Operating Room Techniques

Patient Positioning, Hygiene, Dangers

Herbert Schindler

With a Contribution by F. Rehbein

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Important Note: Medicine is an ever-changing science. Research and clinical experience are continually broadening our knowledge, in particular our knowledge of proper treatment and drug therapy. Insofar as this book mentions any dosage or application, readers may rest assured that the authors, editors and publishers have made every effort to ensure that such references are strictly in accordance with the state of knowledge at the time of production of the book. Nevertheless, every user is requested to carefully examine the manufacturer's leaflets accompanying each drug to check on his own responsibility whether the dosage schedules recommended therein or the contraindications stated by the manufacturers differ from the statements made in the present book. Such examination is particularly important with drugs that are either rarely used or have been newly released on the market.

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Preface

The aim of this book is to provide those working in an operating theater with practical, comprehensible information concerning:

- positioning of the patients for operation
- sanitary measures in hospitals
- work routine in the operating tract
- functional and constructional design of the operating tract, outpatients department and endoscopy unit
- handling of equipment in the operating field
- risk of explosion, fire and burns in the operating field
- risks due to electrical fault current in combination with high-frequency techniques.

The first chapter often refers to norms, specifications, or even laws specific to the Federal Republic of Germany. Although they are as such not applicable in other countries, the goals they serve are international and thus have been retained in the English language version of this book.

I would like to thank Prof. Dr. med. F. Rehbein, for his generous contribution of the chapter "Pediatric Surgery".

After much consideration with regard to the illustrations, we decided to use drawings representing only the most important details so as to make them more comprehensible.

My thanks are also due to Mr. Hans Greiner, who supplied the drawings, Mrs. Kristina Biermann for her assistance in preparing the manuscript, and Mrs. Ulrike Clewing, Osterbekstr. 62, Hamburg 76 for the translation of the book.

I owe special thanks to Dr. Ing. E. Schnelle and Mr. Miller of the Chir. Klinik der Med. Universität zu Lübeck for their expert advice.

I also wish to thank the publisher and particularly Dr. Marlis Kuhlmann and Mrs. Hadler, whose great understanding, patience and good advice helped make this a successful book.

Hamburg,
Autumn 1987 *Herbert Schindler*

Contents

1 General Information

The following topics have been chosen according to their importance for routine work and recovery rates in operating theaters and treatment units, as well as for work procedure and the development of new concepts.

Hospital Infection Control

Introduction

Contrary to today's medical progress, a very alarming number of patients contract infections during their stay in the hospital. It is perhaps understandable that there are still no precise statistics available about such infections. The infection rate, which has been estimated by various investigators at between 3 and 30%, is already alarming enough, and since the problem is an international one, the explanation that unfavorable environmental conditions, such as environmental pollution and climate could be the cause, is by no means satisfactory. It is impossible to underestimate the extent of damage to health caused by infections contracted in the hospital, to say nothing of the worldwide economic losses. (According to Kanz, a decrease of 10 to 25% in the infection rate would cut costs of treatment in German hospitals and subsequent costs by some hundred millions of Deutschmarks. This would be a significant contribution to cost reduction.)

The occurrence of infections contracted in hospitals – inaccurately termed "hospitalism" – has become more frequent over the past 10 years. This has led to increased demands on the hospital staff with regard to measures for the prevention, recognition and control of infection.

The importance of sanitary measures is emphasized by the convictions of a number of well-known doctors who are of the opinion that the prevention of many diseases is more effective, more humane, and less expensive than their treatment. Despite this, less attention is paid in West Germany to preventive medicine than to therapy.

Definition of the Term "Hospitalism"

The rather inappropriate term "hospitalism" was formerly a collective noun for all physical and emotional damage to hospital patients that had no direct connection with the treatment of their original complaint. It included not only infections contracted by patients in the hospital, but also damage resulting from unsuitable diet and care. The terms used today – "infectious hospitalism" and "infective hospitalism" – are more precise, but only the term "nosocomial infection" (nosocomial means arising in the hospital) is really precise and also internationally known.

Nosocomial infections are caused by microorganisms found in hospitals. They constitute an increased risk of infection (virulence) and resistance to a wide range of antibiotics. This is frequently a matter of common pathogenic organisms, such as those found in humid environments, e.g., *Escherichia coli*, Pseudomonas, Klebsiella, Proteus etc., saccharomycetes and fungi, sometimes sporozoa (clostridia), such as the pathogenic organisms of gas gangrene and tetanus. Since the patient's resistance is reduced due to the basic complaint, the transmission of microorganisms during surgical and medical treatment is more likely.

Sources and Transmission of Infection

The human body is without doubt the main reservoir of microorganisms spreading a

variety of hospital germs, such as the pathogenic organisms Staphylococcus, *Pseudomonas aeruginosa*, Klebsiella, Proteus, Escherichia, and Serratia.

This applies in particular to patients with wound infections, especially infected burns, but also to patients with an indwelling bladder catheter or on continuous respiratory care. The following figures depict the high potential of danger arising from the germs that originate in great quantities from these foci and are invisible to the human eye: more than 1 million germs in 1 ml of infected urine, 1 million germs in 1 ml of pus, more than 1 billion germs in 1 cm^2 infected wound, etc.

The hospital staff must also be considered as a source of microorganisms, with unrecognized or at least underestimated infections of the ear, nose, and throat. Slight skin injuries or other skin diseases must also be considered as a source of germ growth. The potential risk caused by these persons is imminent due to massive germ excretion as well as to the distribution of germs during daily work in the various hospital units. Another risk is caused by insufficient care and frequency of hand disinfection.

Another source of infection is the accumulation of microorganisms on instruments and in places where they are able to reproduce rapidly under favorable conditions (humidity, temperature). A few examples of places where germs were found during scientific tests are: air humidifiers, air-conditioners, anesthesia apparatus, respirators, atomizers, inhalers, aspirators, dialysers, milk pumps, incubators, bedpan washers, stagnant water in pipes, desalination units, wash basins, baths and their outlets, floor drains, cleaning equipment and utensils, such as cleaning cloths, brushes, scrubbing brushes, brooms etc., tubes and catheters, endoscopes, and open rinsing and infusion solutions.

The sporozoa found in dirt and dust, which include the aforesaid pathogenic organisms causing gas gangrene and tetanus, are so resistent that they can only be destroyed by means of very careful sterilization. Despite the dangerous nature of these organisms, the expensive procedures of sterilization cannot be made use of at all times and in all places. It is therefore of first and foremost importance that rooms, equipment, and apparatus should be kept clean in order to reduce dust and dirt and thus large numbers of microorganisms.

The main means of conveyance and transmission of microorganisms is the hospital staff, who pick up and spread them via their hands, clothes and shoes unless disinfection is carried out with great care.

The cleaning staff must be mentioned in this context. They can contribute to the risk of infection by not using the correct quantities of cleansing agents and disinfectant solutions and by the inadequate cleansing and disinfection of cleaning utensils; contrary to the intended result, microorganisms can reproduce in large quantities and are moreover distributed throughout the hospital. (The international term "cross-infection" describing an infection that one patient contracts from another proves, among other things, the frequency of the transmission of germs mentioned here.)

Another means of contact is the patient himself, whose hands, clothing, bedclothes, bed, personal utensils such as face cloth, comb and handkerchief transmit numerous organisms.

The apparatus used for the diagnosis, treatment and the nursing of the patients is a further serious means of infections. Microorganisms are unavoidable on such apparatus and, if inadequately disinfected, they reproduce and spread, particularly when apparatus is moved from one place to another.

Less important but by no means negligible are air-borne organisms that penetrate the hospital either from the outside via the aeration or the air-conditioner (primary air-borne organisms or aerobes) or that, already found in the hospital as dust organisms (secondary air-borne organisms), are swirled up and spread.

As we have already mentioned, water, and particularly stagnant water, is a further source of infection. It can, however, also become a means of transmission of micro-

organisms if contaminated water is sprayed, e.g., by means of humidifiers or atomizers, or distributed in the form of contaminated infusion, rinsing, and cleansing liquids.

Measures to Control Infections in the Hospital

Beside the regulations laid down by the Federal Board of Health in Berlin for recognition, prevention, and control of infections in hospitals, the bibliography for this book includes references to laws, edicts, regulations, and German Industrial Standards (DIN), which can be taken as guidelines for hospitals. Construction and functional measures, which will be described in more detail in the following section of general instructions can be seen as prerequisites for this work. The hospital staff is of vital importance, which can only be responsible for effective hospital infection control if well trained and disciplined in their work. This is proved by the successful recovery rates in many hospitals with construction and functional shortcomings. Great praise is therefore due to the hospital infection control practitioners, who create the conditions necessary for good sanitation.

