LOCAL ANALGESIA IN DENTISTRY

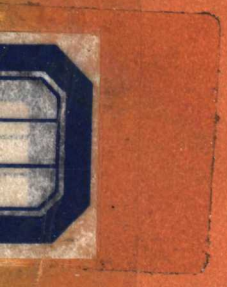
BY

D. H. ROBERTS, FDS RCS (Eng.)

AND

J. H. SOWRAY, BDS, FDS RCS (Eng.), MRCS, LRCP

Second Edition



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WITH A FOREWORD BY

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PREFACE

The purpose of this book remains unchanged in that it seeks to be an up-todate guide to dental local analgesia for students and practitioners. We have described the latest advances, but hope that our emphasis has remained on the practical aspects of the subject.

We are most grateful for the helpful suggestions received from many colleagues and, in addition to those acknowledged in the original edition, we would particularly like to record our thanks to Mr A. K. Adatia, Dr G. C. Blake, Professor I. Curson, Dr Sven F. Högberg and his colleagues at Astra Chemicals Ltd, Mr J. E. McAuley, Dr J. P. Rood, Mr W. M. Tay and Dr B. D. Wyke. Mrs Shirley Austin gave valuable help with the typescript.

In conclusion we would like to express our sincere thanks to Mr John Tyler and the other members of the staff of John Wright & Sons Ltd for all the assistance they have given us in the production of this edition.

D. H. R.
March 1979 J. H. S.

PREFACE TO THE FIRST EDITION

The commonest and safest method of preventing pain during dental treatment is the use of local analgesia. In recent years there have been considerable advances both in the drugs used and in the equipment for their administration. At the same time, modern medical therapy has introduced problems which may have to be carefully considered when a patient's fitness for local analgesia is assessed. The purpose of this book is to discuss these matters and to provide a practical guide to the subject.

The sections on techniques, precautions and instruments have been expanded to lay emphasis on the safest methods of achieving local analgesia. Although prilocaine and lignocaine are the most commonly used preparations in the United Kingdom, others have been mentioned to show how the search for the ideal local analgesic has progressed.

D. H. R.
April 1970 J. H. S.

ACKNOWLEDGEMENTS

Our introduction to local analgesia—or local anaesthesia as it used to be termed—was provided by Mr B. W. Fickling at the Royal Dental Hospital and we are indebted to him for his teaching, which has undoubtedly influenced us in our writing.

This book could not have been written without the generous help and advice of many colleagues, and among those we should particularly like to thank are Mr F. Allott of the Medical Protection Society; Dr R. C. Bret Day; Mr S. L. Drummond-Jackson and his colleagues of the Society for the Advancement of Anaesthesia in Dentistry; Dr P. T. Flute; Dr G. H. Forman; Dr W. Fraser-Moodie; Mr A. R. Halder; Dr M. Harris; Mr F. J. Harty; Dr C. D. T. James; Mr A. Kinghorn; Mr L. J. Leggett; Dr J. F. Lockwood; Professor H. McIlwain; Dr I. P. Priban; photogenic Miss B. S. Ray; Dr D. A. Pyke; Mr A. H. Rowe of the Medical Defence Union; Professor M. J. H. Smith; and Mr G. F. Tinsley.

We owe special debts of gratitude to Dr A. H. Galley and Dr Victor Goldman for their expert help with the sections on pharmacology, pre-medication, and allied topics; to Professor H. C. Killey for information regarding his researches on vasoconstrictors; and to Professor G. R. Seward and Dr R. Haskell for their helpful comments and criticisms of the text. Dr F. Stansfield kindly devoted a lot of time in advising on the anatomy chapter. Mr C. L. M. Brown and his colleagues at the Pharmaceutical Manufacturing Company generously showed us the process of producing local analgesics and Mr Roger Hickson of Messrs Cottrell and Company was extremely helpful with his technical knowledge of instruments.

The majority of the illustrations and photographs were the artistic work of Miss Jennifer Middleton and Mr J. Morgan, respectively. Mrs Angela Birbeck, Mr E. W. Blewett, Mrs Margaret Cooper, Mr P. Kertesz and Mr N. Pearson also kindly helped in this field. The typescript was very ably prepared by Mrs Maria Harrison, Mrs P. Mouncer and Mrs P. Procter.

Finally we should like to express our sincere gratitude to Mr L. G. Owens of John Wright & Sons Ltd for his courteous encouragement and help during the preparation of this book.

D. H. R.
J. H. S.

April 1970

FOREWORD

By SIR ROBERT BRADLAW, CBE

Professor of Oral Medicine, University of London
Hon. Professor of Dental Pathology, Royal College of Surgeons of England

I am very glad to contribute a brief foreword to this admirable book, not only because of the importance of its subject but for its eminently sensible and essentially practical approach. Written attractively with commendable lucidity and directness, it affords a succinct account of what is currently known of analgesia—its mechanism, technique, pharmacology, instrumentarium and application.

