INTRAVENOUS REGIONAL ANAESTHESIA

A SIMPLE METHOD OF ANAESTHESIA FOR LIMB SURGERY

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Regional anaesthesia in one form or another has been practised since the discovery of cocaine. Though usually regarded as an elective method of anaesthesia only when a general anaesthetic is contraindicated for some reason, nerve block has many advantages and would be used much more widely were it not for the difficulties and uncertainties with the commonly used techniques, especially in inexperienced hands. Patients who would otherwise be admitted to hospital could be dealt with speedily in casualty and outpatient departments. More important still, in a large and sparsely populated country such as South Africa, where practitioners are frequently called upon to perform major surgery—often under indifferent conditions with inadequate facilities for anaesthesia available—the advantages of a safe, easy and well-nigh foolproof method of regional anaesthesia are self-evident.

The technique of 'venous anaesthesia' was described in detail by Bier in 1908[1] but the method made no popular appeal and, with some few exceptions,[2] was soon relegated to the introductory pages of textbooks of anaesthesia. Interest in the method has recently been revived by Holmes,[3] Bell *et al.*,[4] and Adams *et al.*[5] During the past year it has been used in more than 100 cases at the Johannesburg General Hospital. The present paper describes the technique employed here and our experience with 53 unselected patients who were studied in detail.

TECHNIQUE

Adequate pre-operative sedation is desirable but may be omitted for short, simple procedures. The patient's blood pressure is determined on the operating table. This is an essential step and a failure in technique can usually be traced to an inadequately inflated tourniquet.

A suitable vein is selected on the dorsum of the hand or foot (though a more proximal vein will serve equally well), a Gordh needle is inserted and kept in place with adhesive strapping. The limb is exsanguinated with a Martin's bandage or (e.g. in the presence of a fracture or some other painful condition) by simply elevating the limb for 3 minutes. A pneumatic tourniquet is then wound around the proximal part of the limb and held securely in place by a few turns of a cotton bandage. The cuff is inflated to 40 or 50 mm.Hg above the systolic pressure and the Martin's bandage is removed. Care should be taken to maintain the tourniquet pressure throughout the subsequent procedure.

A $\frac{1}{2}$% solution of lignocaine is now injected into the Gordh needle: the recommended dose is 0·25 ml./lb. body weight (2·75 mg./kg.). We have used twice this volume without ill-effect for lower limb procedures, but even here a below-knee tourniquet obviates the necessity for these larger doses.

Sometimes injection of the local anaesthetic is followed by marked dilatation of the superficial veins. Again, if exsanguination has been less than perfect, the skin may become purple and blotchy. Neither of these events seems to matter except that it may take slightly longer than usual for analgesia to develop.

As a rule the patient experiences some dysaesthesia within 5 minutes of injecting the lignocaine and anaesthesia is complete 5 - 7 minutes after that. The Gordh needle is now removed.

There is seldom any complaint about the tourniquet but, if this should occasion undue discomfort, a second cuff may be applied immediately distal to the first in the analgesic area, and the original cuff removed.

At the end of the procedure the tourniquet is released and sensation returns within 10 minutes.

Precautions

The precautions recommended for the use of any local anaesthetic are equally applicable here. Lignocaine should not be injected if there is a history of sensitivity to this drug, nor in patients with advanced liver disease. Oxygen (and the means to administer it) as well as vasopressor drugs and a short-acting barbiturate should be readily available in case of severe toxic reactions. The symptoms of lignocaine overdosage are increasing nervous irritability, muscular twitching, convulsions, hypotension and respiratory depression.

The danger of prolonged ischaemia should be borne in mind as well, and this method should not be employed for any procedure likely to take longer than 1½ hours, nor in patients with peripheral vascular disease.