The bibliography of this book refers to the guidelines laid down by the Federal Board of Health in Berlin. Thanks are due to the German and other experts who worked together to achieve this representation of the actual state of infection control in hospitals. Included in these guidelines is a description of the field of work and the responsibilities assigned to a hospital infection control practitioner, to those members of the staff working for him, and to sanitation. Possibilities of further education for the nurses (cf. sections 5.3.5 and 5.3.7 of the guidelines) are also described. The topics in this book are thus confined to those sanitary measures, that can be carried out continuously by the nursing staff without any need of specialized training.

Hand Disinfection

The most important sanitary measure is hand washing, which, according to the situation, frequently means hand disinfection. Contrary to the normal hand washing carried out by every civilized person after going to the toilet or before eating, the time and care taken during hand washing is of great importance. Not only is a high degree of cleanliness required but the disinfectant must also be given time to be effective to the full. (Guidelines: at least 1 minute for hygienic washing and at least 5 minutes for special surgical hand disinfection, e.g., prior to surgical operations). For this purpose, registered and skin protective soaps and disinfectants are to be used in the prescribed concentration.

Here are just a few examples of the many occasions when hand washing and disinfection are necessary:

- Prior to entering and after leaving different hospital units e.g., operating room and treatment rooms, intensive care, infection and dialysis units
- Prior to and after termination of different nursing tasks e.g., giving injections, insertion of catheters, changing dressings, changing bed linen and garments, handling instruments, nursing utensils, appliances and apparatus
- After contact with a patient's blood or secretions
- After leaving one patient and before going to another

Inspection of the Hospital Staff as a Means of Infection Control

Inspections of the hospital staff are necessary to protect all persons in the hospital against infection. Apart from inspections that take place at longer intervals for health control, persons working in critical sections of a hospital (e.g. operating rooms, intensive care units, maternity wards, pediatric wards, dialysis units, and isolation wards) should undergo regular bacteriologic examinations of the nose and throat, i.e., at intervals of 6–8 weeks. Such control is also necessary after recovery from an infectious disease prior to resumption of work.

Members of the staff with slight infections that do not render them unable to

work should for this period of time work in units that are less at risk from infections. Is this not reason enough for the temporary use of oronasal masks?

Protective Clothing

The type and extent of protective garments will depend on the sanitary requirements of the various hospital units:

a) Great demands are made on those units that must be protected against infections, e.g., the aseptic operating room, the treatment unit for burns, the intensive care unit, maternity and pediatric wards, and also, for example, the septic section of the operating room, the isolation ward and the dialysis ward, which are considered to be infection sources.
b) Demands made on the following are less great: general wards, outpatients' wards, X-ray rooms, physiotherapy rooms, sanitary rooms, kitchen, and laundry.
c) Demands made on the following are slight: administration rooms, rest rooms, classrooms, cafeteria, staff accommodation, and workshops.

The special protective garments for work in the units mentioned in a) includes cap, oronasal mask, surgical gloves, shirt or coat that covers the arms and the upper part of the body, trousers, special stockings and shoes, which can be washed and disinfected easily. Due to the risk of particles falling from the skin or hair and thus forming a means of conveyance of germs, the protective garments must cover head, body, arms, legs and feet. (In many surgical units the staff and patients use disposable clothing, since these materials spread fewer dust particles than surgical garments.)

Since germs spread through moist tissue very rapidly, making transmission even easier, such areas are to be covered additionally with impermeable material. Protective clothing is to be worn exclusively in the working area. Further instructions are outlined in the section "Work Routine in the Surgical Department."

Where demands are less great, as described in b), hospital clothes (cap, suit, coat, stockings, and shoes), which are to be changed regularly, will do. Depending on the work to be done, gloves and aprons, which are easy to cleanse and disinfect, should be added to this list.

If the demands on aseptic conditions are only slight, special protective clothing is not necessary.

Sanitary Measures Concerning the Patient

Operations

Since the preparation of the patient for operation is described on p. 33, the following explanations are confined to the disinfection of the skin as an important part of the sanitary measures.

The operative field is first washed and shaved. Disinfection of the area is then carried out immediately before the operation by spraying or rubbing a disinfectant solution over the area with sterile swabs. The use of colored disinfectants is recommended: the disinfected areas of the skin can then be easily seen, as well as places where excess solution has accumulated outside the operative field; particularly in skinfolds and beneath the patient's body, residues of solution can cause skin lesions and should therefore be removed.

The use of disinfectants that have been tested and registered by the German Federal Board of Health guarantees effective skin disinfection without putting too much strain on the skin. The effect of other products that are frequently used during this phase must, however, also be known, e.g., ether and surgical spirit have a degreasing and cleaning effect but do not disinfect. Alcohols containing water only achieve the best bactericidal results when in the correct concentration, without, however, any sporicidal effect; tincture of iodine can easily cause allergic skin reactions; there is a risk of toxic (poisonous) side effects if certain preparations of organic mercury or other compounds are used.

To ensure reliable skin disinfection, the time of disinfection (about 2 minutes) and the repetition of the disinfection procedure

are of great importance. After drying, a film of the disinfectant should remain to keep the number of germs on the skin low during the operation. After the wound has been closed, the operative field is again disinfected prior to the application of a sterile dressing. Sterile incision foil, which is now also available, has meanwhile proved to be very worthwhile. The foil is stuck onto the operating field prior to the surgical operation thus avoiding the spreading of skin germs (remaining effect, from the Latin *remanere*, to remain).

Dressing Wounds, Changing of Dressings, Injections, Punctures, Taking Blood, Infusions, Catheterization

During all these tasks, large accumulations of germs or of excreta containing germs can be expected, e.g., pus, sputum, stool, exudate (liquid and cells extravasating due to inflammations from blood vessels and lymphatic system). Adequate protective garments, including germproof gloves are to be used accordingly.

Contaminated hands (microbiologically contaminated, in this case by germs) are to be cleaned with water and soap after their disinfection. Hands contaminated by excreta containing germs are to be cleansed, prior to their disinfection, with cellulose or a cotton swab moistened with disinfectant. The hand disinfection is then to be carried out twice.

The patient's skin is to be likewise treated with the same care to ensure that germs do not penetrate the patient's body via the incision.

Sterile instruments, dressing material, sterile swabs, gloves, catheters, and sterilely packed catheter lubricant are a precondition for infection control, as is their subsequent disposal in containers, bags, or sacks, which should be as germproof, tearproof and moisture resistant as possible. Disposable material is also an important contribution to hospital sanitation and should be used as frequently as economically feasible.

Never take contaminated protective garments, utensils (such as cosmetics, towels) from one patient to another, since this is an acute risk of the transmission of microorganisms (Infection spreading from one patient to another: cross-infection).

Prevention of Urinary Tract Infections

Indwelling catheters are to be inserted into the bladder only in urgent cases by an experienced member of the staff and for as short a time as possible. The longer the foreign body is in the bladder and the urethra, the higher the risk of infection.

For this reason, a strictly aseptic environment is necessary: sterile gloves and swabs, mucosal disinfectant, sterile catheter lubricant, sterile disposable catheters or a complete sterile set, as now available, are of the same vital importance as hand disinfection, the use of protective garments (washable and disinfectable apron, etc.), covering cloth, and disinfection of the patient's skin.

The patient's genitalia is to be cleansed and disinfected once or several times a day. The following are critical areas: the entrance of the catheter into the urethra, the connection of the catheter to the urine collecting bag, and the connection between the bag and the tube.

After insertion, the catheter should be firmly fixed in order to prevent its slipping. Furthermore, a swab should be fixed at the entrance to the urethra to collect secretion. The swab can be moistened with disinfectant in the inside and is to be changed daily or more frequently.

In view of the high risk of infection, a closed drainage system is to be used, which is only in case of emergency – e.g., rinsing of blocked catheters – to be taken apart or perforated for taking specimens for test purposes (the puncture area in the tube is to be disinfected). Urine collecting bags with a one-way valve avoid bacteria ascending with urine, or reflux into the bladder if the bag is lifted. Urine bags without a valve must therefore not be lifted above the patient's level.

Should rinsing be necessary, antiseptics can be added to the rinsing liquid. Locally acting antibiotics should, however, not be

used, since they have little effect and tend also to make organisms resistant or cause allergies. The effect of sterile physiologic salt solutions is indisputable.

The careful and safe disposal of used linen, protective clothing and material, which is dealt with on p. 7, is of vital importance, in order to prevent the conveyance and transmission of microorganisms (cross-infection from patient to patient). If, despite all sanitary measures, a patient contracts an infection, he should be isolated.