For the best of reasons, anaesthesia and analgesia have long been of special interest to both clinician and patient. Ever since the seventeenth century, when the Royal Society became interested in the use of drugs, especially narcotics, for the relief of pain, considerable thought and effort have been devoted to the better understanding of their rationale.

We have learnt much in consequence as to the mode of action, application and of the physiological response of the tissues. It might be thought that this would make the task of the clinician simpler but this is not the case, for concurrently with our better understanding of pharmacological principles and advances in technique we have recognized new potential hazards .nd the possibility of complications not known to an earlier generation.

The management of patients with cardiovascular lesions, for example, the risks inherent in sickle-cell anaemia, the effects of steroid therapy and other iatrogenic manifestations impose a far greater clinical and legal responsibility on the dental surgeon than hitherto.

This comprehensive and authoritative text should be read by specialist and general practitioners alike; there are few of us who would not find it interesting and helpful. Its usefulness is further enhanced by well-chosen references for further reading, a list of trade and alternative names for analgesic drugs and, topically, a metric conversion table.

CONTENTS

Chapter 1

DEVELOPMENT OF LOCAL ANALGESIA

The use of local analgesia followed the development of the hypodermic syringe with its hollow needle (*Figs.* 1, 2). In 1827 von Neuner produced one which was designed for injecting drugs used in ophthalmic veterinary work. In 1841 an American, Zophar Jayne, patented another type which had a pointed needle, but its insertion into the tissues was facilitated by first incising the skin with a lancet. Some three years later Francis Rynd of Dublin started administering drugs subcutaneously using an elaborate stylet, the solution being forced into the tissues by means of gravity (*Fig.* 3). Thus, although this was not strictly a hypodermic syringe, it was very similar in action.

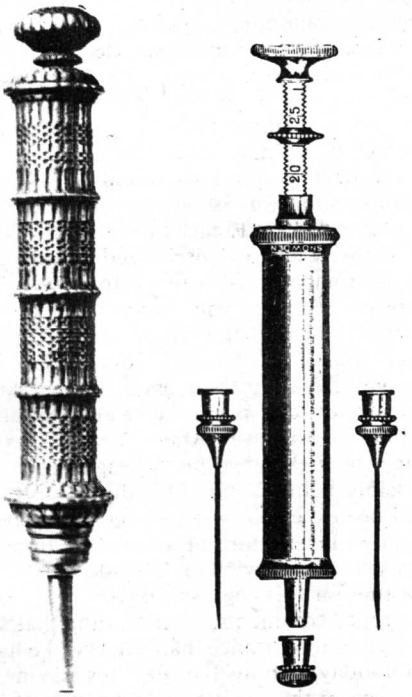

Fig. 1.

Fig. 2.

Fig. 1. Seventeenth-century French syringe of the type from which the hypodermic syringe was developed. Wellcome Historical Medical Museum No. R3655/1936. (*Figs.* 1–8 *are reproduced by courtesy of the Wellcome Trustees.*)

Fig. 2. An early German silver hypodermic syringe illustrated in *A Manual of Hypodermatic Medication,* by R. Bartholow, 1882, 4th. ed. Philadelphia, Lippincott.

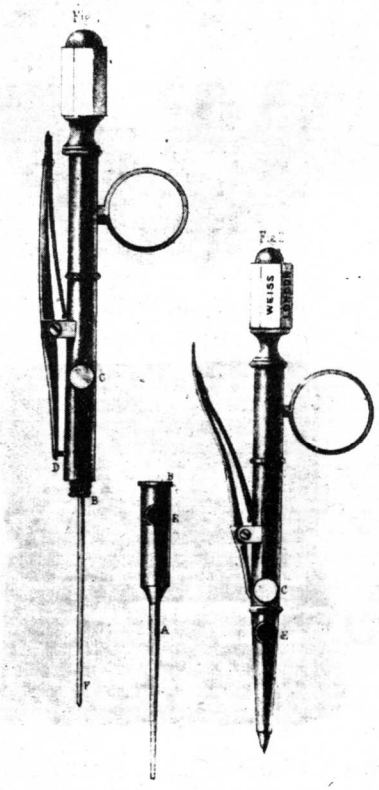

Fig. 3. Rynd's retractable trocar for the subcutaneous injection of liquids. (*From 'Dublin Quarterly Journal of Medical Science'*, 1861, **32**, 13.)