CLINICAL MATERIAL

The 53 patients who were studied in detail are listed in Table I. Their ages ranged from 2½ to 78 years, the volume of lignocaine injected being adjusted to the size of the patient. Most of the procedures were of the sort that would allow the patient to be treated in the casualty department and sent

TABLE I. 53 PATIENTS TREATED UNDER REGIONAL PERFUSION ANAESTHESIA*

Case Number	*Age*	*Upper or lower limb*	*Concentration lignocaine*	*Volume (ml.)*	*Procedure*	*Duration (minutes)*
1	2½	Upper	½%	5	Reduction greenstick fracture of radius	20
2	3½	Upper	½%	15	Manipulation fractured radius and ulna	20
3	5	Upper	½%	10	Reduction fractured radius and ulna	20
4	5	Upper	½%	15	Reduction supracondylar fracture of humerus	20
5	6½	Lower	½%	15	Manipulation fractured tibia and fibula	30
6	7	Upper	½%	15	Reduction Colles' fracture	20
7	7½	Upper	½%	15	Reduction Colles' fracture	20
8	7½	Upper	½%	15	Reduction Colles' fracture	20
9	9	Upper	½%	15	Reduction fractured radius and ulna	30
10	10	Upper	½%	15	Reduction Colles' fracture	15
11	10	Upper	½%	15	Reduction Colles' fracture	20
12	11	Upper	½%	15	Reduction fracture-dislocation finger	20
13	11	Lower	½%	20	Toilet and reduction compound fractures of toes	30
14	12	Upper	½%	15	Reduction Colles' fracture	20
15	12½	Upper	½%	15	Reduction Colles' fracture	20
16	13	Upper	½%	15	Manipulation fractured radius and ulna	30
17	13	Lower	½%	20	Reduction fractured tibia	30
18	14	Upper	½%	35	Reduction Colles' fracture	15
19	14	Upper	1%	20	Reduction of slipped distal radial epiphysis	10
20	15	Upper	1%	20	Reduction Colles' fracture	10
21	16	Upper	1%	20	Reduction Colles' fracture	15
22	16	Upper	½%	30	Reduction fractured radius	15
23	16	Upper	1%	20	Reduction Colles' fracture	60
24	16	Upper	1%	28	Reduction fractured radius and ulna	35
25	19	Upper	1%	20	Reduction fractured radius	10
26	20	Upper	1%	20	Reduction fractured first metacarpal	10
27	24	Upper	1%	25	Reduction Smith's fracture	20
28	25	Upper	1%	20	Manipulation perilunar dislocation of wrist	20
29	25	Upper	1%	20	Incision and drainage of septic finger	25
30	25	Upper	1%	25	Excision ganglion of wrist	40
31	34	Upper	1%	20	Carpal tunnel decompression	20
32	40	Upper	½%	50	Tendon transplantation for ruptured extensor pollicis longus	60
33	40	Lower	½%	55	Excision ganglion dorsum foot	35
34	40	Lower	½%	80	Reduction fractured tibia and fibula	25
35	42	Upper	1%	20	Reduction Colles' fracture	25
36	47	Upper	1%	20	Reduction Colles' fracture	5
37	48	Lower	½%	40	Arthrodesis hammer toe	30
38	55	Lower	½%	80	Reduction fracture-dislocation navicular	50
39	55	Upper	1%	30	Reduction of Monteggia fracture	15
40	55	Lower	½%	80	Reduction Pott's fracture	25
41	56	Upper	½%	30	Incision tendon sheath for De Quervain's disease	20
42	58	Upper	1%	20	Reduction Colles' fracture	25
43	59	Lower	½%	25	Excision exostosis of first metatarsal	15
44	60	Upper	1%	20	Reduction Colles' fracture	10
45	61	Upper	1%	20	Reduction Colles' fracture	10
46	61	Lower	½%	60	Keller's operation for hallux valgus	35
47	62	Lower	½%	40	Arthrodesis hammer toe	40
48	62	Upper	1%	20	Reduction Colles' fracture	10
49	65	Upper	½%	40	Carpal tunnel decompression	25
50	65	Upper	1%	20	Reduction Colles' fracture	10
51	74	Upper	1%	25	Reduction Smith's fracture	30
52	77	Upper	1%	20	Reduction Colles' fracture	15
53	78	Upper	½%	40	Reduction Colles' fracture	10

*Cases arranged by age.

straight home again, though several more lengthy operations are included in the series. Manipulation of fractures, soft-tissue operations and bone or joint operations were all tolerated equally well.

