a second tourniquet. It is reliable and is easily inflated and deflated.

Local Anaesthetic Solutions

Holmes³ recommends the use of 0.5 per cent lignocaine (Xylocaine®) as the least concentration of the agent with which a satisfactory anaesthesia is obtained. It was used in all the patients except three. In two of these, 0.5 per cent mepivacaine (Carbocaine®) was used with success and 0.5 per cent procaine was used in one case with failure to obtain a satisfactory result. The largest dose of local anaesthetic given to one patient was 75 c.c. of 0.5 per cent lidocaine (for bilateral ingrowing toe-nail operation). The smallest dose given was 25 c.c. of 0.5 per cent lidocaine and the average dose was 40 c.c.

Time of Onset and Duration of Analgesia

Good analgesia is usually present after 7 to 10 minutes. During this time a second tourniquet can be positioned and the limb prepared for surgery. The duration of the anaesthetic effect is theoretically as long as the tourniquet remains inflated.

Our longest operation was 1 hour and 35 minutes and the anaesthesia was satisfactory throughout. The average duration in our cases was 25 minutes. While sensory loss is complete, impairment of motor function does occur, but it has not been profound in many cases. On release of the tourniquet, sensations return in 5 to 7 minutes and it is important to warn the patient of this. There was no hyperalgesia.

COMPLICATIONS

The injection of a potentially toxic dose of a local anaesthetic agent into a vein and the possibility of a rapid release into the systemic circulation makes it apparent that a toxic systemic reaction is the most important complication of this technique. The following case illustrates this.

Case 1

A 59-year-old man was admitted for incision and drainage of an abscess of the foot. The incision was made 3 minutes after the intravenous regional anaesthesia was given and the operation lasted 3 minutes. The anaesthetic was not effective. The tourniquet was released without intermittent inflation and deflation.

After a short interval the patient had twitching of the facial muscles, lost consciousness, and had a transient respiratory arrest. A small dose of thiopentone was given and the patient ventilated until the return of spontaneous respiration. He recovered his reflexes gradually and was awake and well 30 minutes later. The implications of the very short time of tourniquet inflation will be discussed later. This also was the cause of the unsatisfactory anaesthesia. Furthermore, this points out the need to have resuscitative equipment available. A short-acting intravenous barbiturate, a short-acting muscle relaxant, a vasopressor, suction apparatus, and a means of delivering oxygen under positive pressure by mask or endotracheal tube should be in the room where intravenous regional anaesthesia is conducted.

In four other patients minor and transient signs of a toxic effect were observed (transient dizziness, 2, tinnitus, 1, paraesthesiae in tongue, 1).

MODE OF ACTION

To investigate the spread of the anaesthetic agent Bier injected methylene blue together with the local anaesthetic solution prior to amputation. He could show that the dye penetrated throughout all the tissues including the perineurium and the periosteum.

Bier thought that the local anaesthetic was primarily detoxified in the tissues. To demonstrate this he injected intravenously 10 times the lethal dose of cocaine into the ischaemic rabbit ear. The tourniquet on the base of the ear was released 10 minutes later and the animal survived.

Using lidocaine this experiment was repeated in the laboratory. For each of nine rabbits the convulsive dose of intravenously injected lidocaine was determined (range 5–10 mg/kg). This dose was then injected into the ischaemic ear and no convulsion was seen when the tourniquet at the base of the ear was released 15 minutes later. In each animal the experiment was then repeated at 3- to 4-day intervals using increasing doses. When four times the convulsive dose was injected, marked depression and lethargy was observed after the tourniquet was removed, but only two of the nine animals had convulsions of a minor nature.

From Bier's work and our own observations the following factors are instrumental in decreasing the occurrence of systemic toxicity.

- 1 The dilution of the local anaesthetic agent in plasma in the veins and capillaries
- 2 The diffusion of the anaesthetic agent into the tissues with subsequent slow release when the circulation returns
- 3 The possibility of detoxification of the agent in the tissues. This is probably of minor importance.

In the case described the time was probably too short for diffusion to take place and most of the agent was still intravascular at the time the tourniquet was released.

It is therefore recommended that the deflation of the tourniquet be delayed in very short cases until perhaps at least a total of 15 minutes have elapsed and that the pneumatic tourniquet be deflated and reinflated three or four times during a 3-minute period at the end of the operation.