A hypodermic syringe of all-metal construction was invented in 1853 by a French veterinary surgeon, Charles Gabriel Pravaz (*Figs.* 4, 5). It was a well-designed instrument with a screw piston rod which enabled precise doses to be given accurately, but, although it was used for administering some drugs, it was not employed to obtain local analgesia. At about the same time Alexander Wood, of Edinburgh, was using a hypodermic syringe for the injection of opiates subcutaneously for the relief of neuralgia. His syringe was made of glass and metal and was a modification of the Ferguson type (*Fig.* 6).

Fig. 4. Charles Gabriel Pravaz (1791–1853).

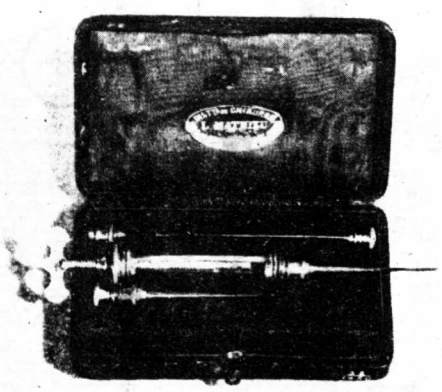

Fig. 5. Pravaz's syringe with screw action and minute trocars and cannulae. Wellcome Historical Medical Museum No. 32/1950.

Fig. 6. The original hypodermic syringe used by Alexander Wood. Museum of the Royal College of Surgeons of Edinburgh (*From Comrie, J. D.* (1932), *'History of Scottish Medicine', 2nd ed., vol. II. London, Baillière, Tindall and Cox, p. 614.*)

For centuries the natives of Bolivia and Peru had been addicted to coca, a mixture of dried leaves containing cocaine which they used because of its exhilarating effect, their custom being to extract the cocaine by chewing the coca with lime which masked the bitter taste. In 1855 a French chemist, Gaedcke, obtained a crude extract of cocaine from the South American plant *Erythroxylum coca* and five years later pure cocaine was isolated by Albert Niemann while working in Frederick Wohler's laboratory, following which extensive studies were made of its pharmacological actions. In 1880 a Russian surgeon, Vasilius von Anrep, reported on the numbing action of cocaine on mucous membranes, and in 1884 Carl Köller (*Fig.* 7), a colleague of the Austrian psychoanalyst Sigmund Freud, wrote a paper describing its analgesic action on the eye. After Freud received this paper he nicknamed his colleague Coca Köller, possibly being inspired by the beverage which had been created by an American pharmacist, John S. Pemberton, at about that time. Freud himself had previously considered the use of cocaine for treating eye diseases, but, as D. R. Laurence comments, 'appreciating that sex was of greater importance than surgery', he had gone on holiday with his fiancée, thus leaving Köller to discover the anaesthetic properties of cocaine which became so valuable in clinical ophthalmology.

In November 1884, exactly 40 years after nitrous oxide was first used for general anaesthesia, William Halsted (*Fig.* 8), at the Bellevue Hospital, New York City, carried out the first blocking of the mandibular nerve by injecting 4 per cent cocaine intraorally. His patients were his first assistant, Dr Richard John Hall, and a medical student, Mr Locke. Dr Hall reported, in a letter published in the *New York Medical*

Fig. 7. Carl Köller, 1857–1944.

Journal of 6 December 1884, that he had also had painless dental treatment of his upper left incisor tooth after being given an infraorbital nerve block. Halsted, who was a brilliant surgeon and pioneered surgical treatment of carcinoma of the breast, unfortunately became addicted to cocaine as did Dr Hall. Following this early work, cocaine became widely used for local analgesia and thus its shortcomings and dangers soon became apparent. This stimulated further research to discover other drugs which did not have its disadvantages and in 1904 a German chemist, Alfred Einhorn, synthesized procaine, which for many years remained the most commonly used local analgesic.

In 1904 a high-pressure syringe was introduced, known as the Wilcox-Jewel 'obtunder', powered by a leaf spring (*Fig.* 9). Another type of high-pressure syringe was produced by the Dental Manufacturing Company in 1912 to a design credited to Dr Thew. This syringe utilized a capstan (*Fig.* 10).

In 1917 Harvey S. Cook devised the cartridge system for loading syringes and this considerably simplified the chair-side process of preparation and sterilization of the analgesic drug.

Fig. 8. William Stewart Halsted (1852–1922). (*From Halsted's 'Surgical Papers' (1924). Baltimore. Johns Hopkins.*)

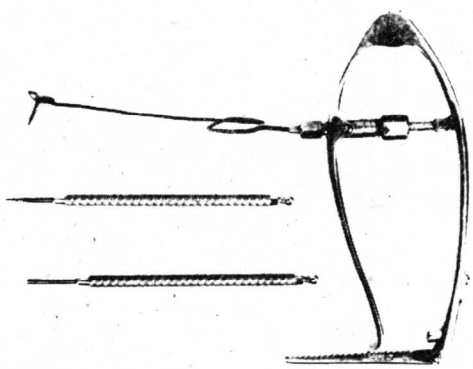

Fig. 9. The Wilcox–Jewel 'obtunder' type of high-pressure syringe, 1904.