Prevention of Respiratory Tract Infections

Infections of the respiratory tract primarily occur in intubated patients (with tracheal tube for respiration), tracheotomized patients, patients with continuous respiratory care during treatment due to inhalation of aerosols. An aseptic environment is therefore essential.

For the aspiration of an intubated or tracheotomized patient, sterile gloves must be put on after the sanitary hand disinfection, so that the sterile and lubricated (disposable) aspiration tube can be inserted safely without putting too much strain on the patient. To achieve complete aspiration of the secretion, the patient should be turned onto his back, left side, or right side; during aspiration of the left side of the bronchial system, the patient's head should be turned to the right; during aspiration of the right side of the bronchial system the head should be turned to the left.

The used catheter is to be put immediately into an instrument disinfection solvent and should not be used again in order to prevent conveyance of microorganisms.

Respirators and inhalers should for the most part be made of disposable products or consist of parts that can nearly entirely and easily be dismantled and sterilized or disinfected, especially in those with a high risk of infection. It is, furthermore, recommended to have a supply of such parts for replacement, in order to minimize waiting times. Water tanks, parts of respirators and inhalers that convey air or water must be dismantled, cleaned, and sterilized in hot steam every day. In the case of heat-sensitive materials, disposable products are preferable, since the cold sterilization (e. g., by gas) or the wet chemical treatment leaves toxic residues that, among other things, can cause mucous membrane peeling. Such residues can be eliminated by careful cleansing with sterile distilled water.

Liquids used in respirators and aspirators and inhalers, such as physiologic saline, distilled water, and dissolved drugs, must be sterile and are to be changed frequently.

Make sure that unused instruments are kept dry and protected from dust.

Prevention of Infections of the Blood Vessels

Indwelling catheters and cannulas in blood vessels are to be inserted only in cases in which they are absolutely necessary and then for a limited time only (if possible, no longer than 48 hours – make a note of the time). Since patients with a lowered resistance are particularly susceptible to sepsis, special care must be taken to maintain strictly aseptic conditions during the insertion and care of indwelling vein catheters and cannulas. This includes the disinfection of hands and skin (spraying and swabbing), the use of sterile coverings and sterile gloves, as well as the subsequent dressing of the puncture site with a sterile dressing. This dressing is to be removed at least once a day to check the puncture site. After a further disinfection of the area, a new sterile dressing is applied.

At the first sign of an infection, the catheter should be removed and, if necessary, a new catheter inserted elsewhere.

Medicine should be administered separately and should not be mixed with infusion solution prior to use, since this might allow microorganisms to enter the solution and then reproduce.

Air cannulas without filter systems should not be fixed into the stopper of the infusion bottle until the infusion solution is about to be used.

Open ampoules or vials must not be kept

for more than 24 hours at refrigerator temperature (make a note of the date of opening on the ampoule or on the infusion bottle).

The connection between the catheter or cannula and the infusion system is always to be covered and must be kept sterile.

Beside the limitation of the period catheters and cannulas are to be used, it is also important to prevent infections by changing the infusion within 24 hours; the infusion set including its accessories should be changed within 24 to 48 hours. Due to the higher risk of infection, three-way cocks should be changed at shorter intervals. To ensure sanitary treatment using infusions, it is absolutely necessary that the time of insertion of catheters and cannulas and the time of change of infusion solutions and of infusion sets are always noted.

Disposal of Used Instruments, Linen, Waste, Excrement, etc.

Objects (e.g., instruments, catheters, syringes) intended for repeated use should be disinfected and cleansed immediately after use, i.e., before dirt has had time to dry. Disinfection prevents a possible conveyance and transmission of microorganisms. Objects for disinfection should be dismantled as far as possible to make sure that all surfaces are exposed to the disinfectant and that air bubbles cannot occur in cavities.

Besides using a disinfectant of the recommended concentration and observing the exposure time (minimum time), objects can also be sterilized in a 0.5% solution of sodium carbonate or in disinfection and cleaning machines for at least 15 minutes.

Chemothermic disinfection and cleaning by means of special registered machines is a time-saving and reliable procedure, but can only be used if the equipment is suited to machine washing. The machine must also have insets for objects with cavities. Such machines have proved very worthwhile due to their efficiency in waste disposal units in the operating departments or for the sterilization of instruments.

If, after disinfection, the objects are cleaned by hand, particular care must be taken with regard to the slits, cavities, and those parts of instruments, cannulas, syringes, catheters, etc., that are difficult to clean. The same applies to the subsequent rinsing with demineralized, nearly germfree water.

After disinfection and cleansing, objects that must be sterile are transported in closed, disinfected, and clean containers and prepared in the sterilization department.

Used linen is to be sorted when collected and checked for foreign bodies. Besides this, movement of dust, and thus microorganisms, is to be avoided. Storage for as short a time as possible in laundry bags and their subsequent transport must be completely separate from the storage and transport of clean linen supplies.

Waste is sorted according to the guidelines laid down by the German Federal Board of Health and should be kept in moisture-resistant, firm, nontransparent closable one-way containers with a maximum capacity of 70 liters for transport to the waste disposal or refuse incinerator.

Disinfection of excrement may be necessary within the hospital either to maintain sewage water quality or to protect against infection (cf. leaflet from the German Federal Board of Health concerning the discharge of hospital sewage water into the sewerage system and other water systems). Careful handling of containers used for excrement (bed pans, urine bottles) and, if necessary, the disinfection of excrement, discharge into special washers or lavatories and subsequent cleaning and disinfection of the containers are a matter of course.

Disinfection of Working Surfaces and Equipment

It goes beyond the scope of this book to describe the numerous methods and procedures involved in disinfection of working surfaces and equipment, although this work is, of course, an important part of disinfection. The following explanations are thus confined to guidelines that should help avoid the mistakes that frequently occur in practice.

Effective disinfection is only to be achieved by using tested and registered disinfectants or a combination of cleansing and disinfecting products. A mixture of disinfectants and cleansing products can only be recommended if special tests have proved their effectiveness. The dosage is a very decisive aspect: underdosage decreases the effectiveness, overdosage is uneconomical and can cause damage to the skin and material and strong odors. In hospitals with central or decentral equipment for mixing disinfectants, dosage mistakes can be avoided. In most cases, however, there is need for staff training in these matters and for the use of safe dosage equipment and standarized buckets or containers for the correct concentration of the disinfectant solution. Moreover, care is always to be taken that disinfectants are not mistaken for cleansing agents.

In order to avoid spreading of microorganisms via cleaning and disinfection utensils (as is frequently claimed), these are to be used exclusively within a limited area and then be put aside for washing and disinfection. The disinfectant solution is to be changed then, too.

Although modern disinfectants are in a position to bridge dirt barriers, visible dirt should be removed by wiping or washing in order to prevent excessive movement of dust and germs.

The following principle is always applicable: first disinfection, then cleansing. Disinfection sprays are easy to use, although it is important that only a thin film should cover the area and not a thick coat that could leave sticky residues.

In the case of disinfection sprays containing alcohol, special regulations laid down by the "Berufsgenossenschaft" are applicable, e.g., "the safety regulations to prevent the danger of fire and explosion due to alcoholic disinfectants."

Type, frequency, and duration of disinfection depend on the requirements of the different hospital units and are carried out according to the instructions of the infection control practitioner in charge.

A complete room disinfection is always necessary, after infectious diseases specified in § 39 of the "German Federal Epidemics Law", and, for reasons of safety, after septic operations or aseptic interventions that proved to be septic after beginning the procedure. In practice, the operating unit is subject to regular room disinfection.

The measures for disinfection mentioned so far are, however, inadequate if the inner parts of large machines, such as anesthesia apparatus, respirators, operating tables, etc., are concerned.

Disinfection cabinets working on the principle of volatilization of formaldehyde solution can accommodate these appliances for disinfection. However, residues of the formaldehyde vapor usually form during disinfection, which, in case of immediate use of anesthesia apparatus and respirators, can cause irritation or even damage to mucous membranes.

It is therefore better to dismantle parts of the anesthesia circuit and to clean, disinfect, or sterilize them separately.

Conclusion

The fact that highly reputed doctors are convinced that the prevention of many diseases is more humane and less expensive than their treatment emphasizes the importance of the measures for the prevention of infection described so far.

Anyone, however, who believes that sanitary measures in hospitals are not only sufficiently justified but that their uniform application is indisputable, will in practice soon be confronted with contradictory opinions.