In our experience there is practically no limitation on the age at which this method can be applied, provided sufficient care is taken to explain the procedure to the patient, to ensure that he is not distressed by the tourniquet or the injection and—especially in the case of children—to elicit his trust and cooperation. In very young children adequate sedation is essential.

In 11 patients intravenous regional anaesthesia was carried out in the lower limb. Apart from the larger volume of lignocaine required in those with the tourniquet above the knee, their management was no different from those undergoing upper-limb procedures.

In 2 patients we failed to achieve anaesthesia. Case 39 was a Greek male, 55 years of age, with a Monteggia fracture of the forearm. Intravenous regional anaesthesia was attempted—unwisely, in the event—for the patient could not understand a word of English and was quite unable to cooperate with us. In case 52 a failure in technique resulted in most of the anaesthetic being injected into the subcutaneous tissues and probably no more than 10 ml. entered the vein.

EXPERIMENTAL MATERIAL

Median nerve conduction under intravenous regional anaesthesia was studied by electromyography in a volunteer. Two points along the course of the median nerve were selected for stimulation: a proximal point just below the antecubital fossa, and a distal point just above the wrist. A needle electrode in the abductor pollicis brevis muscle recorded the response to stimulation, first at the proximal point and then at the distal point. The tracings were read on a cathode ray oscilloscope, first before applying the tourniquet, then at varying intervals after application of the tourniquet and injection of lignocaine, and again after release of the tourniquet. The results are shown in Fig. 1.

Conduction slowed down progressively in both the proximal and the distal segments of the nerve after intravenous lignocaine was given. The amplitude of the response to proximal stimulation decreased rapidly and at 20 minutes after injection there was no response at all. By contrast, the amplitude of the response to distal stimulation did not alter very much during the first 20 minutes after injection; only after 35 minutes was there a marked diminution in response. During the entire period from 10 minutes after injection to the release of the tourniquet there was complete loss of all modalities of sensation and the hand was paralysed.

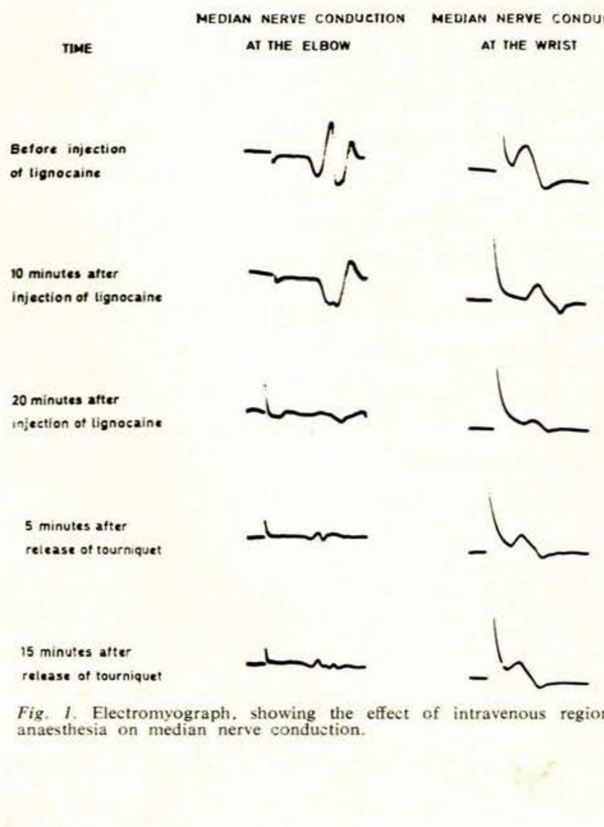

Fig. 1. Electromyograph, showing the effect of intravenous regional anaesthesia on median nerve conduction.

When the tourniquet was released sensation was rapidly regained and 10 minutes later it was almost normal. However, motor nerve conduction at the elbow was still diminished 20 minutes later.