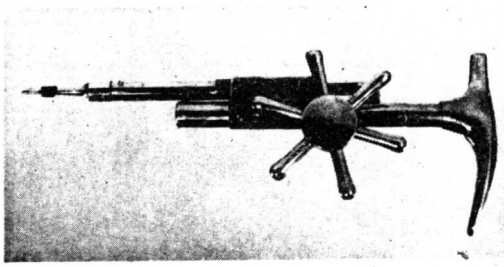

Fig. 10. Thew's capstan pattern high-pressure syringe, 1912.

In 1943 a Swedish chemist, Nils Löfgren, synthesized lignocaine and five years later this product was marketed. This local analgesic drug is by far the most commonly used at the present time, although newer products such as prilocaine are now available.

The more recent advances in local analgesia include the use of felypressin as a vasoconstrictor, improvements in equipment, such as aspirating cartridge syringes, power-operated syringes and jet injectors, and the use of presterilized equipment. These developments will be discussed in the later chapters.

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Chapter 2

METHODS OF CONTROLLING DENTAL PAIN

Analgesia is a condition in which pain cannot be appreciated but the patient is aware of what is happening. 'General analgesia' means the loss of the sensation of pain throughout the body and can be induced with drugs such as nitrous oxide or Trilene (trichloroethylene), which may be used during labour. 'Local analgesia' means the loss of the sensation of pain in a limited region and can be induced by surface application or infiltration, and regional injection of drugs.

Anaesthesia means the complete loss of all sensation including that of pain, although this word is sometimes inaccurately used to describe the loss of only tactile sensation. 'General anaesthesia' is a condition in which the patient does not react to any stimuli, including pain, and also does not have any memory of what has been happening, which implies that the patient has been unconscious. The term 'local anaesthesia' means that a potent drug has been used to produce the temporary loss of all modalities of sensation in a limited region of the body.

Usually in dentistry we are attempting to obtain analgesia because we wish to prevent pain. Sometimes we will also achieve anaesthesia and this may be desirable, although theoretically surplus to our requirements, as it should not matter whether our patient is aware of tactile sensation or not. However, some patients, particularly those of low intelligence, have difficulty in appreciating the differences between touch or pressure and actual pain and this is sometimes responsible for apparent failures in local analgesia.

Local analgesia is obtained most commonly by placing a drug called an analgesic near the sensory nerves so as to temporarily prevent the conduction of pain impulses to the brain. This deposition is usually carried out by injecting a solution into the tissues.

In dental surgery local analgesia of the teeth is obtained in two basic ways. It may be achieved by *infiltration analgesia*, which is the deposition of an analgesic solution close to the apex of the tooth so that it can diffuse to reach the nerves entering the apical foramina. The second technique, known as *regional analgesia*, is to block the passage of pain impulses by depositing analgesic close to a nerve trunk, thus cutting off the sensory innervation to the region it supplies. This injection is normally at a site where the nerve is unprotected by bone and therefore readily accessible to the solution.

DENTAL USES OF LOCAL ANALGESIA

1. Elimination of Pain during Treatment

This is the most common use of local analgesia in dental surgery. By its employment the dental surgeon is able to carry out painlessly routine treatment such as the extraction or conservation of teeth. Similarly, minor oral surgery for the removal of small cysts and tumours, periodontal surgery, and, in special circumstances, quite major operations may be performed. When the dental surgeon is on active service in war zones or working in remote parts of the world, he may have to treat severe jaw injuries under local analgesia because the more elaborate facilities required for working under general anaesthesia are not available.

Allied to the use of local analgesia for eliminating pain during treatment is its use to assist in relaxing patients. Some people are difficult to treat, not because the dental surgeon is hurting them, but because they think that he may be about to do so. If a local analgesic drug has been administered then the patient knows that whatever the dental surgeon does during his treatment no pain will be felt. Because of this knowledge he relaxes and becomes easier to treat. It is for this reason that occasionally a dental surgeon will administer a local analgesic drug for what might well be a painless procedure.