For example, some are of the opinion that expensive floor disinfection is not compensated for by a decline in the infection rate in hospitals, or that the effectiveness of a cap, oronasal mask, shoe covers, adhesive mats, etc., in intensive care units and general wards has yet to be proved. In objection to this view it can be said that cross-infection is encouraged if these measures are not taken in the patient's environment.

The different opinions shown in these examples may cause confusion. However,

they rather emphasize the necessity for close cooperation with the hospital infection control practitioner. This should help to eliminate doubts in the search for the sources and means of infections, to recommend appropriate sanitary measures in a well-balanced cost/efficiency ratio, to review these measures continuously, to supervise specialized wards in the hospital, for instance, the central sterilization department, bed disinfection, etc., and to encourage the education or continuing education of the staff. Supported by a well-trained disciplined staff, it is possible to develop effective hospital sanitation on this basis.

Work Routine

Introduction

The guidelines given in the foregoing sections about hospital sanitation describe and govern a work routine that is characterized by increased discipline. The conditions for this work are chiefly made by those working in a hospital who, if well trained and conscious of infection control, always endeavor to avoid personal misconduct and to carry out their work as hygienically, humanely, and economically as possible.

As can be seen from the term "guideline," the following sections do not contain a complete description of procedures but describe some of their most essential characteristics, confined to the operating and therapy areas.

Work Routine in the Surgical Department

The routine in a surgical department of the staff, patients, and material is strongly influenced by barriers that are designed to interrupt the paths of infection, and thus an effective contribution to sanitary measures in the hospital. The consequential use of the barrier system ensures that pathogenic organisms can neither reach the aseptic operating area nor be spread from the septic operating room.

This main effect, however, is often disturbed by interruptions and delays in the work routine: these must be accepted, but the many consequences arising from them should neither be ignored nor neglected. Of particular significance are those members of the staff who have to work in different units, e.g., anesthetists and nursing staff who frequently move between operating room, recovery room, and intensive care unit.

The Staff

It is advisable to change street clothes and shoes for hospital clothes and shoes immediately after entering the hospital; this is not only sanitary but also practical, since the staff rooms before entering the operating room are usually of limited size.

Entrance to the surgical department via special rooms is made easier if sanitary and ergonomic requirements have been met by construction measures. If possible, this should include forced sequence and one-way arrangements (further details are given on pp. 13 to 24). Watches, jewelry, shoes and hospital clothes are taken off in the anteroom or in the nonsterile outer area of the personnel locker room. This should include all clothes down to the pants, at the least, since, for example, stockings, shirts, blouses and underwear have been found to become contaminated by germs very quickly, thus forming an often neglected means of infection.

The next step is a quick hand disinfection. This is done by rubbing in 1–2 ml of disinfectant. For this purpose, wall-mounted disinfectant dispensers at the entrance to the clean changing area have proved worthwhile; they are frequently combined with electrical door openers so that access to the changing area is only possible after disinfection.

A barrier with a bench interrupts the means of contact for floor germs. In a sitting position the staff can lift their legs and swing them over into the clean inner section. Shoes for the operating theater and clean stockings are put on, which should keep microorganisms on the soles of the feet from spreading. Then, the protective clothes are put on – long trousers, shirt and gown, cap, oronasal mask. In most cases these are colored – (cf. p. 4, "Protective Clothing"). They

should be ready on the shelves of the clean dressing unit.

The members of the staff who are directly involved in the operation then enter the washing room for preoperative hand disinfection. The surgical hand disinfection renders innocuous microorganisms on the skin surface and those that are found in the hair follicles, sebaceous glands, and sweat glands. First, the skin should be cleaned using hot water and soap to remove dirt, sebum, sweat and skin particles. In order to prevent skin irritation or damage (with subsequent intolerance for disinfectants), it is advisable to use brushes for the finger pads only.

Special sterile operating clothes and gloves are then put on. This takes place according to firm regulations that are of first priority for the maintenance of aseptic conditions and are a part of the special training necessary for surgical work. This book will therefore not go into details.

On the recommendation of some hospital infection control practitioners, the shoes are sometimes covered again before entering the operating room in order to interrupt the transferrat of floor organisms for a second time. This measure is to be recommended if there is no barrier and bench, as just described, thus allowing floor germs easy access from the changing area to the operating rooms. However, it must be noted that this requires twice as many shoes and thus more cleaning and care.

After the operation, the special surgical clothes, including the surgical gloves, are taken off and stored in moisture-resistant receptacles that can be closed and easily transported (e.g., plastic sacks, containers, etc.). This is carried out after the patient has left the operating room or preferably in the postanesthetic room or in the waste disposal room in order not to increase the number of air-borne germs in the operating theater before the next operation (cf. pp. 11 to 13 "Material"). The staff wash and disinfect their hands prior to returning to the unclean inner section, where all surgical clothes, including shoes, are taken off (cf. Fig. 1 and text on p. 20 to 21).

Next to the shelf for surgical shoes, plastic sacks are provided for disposable objects and linen that can later be removed safely.

Then the "unclean area" or staff anteroom can be reentered for changing into hospital clothes.

To safeguard permanent effective hospital sanitation, the changing of clothes of the staff in this form and without restrictions is to be recommended. It is necessary for each entrance – even for a short time – or exit from the operating area, despite the inconvenience of higher costs and an increase in work, time, and material. The damage caused by infections contracted in the hospital and the costs of treatment and convalescence are much higher, which justifies such an expensive control system.

The Patients

The equipment used for the transport of the patient into the surgical department area, especially patient beds, are soon contaminated with organisms despite regular cleaning and disinfection. This equipment should thus only be brought into the operating theater in exceptional cases, i.e., if necessary to save a life.

According to the barrier principle, the patient is usually moved to another bed in a special room before the surgical department so that the means of contact of germs is interrupted.

The patient transfer system consists in one clean and one unclean area, which are separated (cf. p 20). This should greatly reduce the number of microorganisms reaching the operating theater, apart from the inevitable germs found on the patient.

The patient is undressed in the transfer area and moved to the operating table. The staff responsible for the transport and the bed remain in the unclean area, and the operating room team takes over the responsibility for the patient in the clean area. They identify him and make sure that he enters the operating room without jewelry,

dentures, etc. The patient's documents must also be examined:

Radiographs
Temperature charts
History
Informed consent
Anesthetic report
Accompanying documents for preparation and smear.

The patient is covered with a sterile cloth and cap and is pushed into the preparation room for anesthesia induction (see also information on p. 33).

An increasing number of hospitals use mechanical equipment for the transfer of the patients, thus putting less strain on him during movement from the transport equipment to the operating table and back. This also provides a barrier separating the clean from the unclean areas. Mechanical patient transfer makes the staff's work much easier considering, for example, the weight of the patients who are to be lifted and moved, sometimes twice, in just one working day in the operating room.

However, it must be mentioned that mechanical transfer equipment, which in most cases is new and unfamiliar to the patient, can be an additional emotional strain on him. The patient should thus be informed accordingly in the preparation stage prior to the operation and, if desired, play an active part in this procedure. Special care with regard to sanitation is to be taken of the transport belt of the mechanical transfer equipment; regular cleaning and disinfection, if possible after each patient transfer, will prevent transmission of microorganisms.

Many hospitals now use operating tables that consist of columns firmly mounted in the operating theater (cf. also pp. 18 to 19 "Operating Theater") and removable table tops that can be easily transported on trolleys and that, due to their light weight and large wheels (easily accessible for cleaning and disinfection purposes), do not damage the floor. These operating tables have so far proved very worthwhile. Two operating table tops are usually used for one column or one operating room, thus allowing the operating program to run as smoothly as possible.

After the operation, the dressing is applied and, once the patient is in the postanesthetic phase, he leaves the operating room.

In the exit room the anesthetic state can be terminated. In addition to this, the location and function of the drainages, probes, and infusions and the patient's documents are to be checked for completeness. The patient is then covered again to prevent major loss of heat with hypothermia. When this is not possible due to lack of room, this is carried out in the operating theater, entailing, however, the risk of longer preparation time before the next operation.

On the surgeon's instruction, the patient is transported to the recovery room, where he is moved onto another bed, and later to the ward or, without interruption, directly to the intensive care unit. The operating table or the top of the operating table and trolley remain in the operating area and are carefully cleaned and disinfected and prepared for the next patient.

Material

Material as a collective term includes sterile material, equipment and accessories, which, similar to the hospital staff and the patient, enter the surgical department via a barrier system to the holding area for clean material.

The barrier principle must be adhered to in order to achieve perfect hospital sanitation. This also includes the division into two tracts: the clean material holding area for the provision of the operating theater and the unclean material holding area tract for waste disposal.