CLINICAL APPLICATION

Intravenous regional analgesia was used in 31 male and 16 female patients, 26 times on the upper and 21 times on the lower extremity. The youngest patient was 9 years old and the oldest 84 years old, the average being 39 years. The following operative procedures were carried out (Table I). The anaesthetic was completely successful in 36 patients and partially successful in 6. There were 5 failures.

The failures include the first two cases (faulty technique), the case described above, one case with poor exsanguination, and one case in which the failure could not be attributed to a particular cause. The partially successful cases include those requiring thiopentone in sleep doses due to anxiety, two cases in

TABLE I
OPERATIVE PROCEDURES

Excision of ingrowing toe-nail	9
Excision of ganglion	9
Excision of scar tissue	3
Excision of bunion	3
Reduction of fracture	5
Removal of foreign body	3
Wound debridement, skin grafting	3
Incision and drainage of abscess	2
Joint capsulotomy, excision of bursa, patellectomy, hammer toe	5
Trigger finger, tendon repair	2
Amputation of finger	3
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which anaesthesia was not entirely satisfactory but the operation could be completed, and one case of a patellectomy where probably the dose was insufficient and local infiltration was needed to reinforce the anaesthetic

In the following two cases we felt that intravenous regional analgesia was the method of choice

Case 2

A 67-year-old lady suffered from a painful interdigital neuroma. Because of her discomfort, she was almost unable to walk. Several years ago she had suffered brain damage with aphasia following a general anaesthetic. The details of the mishap are unknown but she had made a marked, though not complete recovery. Her X-ray showed considerable osteoarthritis of the spine. She refused for these reasons to have either a general, spinal, or epidural analgesia. The operation was done under intravenous regional analgesia and the patient wrote us a very appreciative letter a few days later.

Case 3

A 64-year-old man on steroid therapy with ischaemic heart disease, cirrhosis, peptic ulceration, chronic bronchitis, and emphysema, whose life was being made even more miserable by a painful bunion, requested treatment. Intravenous regional anaesthesia was commenced and after a few attempts with a needle it was decided that, as his veins were so fine, friable, and restricted in number by previous cutdowns, a cutdown should be done using a fine polyethylene catheter. This was done and the operation was completed without incident.

SUMMARY

Our experiences with a regional block using intravenous local anaesthetic agents have been described.

This method has the advantage of using simple equipment and requires neither specialized nor detailed anatomical knowledge. It can be used in any short operation on the extremities either requiring, or having no contraindication to, the use of a tourniquet. Possible toxic effects can be minimized. While it is not suggested that this method replace the present well-known techniques, it is felt that it can be recognized as having a greater application than is at present acknowledged in the modern texts, and in certain cases can be the technique of choice.

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RÉSUMÉ

La technique d'anesthésie régionale, décrite par Bier¹ en 1908, n'est pas d'usage courant et ce n'est que récemment^{4,5} que sont apparus des rapports d'expérience clinique avec cette technique. La méthode consiste à injecter dans les veines une grande quantité d'une solution diluée d'anesthésique local (25 à 100 ml de xylocaine à 0.5 pour cent selon la masse de tissus à anesthésier) dans un membre rendu exsangue par la compression avec une bande élastique et le gonflement d'un tourniquet au-delà de la tension artérielle. Si le malade se plaint du tourniquet, on peut placer un deuxième tourniquet, ce dernier sur la région anesthésiée, et le gonfler. Ensuite, on enlève la pression dans le premier tourniquet. À la fin de l'opération, on diminue la pression de façon intermittente et la sensibilité redevient rapidement normale. Nous avons pratiqué diverses opérations sur les membres supérieurs et inférieurs, chez 47 malades des deux sexes dont l'âge variait de 9 à 84 ans. La durée des opérations, en moyenne, a été de 25 minutes, et la dose de xylocaine à 0.5 pour cent de 40 ml.

Trente-six cas ont été des succès, six ont été satisfaisants sans être des succès et cinq, dont les deux premiers de la série, ont été des échecs à cause d'une mauvaise technique.

Nous ne prétendons pas que cette méthode puisse remplacer certaines techniques actuelles bien connues, mais nous considérons qu'elle a beaucoup plus de valeur qu'on veut bien lui en reconnaître actuellement et, dans certains cas, elle peut être la technique de choix.

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