2. Diagnostic Purposes

The cause of facial pain is sometimes one of the most difficult conditions to diagnose correctly. This is because the major part of the face

receives its sensory supply from the trigeminal nerve which also innervates the jaws, teeth, and structures such as the maxillary antra. Severe pain may originate from any of these and it may be impossible for the patient to localize accurately, possibly because of the phenomenon of *referred pain*. When a nerve has several branches, pain originating from a structure innervated by one branch may be misinterpreted by the patient as being localized in another structure innervated by a different branch. Diagnostically, the problem facing the dental surgeon arises because, for example, an abscess in a mandibular premolar may cause symptoms of acute pain in a maxillary tooth on the same side. Fortunately pain from a lesion innervated by the trigeminal nerve is not referred across the midline so that if the patient complains of pain on the left side of the face then the lesion causing these symptoms is to be found on that side. The only exceptions to this rule occur in the region of the upper and lower incisors where the innervation is derived from a network of nerves from both sides.

Local analgesia can be very helpful with some diagnostic problems because if an injection is given to block nerve conduction in a particular region and the pain is relieved, then it can be deduced that the causative lesion is in the tissue innervated by that nerve.

3. To reduce Haemorrhage

Strictly, this is not the use of a local analgesic but of the vasoconstrictor drug which usually accompanies it. However, this use is mentioned here because a local analgesic solution is a very convenient vehicle for administering a vasoconstrictor. It may be of use during surgery under general anaesthesia as it is much simpler to operate in a field where vision is not obscured by blood. The presence of the analgesic in the solution is very desirable as drugs such as lignocaine tend to prevent cardiac arrhythmia occurring.

Another use of a vasoconstrictor is to control postextraction haemorrhage. An injection of local analgesic solution is given into the soft tissues surrounding the socket and this will eliminate pain from the region and also reduce or stop the haemorrhage by constricting the vessels in the area. This permits the dental surgeon to examine the socket carefully to assess whether further treatment such as a suture or haemostatic dressing is required before the effects of the vasoconstrictor have worn off.

4. In Conjunction with Sedation Techniques

Nervous patients may become more confident and relaxed if sedation techniques such as the 'relative analgesia' method of Dr Langa in which nitrous oxide with high concentrations of oxygen is inhaled, or the Jorgensen technique which is basically a form of intravenous premedication followed by an injection of local analgesia, are used. The sedation technique relaxes the apprehensive patient and the local analgesic ensures that the treatment is painless. With these techniques, which are described in Chapter 13, the patients remain conscious and cooperative with the protective reflexes fully maintained and thus they are not subject to some of the hazards which may be associated with general anaesthesia.

ADVANTAGES OF LOCAL ANALGESIA OVER GENERAL ANAESTHESIA

1. Safety

Local analgesia is safer than general anaesthesia. Although it is uncommon for a fit patient to die because of the administration of a general anaesthetic, it is extremely rare for a fatality to occur from local analgesia, and this aspect is discussed further in Chapter 4.

2. Ease of Administration

The administration of a general anaesthetic by a dental surgeon who is also going to carry out treatment on the patient at the same time is a procedure which is to be deprecated. Very special circumstances may occur where this cannot be avoided, but these are few. In the United Kingdom a coroner could be highly critical of someone working under these conditions if any mishap occurred to the patient, and thus two qualified persons are required for safe treatment. This opinion was confirmed in June 1975 when the Chief Dental Officer of the Department of Health, Mr G. D. Gibb, wrote to all National Health Service dentists informing them that the Standing Dental Advisory Committee had advised against operator-administered general dental anaesthetics. The letter stated, 'I accordingly appeal to any in the profession who may still be following the practice to cease it (unless exceptionally it can be justified in extreme emergency) in the interests of their patients and themselves.'

The administration of a local analgesic usually entails the dental surgeon injecting a small quantity of solution into the oral tissues and then waiting for a few minutes until this has achieved the desired result before continuing treatment. From this comparison with

the administration of a general anaesthetic it will be seen that local analgesia is a very much simpler procedure. Under general anaesthesia pain elimination and treatment are performed simultaneously whereas under local analgesia the procedure of pain elimination is followed by that of treatment.

Normally, local analgesia imposes no restrictions on the patient either before or after its administration and has the advantage over general anaesthesia that the patient does not have to fast beforehand. Most anaesthetists recommend that their patients have nothing to eat or drink for at least 4 hours prior to a general anaesthetic. With local analgesia it is advantageous if the patient has eaten beforehand to reduce the likelihood of fainting during treatment.

Local analgesia is less costly than general anaesthesia because it does not involve the payment of a separate fee for the services of an anaesthetist, and there is normally no need for the patient to remain in order to recover after treatment has been completed.

3. Cooperation of the Patient

If a patient has a general anaesthetic then it is impossible to obtain the help from him which would normally be available under local analgesia and there are many occasions during dental treatment when it is very desirable to have that cooperation. An example is the checking of the contour of a newly inserted filling by getting the patient to occlude.