In the clean material holding area, which can be a corridor or a room, material is reloaded, transport packaging removed and, in particular, nonpacked equipment and accessories disinfected prior to their entering the operating room.

Material from the surgical department passes through the unclean material tract in moisture-resistant and germproof recep-

tacles for disposal. Doors with reciprocal interlocking devices and other construction arrangements help avoid contact with the staff before and after removal. Thus, the risk of germ transmission is avoided as far as possible (cf. p. 21 "Material Sluice").

Some materials, e.g., industrial sterile products such as syringes, cannulas, tube systems, dressing materials, suture material, and also equipment and accessories are often delivered to the hospital from varying places and great distances. During these journeys dirt and microorganisms settle on the outer packing. It is thus sensible to remove the transport packing soon after its arrival in the hospital. Industrial sterile products are often doubly packed. The second layer of packing is then removed when passing through the material barrier into the surgical department. The last layer is removed, so to speak, at the operating table. Since this covering is sterile inside, it is a suitable tray for the sterile material. Prior to their entering the surgical department, material without multiple layer packing, e.g., equipment, apparatus, accessories, must be carefully cleaned and disinfected.

The major part of the material, particularly sterile material, such as instruments and linen, is prepared by specially trained staff in the hospital's own special units. For these tasks, different kinds of packing are used, e.g., drum sterilizers, containers, or paper either singly or in combination with each other. All these methods, however, do not change anything regarding the principle of sterile double packing.

This book is confined to the following guidelines for the surgical-technical staff with regard to the routine of provision and disposal of sterile materials in the surgical department. For more information, refer to the extensive literature on sterilization and disinfection.

After passing through the material barriers, the sterile material is stored in dust-proof, moisture-proof areas, which, if possible, should be air-conditioned. Experience has shown that stores should not exceed the turnover rate, so that expiration dates are not exceeded due to too long storage.

According to the organization, each operating room is equipped with suitable transport equipment prior to the operation or the operation program. The path of the sterile material, for both supply and disposal, depends on the arrangement of the operating area, e.g., single corridor, double corridor, or multi-corridor will be dealt with in more detail in the following section "Functional and Construction Design of the Surgical Department".

The prerequisites for aseptic conditions during the operation have been achieved if, immediately before the beginning of the operation, the last layer of the sterile packing is opened at the operating table. A risk with regard to sanitation, however, exists in the multiple withdrawal of sterile material from the drum sterilizer, since, due to the movement of the hinged cover, air-borne organisms can enter the drum and thus settle on the remaining sterile material.

During disposal of the used material after the operation, it must be assumed that the material is contaminated and was in contact with the operating clothes of the surgical team, the operating table, equipment, apparatus and the floor of the operating theater.

It is sensible to pack this material immediately into moisture-proof, germproof receptacles in order to prevent the microorganisms spreading from the operating room. Used instruments can be stored in containers with disinfectant but must be transported carefully. The packing of operating cloths and clothes presents a problem, however, since during packing contaminated particles can rise from the textiles and be swirled up, thus increasing the number of air-borne organisms in the operating room prior to the next operation.

In practice, there are various disposal methods, depending on the organization and efficiency, on the kind of packing, the arrangement of the rooms and the technical equipment. Each method has its own advantages and shortcomings, so that the qualifications and the discipline of the hospital staff are in the end decisive for the success of their work.

The used material, stored in germproof packing and divided into material to be reconditioned and scrap, is transferred to the unclean tract and taken over by the staff in charge outside the surgical department.

Immediately after transport of the material out of the operating room, the operating table, equipment, apparatus that is to be used again, and the floor of the operating room are thoroughly cleaned and disinfected before the theater is prepared for the next operation.

Here, too, there is the risk that loose dust particles that are contaminated with microorganisms may swirl up, spread into the room, and settle, unless they are drawn into the room air control system. Another inconvenience is the long exposure time of registered disinfectants, from one to several hours, which theoretically would lead to too long interruptions between operations.

There is no easy solution to these problems. However, once they have been recognized as such by the staff, disciplined procedures can lead to successful work.

Functional and Construction Design of the Surgical Department, Outpatient's Department, and Endoscopy Unit

Introduction

Hospital work centers around the patient and his search for physical and mental recovery. Not only are the nursing and therapeutic measures a means to this end, but hospital architecture is also of significance, since architecture creates the construction preconditions for flexible and economic procedures, good working conditions and increased efficiency. The following guidelines should increase the understanding of the surgical-technical staff in matters of reconstruction and new building concepts. It may also constitute additional information to the advice given by hospital architects, medical planners and engineers.

The Operating Surgical Department

In the 19th century most hospitals were built in pavilion style, with the hospital units being accommodated in individual buildings. This was due to the fear of bacteria. The same applied to the operating units of the respective departments. Otherwise, the outward appearance of these buildings – the architecture – was more important than the functional aspects. It was not until the 1920s that this changed, due to the birth of functionalism in architecture.

The long distances between the separate buildings were recognized as inconvenient. After study of the subject, the building experience of manufacturing and industrial processing plants and economic judgment found their way into hospital planning. The advances in research and the fight against pathogenic organisms also contributed to the fact that hospital departments along with their surgical departments which were still separated according to their special discipline, were combined in larger buildings.

The Central Operating Suite

Later, central surgical departments were formed combining the various disciplines. Today, these are sometimes of considerable size. Operating suites with 10 to 30 operating theaters can be found in the new buildings of large hospitals, such as those in Berlin, Göttingen, Münster, Aachen, and Munich. These new hospitals, together with those of smaller or medium size, form a broad basis of experience for future developments in hospital construction.

The following medical, technical, sanitation and organizational considerations justify the central surgical department.

Due to centralization and the presence of specialists, a wide range of excellent treatment is available. The high medical standard corresponds to the technical standard of the equipment, forming a sound basis for successful treatment. This justifies considerable investment in technical equipment as well as its full and thus efficient exploitation.

The central surgical department fulfils all

preconditions with regard to space (e.g., anterooms, which are necessary for effective hospital sanitation). The flexible assignment of staff and the efficiency possible when working to capacity justify the central surgi cal department, too.

Among the possible disadvantages of large surgical departments is the difficulty of controlling infection control, considering the large number of staff working there. There are many opportunities for conveyance of microorganisms, also with regard to the material and equipment used. Another disadvantage is the difficulty of coping with staff and the organization problems in order to ensure the smooth running of the operating schedule.

For these reasons, the following is stated in regulation 4.3.3 "Hygienic Requirements of Functional and Constructive Arrangement of Surgical Department" laid down by the Federal Board of Health in Berlin: "due to the sanitary disadvantages arising from the increased number of persons and equipment, a surgical department shall not have too many separate units for operations (about 8 units)." The term "separate units" is to be understood as specialized groups of rooms, e.g., the operating room with its adjacent rooms such as anesthesia induction room, exit room or waste disposal room, wash room, patient, staff, and material rooms, the storage rooms for sterile material and equipment, staff rest rooms, etc.

Often in practice an even smaller number of separate units are recommended for the surgical department. In this case, however, it is necessary to consider which surgical disciplines can be combined in one surgical department. Such considerations must take the strict separation of aseptic and septic operating areas into account.

Apart from the various possible means of transmission of microorganisms – from the outer to the inner section of an aseptic operating tract and from the inner to the outer section of aseptic operating tract – the principles concerning infection control, work routine, architecture and equipment are identical in both tracts. Nevertheless, examples of low-standard septic operating tracts are frequent. Contrary to many aseptic operating tracts, these usually lack anterooms. Even more dangerous is the common opinion that casualties must be treated in a septic operating theater, since they come from the street and are thus "dirty." Regardless of all preoperative cleaning and disinfection of the patient, a person injured in an accident should be brought into the aseptic operating theater or into the aseptic emergency and casualty operating theater.

Corridor Systems

A crucial point in the construction of hospitals in recent years has been the arrangement of the surgical department.

With the main objective being to improve infection control in the operating tract by means of separated paths, the one-corridor system gradually developed into a system with two or more corridors. Areas with different degrees of cleanliness and different activities were thus separated to create calmer, smoother work routines.

Examples of this are the supply and disposal of sterile material via separate corridors, the separation of patients entering and leaving the operating theater, the separation of the anesthetic team from the surgeons and their assistants, who enter the operating theater via separate corridors and wash rooms. Since, however, it is impossible to achieve completely separate paths in the surgical department and since the discipline of the staff working in the operating room is more important than construction measures, the two-corridor and multi-corridor systems can hardly be justified on grounds of infection control. Wounds are covered prior to leaving the operating room; instruments, material, and linen can be safely packed and transported on the same corridor that is used for patients and the staff. It is also striking that the guidelines of the German Federal Board of Health, mentioned previously, do not describe or recommend any particular corridor system.