These findings suggest that peripheral analgesia was due to a combination of tissue anoxia and local nerve block. The intravenous lignocaine could not have diffused into the tissues to any large extent, for the blocking effect was confined to a small segment of the nerve and even then was insufficient to maintain analgesia once the circulation was restored.

DISCUSSION

Applications

Indications for intravenous regional anaesthesia. This simple technique is ideally suited for all operative and manipulative procedures on the extremities in patients considered unfit for general anaesthesia. It has an even wider range of usefulness, however, in patients requiring operations which can be carried out effectively in casualty or outpatient departments, thus avoiding the necessity for hospital admission. Patients with full stomachs may be spared an unnecessary, and sometimes harmful, delay by employing a reliable substitute for general anaesthesia.

The effectiveness of intravenous regional anaesthesia. In an analysis of 206 block anaesthesias of the upper arm, Leahey *et al.*[6] noted an over-all failure rate of 20%, and observed that the surgeons for whom they regularly administered anaesthetics now avoided this procedure for elective operations. Doubtless there are some who have had a more fortunate experience with brachial plexus block anaesthesia, but the average surgeon working on his own would probably admit to an even higher rate of failure. By contrast the method of intravenous regional anaesthesia is extremely simple and, provided the technique described is followed carefully, it is found to be effective in almost 100% of cases. Anaesthesia commences 7 - 12 minutes after injecting the lignocaine and lasts until the tourniquet is released. All sensation and motor activity are abolished and any type of operation can be carried out. There appears to be no advantage in using higher concentrations of lignocaine; on the contrary, by permitting the use of larger volumes of anaesthetic, the $\frac{1}{2}$% solution has proved to be the most effective in our hands. This view is shared by Holmes,[3] who found that further dilution is less satisfactory.

The dose of lignocaine injected varies with the size of the limb. Nerve conduction studies suggest that there is no need to fill the vascular tree, but a sufficient volume is required to ensure blocking of the larger nerve trunks which are usually placed quite deeply in the proximal part of the limb. In our hands 2·75 mg./kg. gave complete anaesthesia in the upper limb or the distal part of the lower limb in almost every case. Bell *et al.*[4] were able to obtain analgesia with smaller doses (1·5 mg./kg.) by producing arterial occlusion for 20 minutes before injecting lignocaine, but this modification of technique seems unnecessary in view of the absence of side-effects with the method described here.

Exsanguination of the extremity increases the effectiveness of the anaesthetic, partly by allowing better penetration into the vascular tree and partly by increasing the degree of local anoxia in the limb.

Safety of intravenous regional anaesthesia. The pulse rate, respiratory rate and blood pressure were measured in 30 patients before, during and after intravenous regional anaesthesia. There were no marked changes in these measurements and only 2 patients complained of transient light-headedness after the tourniquet was released.

Intravenous lignocaine has been used by several workers in far higher concentrations than those employed here, without ill-effect, and only after reaching plasma levels of 5 μg./ml. were toxic symptoms recorded.[7,8] The maximum blood level reported by Bell *et al.*,[4] after doses of 3 mg./kg., was only 1·2 μg./ml., so the dosage recommended here would appear to be safe. Further work on the exact fate of the injected lignocaine and blood estimations after release of the tourniquet is in progress and will be reported later.

SUMMARY AND CONCLUSION

A simple method of regional anaesthesia is described. After exsanguination of the limb and application of a proximal tourniquet, the local anaesthetic ($\frac{1}{2}$% lignocaine) is injected intravenously, the dosage varying with the size of the patient.

The recommendations made here are based on a study of 53 patients ranging in age from $2\frac{1}{2}$ to 78 years, and supported by nerve conduction studies of the effects of intravenous lignocaine.

The procedure is considered to be safe and, with reasonable attention to detail, is effective in almost 100% of cases.

ADDENDUM

Since submitting this work for publication, a case of cardiac arrest attributed to intravenous regional anaesthesia has been reported (Kennedy *et al.*, 1965: Brit. Med. J., **1**, 954). External cardiac massage was applied and the electrocardiograph returned to normal 23 seconds after the arrest. This is the only incident of this kind encountered among several thousand cases now reported.

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