4. Unlimited Operating Time

Most general anaesthetics administered to outpatients last only for a few minutes and hence the dental surgeon is unable to carry out prolonged operative procedures. With the progress in modern anaesthesia this situation is altering, but nevertheless outpatient general anaesthesia still tends to be used mainly for treatment which can be performed quickly.

With local analgesia, the operating time available for the dental surgeon is limited only by the patient's ability to sit still and cooperate. If the effects of the local analgesic are wearing off before treatment has been completed then it is a simple matter for the dental surgeon to inject a further quantity. A patient will usually tolerate conservative treatment for a longer period than oral surgery. Whenever possible, complex surgical treatment should always be done under general anaesthesia with the patient being treated as a hospital inpatient.

5. Reduces Bleeding during Surgical Treatment

As discussed earlier, most local analgesic solutions contain a vasoconstrictor which, besides prolonging the action of the analgesic, also reduces the severity of the haemorrhage which would usually occur during surgical treatment.

6. When the Patient is Unfit for a General Anaesthetic

In these circumstances local analgesia is of particular value. The fitness requirements prior to the administration of a general anaesthetic are far stricter than for local analgesia and they should also be more stringent for an outpatient than for an inpatient. Some of the criteria which lead to general anaesthesia being considered undesirable are :

a. Airway problems, such as nasal obstruction due to deflected nasal septum or nasal polypi, micrognathia, Ludwig's angina, and infections predisposing to oedema of the glottis.

b. Respiratory infections, such as coryza, pneumonia, bronchitis, bronchial asthma, pulmonary tuberculosis and bronchiectasis.

c. Cardiovascular disease which is severe enough to cause dyspnoea at rest, ankle oedema and engorgement of the neck veins.

d. Mechanical problems, such as inability to flex the cervical spine, and conditions in which there is difficulty in opening the mouth, such as trismus or muscle spasm, ankylosis of the temporomandibular joint or obstruction due to neoplasm.

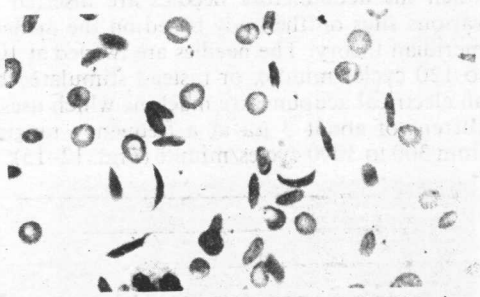

Fig. 11. Sickle-cell anaemia. Blood-film showing abnormal shaped red cells.

e. Sickle-cell anaemia, which is a severe familial anaemia occurring in Negroes, characterized by sickle-shaped red cells in the blood (*Fig.* 11). This affects a patient's fitness for general anaesthesia far more than other anaemias, as even mild hypoxia will stimulate the formation of the abnormal sickle cells and

these will obstruct the small vessels and capillaries thus causing serious tissue damage due to infarction. These patients also have very poor wound healing. It should be remembered that if the anaemia is severe then, whatever its type, general anaesthesia will be contra-indicated.

Relative indications for avoiding outpatient general anaesthesia are conditions such as pregnancy during the first 3 months and last month to reduce the risks of abortion and premature labour respectively, these risks being dealt with better if the patient is admitted. Some of the other patients who should be admitted are those with a history of coronary thrombosis, and those receiving systemic steroids, who may include the rarer group of insulin-resistant diabetics.

FURTHER METHODS OF CONTROLLING DENTAL PAIN

These are lesser used methods which have been employed to achieve pain-free dental treatment in the conscious patient.

1. Acupuncture Analgesia

This type of analgesia is thought to have originated in China about 3000 or more years ago and there are records of it being used during the Classical Age (600 B.C.–A.D. 200), which is considered to have been a prosperous period in Chinese history.

The term 'acupuncture' is derived from the Latin word *acus*—a needle and *punctura*—a puncture. The Chinese have used acupuncture as a type of therapy for many medical conditions, and also for analgesia or pain blocking when the acupuncture needles are inserted at various sites on the body based on the ancient meridian theory. The needles are twirled at 100 to 120 cycles/minute, or instead stimulated by an electrical acupuncture machine which uses a current of about 3 μa at a frequency ranging from 300 to 3000 cycles/minute (*Figs.* 12–15).