It is therefore not surprising that the single corridor system is at present becoming more in demand in hospital planning. Advo-

cates of this system mention humanitarian, organizational, and economic reasons:

The surgical department with a single corridor system can be arranged so that the operating rooms, or the corridors and rooms immediately next to it, can have daylight and allow one to look out. Rooms without windows, which are often likened to air raid shelters, and their inevitable artificial lighting, can thus be avoided.

A surgical department with a single-corridor system has shorter distances between rooms, facilitating the work routine and making the work situation clearer.

Because less space is required, the costs of construction and the subsequent working and maintenance costs can be reduced.

Barrier Rooms

The barrier system, as laid down in the guidelines of the German Federal Board of Health, is used to attain safe and reliable entry of patients, staff, and material into the surgical department. This principle is, meanwhile, generally acknowledged and is almost always taken into account in new buildings. Barrier rooms are being installed more frequently in old buildings, although the available rooms are frequently very small, thus making compromises or restrictions necessary.

Floors, Walls, and Ceilings

An essential part of construction measures is the design of floors, walls, and ceilings. Surfaces should be even, with as few joints as possible to allow easy cleaning and disinfection.

Walls made of mortar and then tiled have many joints and the joint material is frequently damaged by the cleaning agents and disinfectants used today. In these damaged areas microorganisms can reproduce in numbers that can hardly be controlled or destroyed, not to mention the necessary regular maintenance of the building, which can disturb the work in the operating room and cause additional costs. In contrast to such walls, materials such as chrome-nickel steel and steel with enameled varnishing or antistatic plastic coating have an even surface without pores and are thus resistant to cleaning agents and disinfectants. In connection with premanufactured systems for surgical departments, large-surface wall elements have fewer joints. For the purpose of maintenance, repairs, and new installations, and even complete rearrangement of the rooms, these standardized wall elements can be disassembled easily, quickly, and cleanly for reassembly or replacement. According to advocates of this system, other advantages include the short assembly times as well as the flexible technical planning and coordination of all components until immediately prior to their assembly. However, the assistance of hospital architects, planners, and special engineers is strongly recommended.

The floors in rooms used for medical purposes are frequently made of electrically conductive plastic coverings of welded or bonded strips or plates. The floor covering is even, without joints, and to avoid joints between floor and wall the floor is frequently drawn upward to form a curved edge.

The material is very inexpensive and can be laid easily. It does, however, require a firm, adequately treated foundation.

Air Conditioning

Air conditioning, which in technical terminology is more adequately called room air control, should:

- Reduce the quantity of air-borne microorganisms
- Discharge anesthetic gases and possibly inflammable air-gas mixtures
- Create good working conditions by regulating temperature and humidity

The room air control system necessary to achieve these goals produces the directions of airflow, which are adapted by means of overpressure (protective pressure) to infection control requirements. In an aseptic operating room the protective pressures prevent unfiltered and thus germ-contaminated air from entering. Conversely, the protective pressure in the adjoining rooms ensures that dangerous microorgan-

isms are not conveyed in the air out of the septic operating room (cf. Guidelines of the German Federal Board of Health's "Hygienic Requirements Regarding Functional and Constructive Arrangement of Surgical Department" No. 4.3.3, Paragraph 10, Room Air Control System.

The maintenance of the protective pressure with an incline of air pressure toward the area to be protected requires a joint sealed construction, locks, use of suitable doors, such as sliding doors and, equally important, disciplined operating staff. These prevent uncontrolled exchange of air and air movement exceeding the minimum movement allowed.

By means of air filters, mixture of room air with particle-free air, or displacement of the room air by means of particle-free air, the level of air-borne microorganisms can be considerably reduced.

The requirements for room air control in surgical departments are determined in the DIN (German Industrial Standards) 1946, Part 4, b "Equipment for Room Air Control in Hospitals," and include:

- Outside air operation – suction orifice more than 3 m above the ground – circulating air to such an extent as is possible without the enrichment of inflammable gas compounds
- Air input center next to the rooms to be supplied
- Aspiration channel and aggregates easily accessible for checking, cleaning, disinfection, and maintenance of the filter during operation
- Twenty-fold air exchange per hour in the operating rooms*
- Directing of airflow in the operating room from top to bottom – from the patient's feet to his head in order to prevent the formation of gas compounds in the operating area – exhaust air 25% at the top, 75% at the bottom in order to achieve an even circulation within the room
- Maintenance of the protective pressure as already described
- Three-step filtration of input air, last step with filter for floating particles, possibility of surface disinfection after the third step
- Devices for measuring differences in pressure to check filter contamination
- Connection of the room air control system to the emergency power supply
- Continuous operation; outside the operating programs the system can be run at 50% performance
- Temperature, humidification, dehumidification, carrying-off of excessive heat, recovery of heat
- Separation of rooms or groups of rooms with regard to ventilation, in order to limit the consequences of sudden emission of germs, if, for instance, an operation that was believed to be aseptic turns out to be septic, or to spatially confine technical problems, repairs, or maintenance work, without disturbance of the nonaffected areas.

The rate of postoperative infections depends on many factors and by no means on the quantity of air-borne germs and of air replacement only. For this reason, the exchange of air that is presently stipulated in the DIN 1946 as a 20-fold replacement is a compromise between sanitation and economic needs and requirements.

Apart from the numerous room air control units built in accordance with these standards, special room air equipment has been developed in recent years that is especially designed for high-risk operations, e.g., orthopedic surgery, transplants, cardiac and neurosurgery, or patients with reduced resistance.

Clean room technology with nearly nonturbulent displacement airflow, a technique used in industry and space travel, is based on a high air exchange rate (up to 600 times/hour) and a uniform vertical or horizontal airflow (0.45 m/sec) which acts like a piston, thus displacing the air particles. By means of high-capacity particle filters (HOSCH-filters), the air can be rendered nearly particle-free. Since the airflow extends over the entire operating room, the

* The DIN (German Industrial Standard) Committee is at present discussing a possible amendment to the regulation, e.g., to 15-fold air change.

operating team and equipment, such as x-ray image intensifier, anesthetic apparatus, and lighting, are not disturbed. After initial reports of success based on a drastic reduction in postoperative infection rates, later reports were contrary to this opinion, which is not surprising in view of the numerous influences to be taken into account. Apart from that, the solution of some of the existing technical problems was only partially possible or involved high expenditure, e.g., ceiling supports, equipment and operating lighting suspended from the ceiling, and the persons around the operating table sometimes produce disturbances in the airflow. The emission of particles via respiratory organs and the skin of personnel working in the operating room can only be prevented by several protective garments that must cover the whole body and by the technical development of the Drägerwerk Lübeck, a protective helmet, with the suctioning out of respiratory air.

Due to the high level of technology and expense, clean room technique remains confined to a few special cases only. However, since each patient is entitled to the best medical treatment possible, it is doubtful whether the "principle of equality" can be maintained in the long run, if aseptic and highly aseptic operations cannot always be distinguished from one another if, linguistically and hygienically, there is no comparative form of the term "aseptic."

By a limitation to clean room compartments within the operating room, the level of technology and expense can be reduced a certain amount, although this restricts the movement of the operating staff and of equipment in the compartment. The side walls of the compartments are of glass or plastic curtaining and are easy to install. They are generally arranged so that the patient's head, the anesthesiologist and the anesthetic equipment remain outside the compartment. This has proved very effective and is being recommended more and more as a so-called germ-protection wall apart from the clean room technique, together with the room air control equipment mentioned previously.

Similar conditions to those achieved by clean room technique can be achieved with the "clean area system" from Esdorn and Nouri. This is used directly within the operating area and blows filtered air, which is nearly particle-free, out of perforated tubes. Bacteriologic tests confirmed the advantages of the "clean area system," which works independently of the quantity of particles in the operating room. Turbulences, due, for instance, to the personnel working at the operating table, can be more easily controlled and avoided.

The "clean area system" can, however, only be used together with a room air control system that takes over other necessary functions, such as the carrying-off of gas-air compounds and excessive heat, inlet of fresh air, and regulation of temperature and humidity.