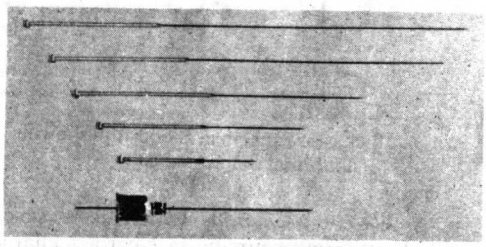

Fig. 12. Acupuncture needles shown with a 27-gauge long dental hypodermic needle for comparison. The acupuncture needles are not hollow and are very fine. (*Figs. 13–15 are reproduced by courtesy of Dr Neill W. Kerr.*)

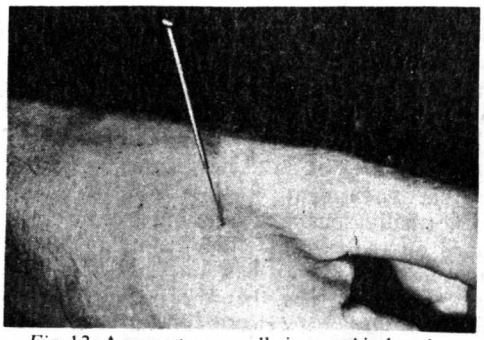

Fig. 13. Acupunture needle inserted in hand to produce analgesia in the jaw.

Fig. 14. An acupuncture needle being stimulated by twirling it.

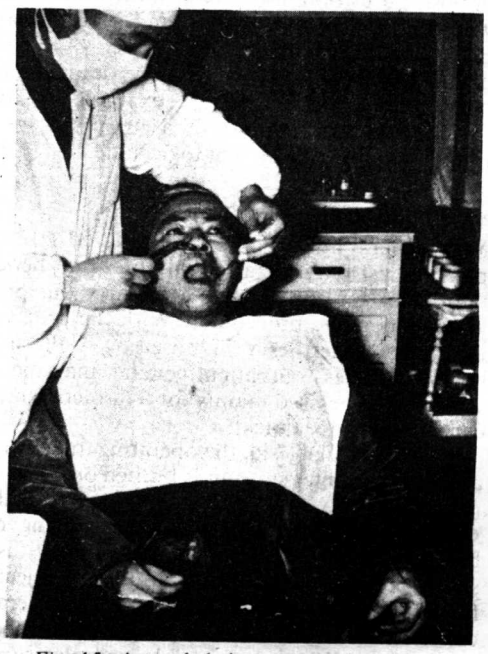

Fig. 15. A tooth being extracted under acupuncture analgesia produced by the two needles in the hands.

Acupuncture analgesia is not always successful but there is no doubt that some patients are able to undergo quite major surgery in comparative comfort using only acupuncture. With this type of analgesia the patient remains completely conscious, and there is no disturbance of the normal physiological functions as there would be during the administration and subsequent recovery period associated with an orthodox general anaesthetic. The mechanism of acupuncture analgesia is not understood, but one theory has suggested that analgesia is the result of stimulating the peripheral nerve and causing the large A-beta fibre impulses to block the pain-carrying small nonmedullated C fibres at the substantia gelatinosa in the spinal cord and at the posterolateral and posteromedial ventral nuclei of the thalamus.

2. Hypnotism

Hypnotism is sometimes employed to reduce dental pain in susceptible patients. Initially, the induction of a hypnotic state may be a time-consuming process, but as the patient becomes increasingly conditioned hypnosis will become much more quickly induced. Hypnotism produces a trance-like state in which the patient's attention is focused on the operator so that awareness of other stimuli such as pain is markedly reduced, or not appreciated at all. This makes dental treatment much easier, even when the additional help of a local analgesic injection is required. The use of hypnosis may change a very difficult patient into one who will readily accept treatment.

The disadvantages of this method of pain prevention are that initially it may be time-consuming and also it does not work for all patients. Other objections are that it is a technique which is not properly understood and some patients may dislike the thought that their behaviour might be controlled or influenced by another person.

3. Audio-analgesia

This is a method of analgesia, described by Gardner and Licklider in 1959, in which the use of loud sounds is said to produce insensitivity to pain in some patients.

A common technique would be one in which the patient wears stereophonic earphones and controls the volume and type of sound—which could be music or a rushing, roaring noise derived from 'white sound' and resembling the sound of sea waves or a waterfall. The patient having selected a programme of music to induce relaxation he will adjust the volume to a comfortable level and then increase it when the tooth becomes uncomfortable. If the discomfort becomes worse, then the sea noise may be used to eliminate or drown out the pain. Exposure to excessive noise may be dangerous and hence safety standards for audio-analgesia equipment have been recommended by the American Dental Association Council on Dental Therapeutics.

It is possible that audio-analgesia depends to some extent on the suggestibility of the patient. Certainly the music will aid relaxation as it diminishes the noise of the dental drill and the action of the patient in controlling the choice and volume of sound will divert attention from the actual dental treatment. When both the music and water noise are selected, then the patient will need to concentrate in order to hear the music and this will minimize the awareness of the dental treatment. Physiologically, the pain and auditory pathways are closely associated in the reticular formation and lower thalamus with interactions which are largely inhibitory. The suppression of pain sensation by marked stimulation of another sensory pathway is a common occurrence, possibly due to cross-sensory masking of pain impulses, and this could be an explanation of how audio-analgesia works. However, the appreciation of pain is a complex psycho-physiological phenomenon and as yet a simple explanation of audio-analgesia is not possible. The wider use of audio-analgesia has not occurred because it is not effective for all patients and also there may be a problem in communicating with the patient.