A good compromise is the combination of the room air control system according to DIN 1946 with a special clean air ceiling panel of the operating theater. This air supply ceiling panel measuring 3600/3000 or 3000/3000 mm comprises a pressure chamber with symmetrically arranged particle filters (classification R or S according to DIN 24184) and ceiling mounted elements in a coffered shape, specially molded and perforated for air conduction. Thus, a stable and nearly particle-free airflow is directed downward, being most effective in the area of the patient. A curtain of air at the edges of the air ceiling panel is directed slightly outwardly. This stabilizes the flow in the marginal areas and prevents the access of germ-contaminated room air into the clean air area, provided there is a regulated, even flow speed of the curtain of air. If the flow is too weak, the contaminated air in the center of the air inlet area, i.e., over the operating area, climbs instead of flowing away downward. Inlets for exhaust air in the lower wall area of the four corners of the room and in two places in the ceiling are part of the air conduction and ensure even air circulation within the room.

The clean air ceiling panel of the operating room often has a further rigid nozzle directing a supporting jet of additionally

cooled and faster flowing clean air directly onto the operating area. The additional cooling and higher flow speed are necessary to make sure that the supporting jet is fully effective. However, this can cause draughts, with the risk that fine objects in the operating area, such as suture material used in microsurgery, are blown away. Since the direction of the jet cannot be changed, the operating table with the patient must be moved according to the type of surgical operation being performed. In many cases the position of the operating table is already determined by ceiling supports, lighting, etc.

Operating Room

Based on many years' experience and due to the modular dimensions used in the construction of hospitals, the average size of operating room is about 40–49 m². A minimum room width of 7.20 m (modular dimension) should be aimed at in order to allow the rooms located outside the operating room to be arranged side by side, e.g., anesthesia induction room, exit room, wash room. This applies to surgical departments with various operating theaters and a single corridor system. Departments with double- or multi-corridor systems vary with respect to room dimensions, arrangement and function.

A precondition for perfect routine in the aseptic environment is the division of the operating room into a traffic area with patient transport, working area of the anesthetic team, the nurses, and the auxiliary nurses (stand-by staff), and a quiet area for the surgical team, instrument tables, and sterile material.

Correspondingly, the number of doors in the surgical department should be kept low and arranged mainly in the traffic area. For sanitary and practical reasons, automatic sliding doors are advisable. These should be arranged on the outer side of the operating room and should have easily accessible runners.

The walls of the operating room should, as far as possible, have smooth surfaces and be easily accessible for cleaning and disinfection. Cabinets and shelves for the storage of instruments, sterile material, etc., should thus be installed in adjoining rooms. (The sterile material needed for 1 day can be stored in the operating room on carts.) This is not applicable to operating suites with limited space: if it is necessary to store material in the operating rooms, built-in cabinets are recommended. These should be made of chrome-nickel steel or steel with enameled varnish that is resistant to disinfectant, and should have flush doors that are made dustproof by means of disinfectant-resistant rubber sealings. Their construction should be such that easy cleaning and disinfection are possible when necessary. It has also proved worthwhile to sink built-in electrical equipment with knobs and switches into the walls of the operating room. These should have transparent flush doors.

For reasons of infection control, floor drainage outlets in the operating theater are no longer installed. Special operations, however, needing large quantities of liquids for rinsing, e.g., urologic operations such as transurethral resection, require a compromise.

A tubelike drain of chrome-nickel steel projects out of the floor to an extent that the risk of stumbling is excluded. The drain is equipped with a one-way valve and a thread or bayonet socket, so that during an operation a reliable tube connection can be established between the funnel or rinsing basin at the operating table and the drain. After the operation, the valve can be shut and a hermetically (from Greek, airtight and waterproof) closing metal cap be screwed on. Except for the water sterilizer with inlet, which is generally used during this operation, and which is installed in the ceiling, the operating room should not have any water taps.

Connections for compressed air must supply particle-free filtered and dehumidified air.

The location of the operating table is determined by the following rule of thumb: the intersection point of the diagonals of the room indicates the center point of the operating table. In operating rooms for

orthopedic surgery, gynecology, neurosurgery, etc., it is generally enough to move the operating table by up to 0.5 m in a longitudinal direction. The positioning of the operating light should be adjusted likewise. All other ceiling-supports, devices for monitoring the patient, for high-frequency surgery, x-ray image intensifier, etc., should be placed as near as possible to their place of use around the operating table and operating light. This, however, requires careful coordination between the persons working in the operating room and the hospital architects, specialized engineers and suppliers. The resulting fixed points for ceiling-mounted devices are also reasons for an operating table system that is firmly mounted in the operating room with removable table tops that can be used alternately and easily be transported on carts.

Even when used together with clean air enclosures or curtains and germ-protective walls, this operating table system has many fields of application. The column of the table can be moved around its axis and with its various table tops, which, among other things, can be shifted by means of an electromotor in a longitudinal direction, enables adjustment into the positions necessary for all operations, particularly orthopedic surgery on the upper and lower extremities.

Anesthesia Induction and Exit Rooms

In order to attain a smooth, rapid, and hygienically reliable routine of work in the anesthesia induction and exit area, two separate rooms should be available for these purposes with a width of 3 m for the preanesthetic room and of 2.5 m for the postanesthetic room, based on the modular dimension of an operating theater of 7.2 m. With a room length of about 4.2 m in the preanesthetic room, enough space is provided for the connections and equipment used for anesthesia and patient monitoring, and also for a wall unit consisting of high cabinets for the storage of drugs, anesthetic and operating table utensils, sterile material, a refrigerator for drugs that should be kept cool, cabinets for infusion solutions, tilting unit for vein catheters, working surface with sink and water connection, drawers with compartments for ampoules, syringes, cannulas, and below a cabinet with waste collector and tilting door. Apart from the care of a postanesthetic patient, the exit room is frequently used as a disposal room where used instruments, linen and waste are collected and packed in germproof containers for transport. Often, used instruments and utensils are cleaned and disinfected in this room prior to transport so that the installation of a washing unit with suitable large sinks for the instruments, together with a washing and disinfection machine and a drainage unit, is recommend ed. The cabinet space below the working surface is used for the storage of cleaning agents, disinfectants, etc.

Scrub

The modular dimensions for the operating room, anesthesia induction room, and exit room already mentioned allow an arrangement of the scrub with a width of about 1.8 m, likewise outside the operating theater. Thus, three sinks can be positioned side-by-side in the room if washing tubs with several fittings are not installed, as is more often the case today. Since the rubbing of hands for washing and disinfection no longer takes place over the sink, tubs can be equipped with more fittings than single sinks would allow within the same space. The conventional single lever mixing taps are being replaced more and more frequently by valves for foot operation or photoelectrically controlled fittings where water only flows when the hands are held under the tap. Windows between the scrub and the operating room allow the surgical team to observe the stage of preparations in the O.R. A window between the scrub and adjoining preparation room is only provided when there is no independent anesthetic unit.

Equipment Room

Equipment and apparatus that are not in continuous use (e.g., x-ray image intensifier,

extension devices) can be stored in the equipment room. Utensils and small pieces of equipment should be stored on shelves with a chrome-nickel steel coating, which have a high load-bearing capacity and can easily be cleaned and disinfected. These should be fixed on smooth wall rails and consoles.

Recovery Room

There is no doubt about the need for a recovery room, since a patient who has just undergone an operation should be kept under careful observation following a general anesthetic. For this purpose, the anesthesiologist must have direct access to the patient and all means for immediate intervention in case of possible complications, even leading to a further operation, which, however, is rare. It is therefore sensible to arrange the recovery room within the surgical department. A possible objection to this is that the patient must either remain on the operating table or a bed must be brought into the operating suite, whereby both methods would involve undue strain on the patient, and also a risk to infection control in the surgical department. As a compromise, the recovery room can be located outside the surgical department but in its immediate vicinity. The possibility of the patient's immediate transport back into the surgical department in case of complications should be taken into account. In larger departments such a compromise can be realized more easily, since during operations a skilled anesthesiologist can be on continual duty in the recovery room. In smaller departments a solution should be developed in close cooperation with the personnel working in the operating room and the responsible hospital infection control practitioner, the hospital architect, planner, and specialized engineer. Other solutions, e.g., transport into the surgical department without contact with the floor of a clean, sealed bed or use of special carts or stretchers within the operating suite with broad, well-padded surfaces and guard rails, have not proved successful until now due to sanitary and technical problems, which remain unsolved.

Staff Rest Room

Within the surgical departments the same requirements are applicable to the rest room as to others. The staff rest room should be adjacent to the surgical departments, which can cause problems with regard to infection control. Care is to be taken that there is sufficient room, good ventilation, and that there are windows to look out of the building and to allow daylight to enter. The room should be pleasantly furnished, using materials that allow easy cleaning and disinfection.