4. Electric Anaesthesia or Anelectrotonus

In 1950, Professor K. Suzuki described a method of blocking nerve conduction in the peripheral part of the pain pathway, by use of a direct electric current. The physiological basis of this type of anaesthesia is that a pain impulse is accompanied by a negative potential and depolarization of the nerve fibre is prevented by introducing a positive potential due to a direct electrical current.

This method of pain prevention has been recommended usually only for the conservative treatment of teeth. A carious tooth has an electrical resistance reported as ranging from 27 000 to 2 300 000 Ω and being smallest with incisors and greatest with molars. To achieve anaesthesia with this method, which has no time-lag and produces immediate desensitization, it is necessary to keep the tooth moist,

otherwise the electrical conductivity of the system is reduced and anaesthesia ceases.

A paper by A. I. Rybakov and T. V. Nikitina from the Russian Central Research Institute of Stomatology reported on the treatment of 16 500 carious cavities in 7320 patients ranging from 8 to 60 years. It was found that the best results were obtained in children up to the age of 10 years when 92 per cent were successful, and between the ages of 20 and 40 years when 75 per cent were successful, while practically no effect was obtained in patients over 50 years old, these results being assessed by means of pupil and skin-galvanic reactions. These authors recommend the combination of electric anaesthesia with premedication.

A Russian form of the apparatus was the 'Elos–1' machine which was powered by 18-volt batteries. It was fixed to the head rest of the dental chair with the anode being connected to the dental handpiece, which had an insulating sheath, and the cathode being clipped on the lobe of the patient's ear. The apparatus did not need to be earthed and the current applied to the tooth was unlikely to exceed 30 mA.

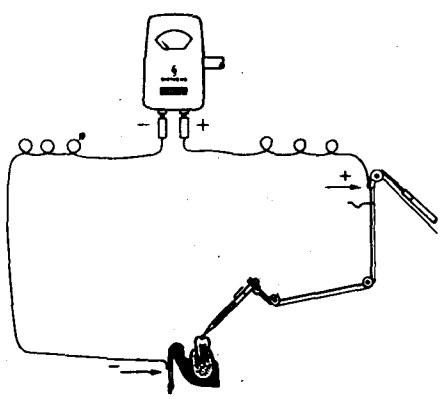

Fig. 16. diagram showing the circuit used by the Siemens apparatus for producing electric anaesthesia.

For a time the German firm of Siemens produced a similar apparatus powered by 6 V batteries and having the cathode attached to a saliva ejector instead of the patient's ear, the circuit used being shown in *Fig.* 16. The Siemens equipment is no longer marketed as the results obtained from it were unsatisfactory.

5. Anaesthesia by Cold Air

It has long been appreciated that when a part of the body becomes sufficiently cold, pain sensation is abolished. This principle has been used in the Nondolor apparatus which was produced in France.

It is claimed that the Nondolor apparatus compresses air, cools it, and then dehydrates and sterilizes it with ultraviolet rays. The works are contained within a mobile metal cabinet and the cold air may be applied by means of a pistol with a glass nozzle. The normal rate of delivering compressed air is 60 litres per minute which may be at a temperature varying from 35 to 1 °C.

The technique recommended for using the Nondolor is to lower the temperature of the tooth progressively from 35 to 4 °C by projecting the air stream on to the tooth. When this cooling has been achieved, then anaesthesia will begin and the operator should continue to lower the temperature to 1 °C and maintain it at that level. This takes about three minutes for incisors and a little longer for posterior teeth. It is essential that the dental treatment is done in absolutely dry conditions and anything such as the tongue, cheek or operator's finger touching the tooth should be avoided, as otherwise cooling will be disturbed. The flow of cold air on the tooth has to be maintained throughout treatment.

This method of anaesthesia has some disadvantages. The tissues become very dry and hence articles such as cotton-wool rolls will stick to the mucous membranes and cause painful ulcers unless the rolls are moistened prior to removal. Also, very sensitive teeth may need a protective covering such as a temporary filling material prior to being cooled, the makers advising that vital teeth with large metallic fillings or crowns may require similar protection. The tooth being treated cannot be cleaned with a water spray or the anaesthetic effect of the cold air is lost, and also the drilling or grinding has to be done in very short stages to avoid generating heat. These disadvantages appear severe enough to discount this method of pain prevention being of use in dental surgeries.

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