Patient Transfer Area

The patient barrier system considered necessary on pp. 10 to 11 "The Patients" is to be arranged in relation to the surgical department so that neither the pressure drop created by the room air control unit is destroyed nor the direction of the airflow changed. If necessary, an unclean and a clean area must be provided with interlocking doors or, if there is not enough space for a closed room, the barrier between the two areas is to be equipped with a closable window.

A movable receptacle can be provided in the unclean area for the patient's clothes. The clean area should be equipped with cabinets and shelves for the storage of sterilized cloths, caps, etc., as well as operating table utensils.

The number of patient rooms depends on the dimensions of the surgical department and on the number of operations. In large departments preoperative and postoperative rooms are separate.

Staff Changing Rooms

There are many different kinds of systems, chiefly characterized by the space available. One type of system has been developed that is generally recommended by hospital infection control practitioners. Its principle is a step-by-step progression from the outside area into the surgical department, thus providing almost completely reliable conditions for infection control.

Figure 1 on page 22 shows a staff sluice system consisting of three rooms (for the functions, cf. pp. 9 to 10 "The Staff").

Closable compartments or lockers are provided in the unclean anterooms that the personnel enter wearing hospital clothes. After undressing, clothes and shoes, etc., are stored in these lockers. There are also toilets and showers in this room. A disinfectant dispenser for hand disinfection at the entrance to the clean inner room can be combined with a release for the electrical door opener. (In this area there may also be a spray device for foot disinfection). The clean inner room has a barrier with a bench and shelves for the storage of special stockings, shoes and clean clothes used in the operating room. Only the movable receptacles for used linen and disposable items, such as surgical masks and caps are left in the unclean inner room.

Material and Equipment Sluice

To achieve a high standard of hygiene, separate pathways are necessary for material supplies and disposal. The rooms have interlocking doors allowing sufficient room for the removal or reloading of transport packings of material and equipment and for the transfer of a disinfectant spray into the operating room. There is also sufficient room for the storage of used materials and waste in germproof sacks and containers.

In practice, hatches above floor level are often provided for this purpose. These interrupt the path of conveyance of floor microorganisms, but for larger equipment additional disinfection and transport through successive rooms is needed.

Cleaning and Preparation of Equipment

More and more often suitable rooms, divided into nonsterile and sterile areas, are being provided for the disassembly, cleaning, disinfection and assembly of equipment that remains in the surgical department. Since they were primarily intended for anesthetic equipment and utensils, they are equipped with special working tables, thermochemical cleaning and disinfection machines, drying units and storage cabinets. Gradually, mechanical and surgical equipment are being included here so that expensive, time-consuming and not always reliable manual work is being replaced by high-capacity washers that clean thermochemically, disinfect and dry. The consumption of energy and water, which was high in the beginning, has meanwhile been reduced by using reverse cycle heating systems and water recycling systems.

Outpatients' Department

The location of the outpatients' department at the entrance of the hospital and the fact that there is no constructional separation by means of successive rooms, which would disturb the work routine, makes particular infection control necessary when treating patients (cf. p. 5 "Dressing Wounds, etc."). This is especially important if there are not enough special waiting rooms and treatment rooms for patients with possible infections.

The simultaneous treatment of several patients in one room puts additional strain on patients due to noise and unintended overhearing of conversations.

The outpatients' department usually includes:

Waiting rooms
Patient toilet
Reception and organization
Examination and treatment rooms, the latter with facilities for applying small plaster casts
Cast room for the conventional treatment of fractures
Perhaps a room for minor operations
Perhaps a rest room and an observation room for postoperative patients
Clean storage room for sterile utensils, material and drugs
Equipment room
Disposal room
Room for cleaning equipment, cleaning agents and disinfectants
Staff changing room and toilet, if not situated near the outpatients' department

Wall surfaces and floors should allow the same easy cleaning and disinfection as in the surgical department.

Rooms in which plaster casts are applied are to be equipped with fixed or mobile plaster collectors to prevent the blocking of outlet pipes with plaster. "Plastering benches" made of chrome-nickel steel have proved very worthwhile. They consist of a 2–3 m long working top with sink and a surface for spreading the soaked long plaster cast (6–8 fold layers of plaster laid lengthwise), a movable plaster collector, and lower cabinets with specially arranged drawers in which plasters of different sizes are stored. These can be pulled out to the required

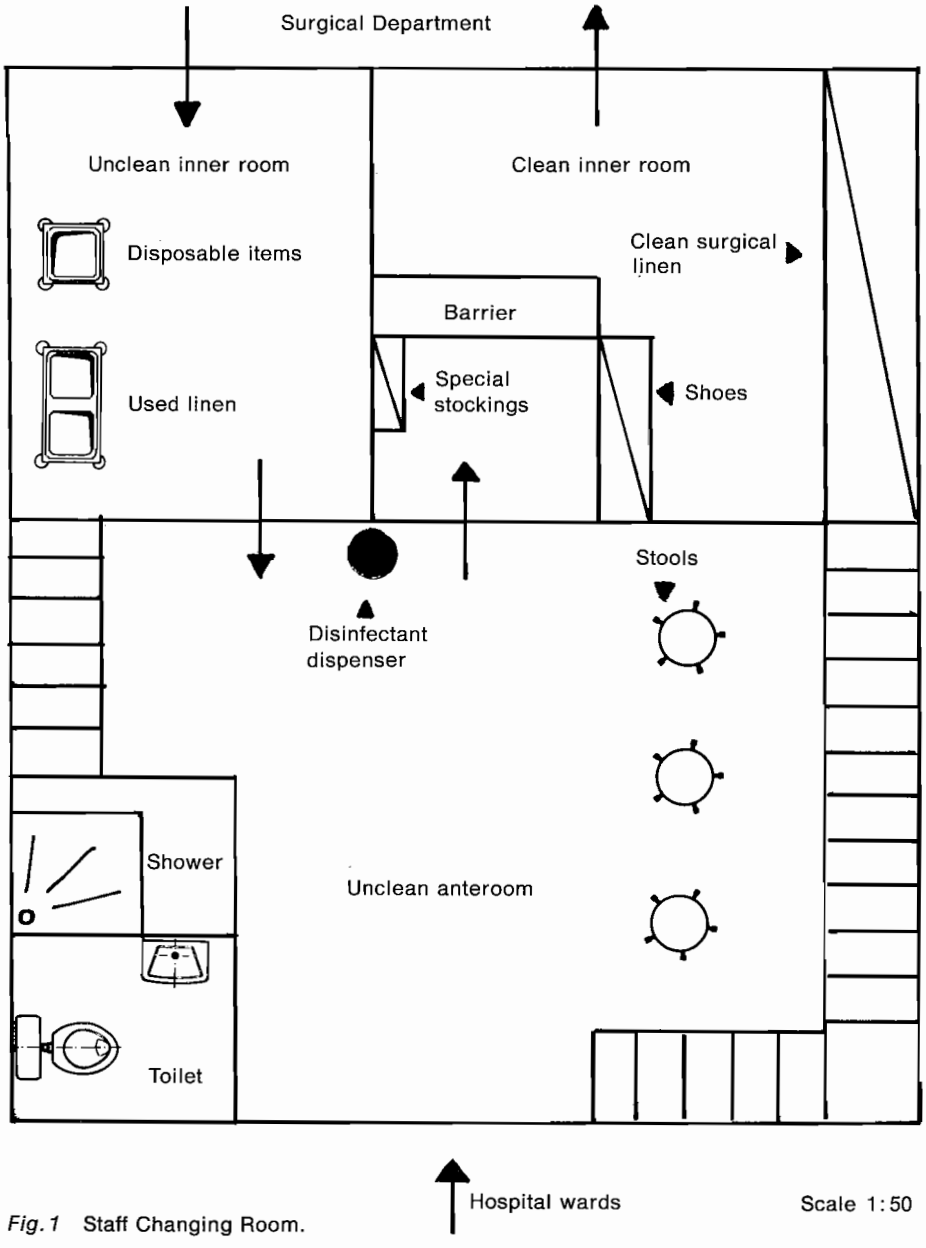

Fig. 1 Staff Changing Room.

length and cut without opening the drawers. Wall cupboards above the plastering bench and high cabinets next to it serve as storage space for plaster dressings, dressing material and instruments.

Endoscopy

For reasons of infection control, the endoscopy rooms should be arranged in a quiet area with no through traffic. Examinations where aseptic operations are necessary, e.g., laparoscopies, are only to be carried out in rooms that are clearly separated from those where large quantities of microorganisms are involved, e.g. proctoscopy. If this is impossible, these examinations should at least be carried out at different times, beginning with those examinations requiring an aseptic environment. Careful cleaning, disposal, and disinfection of instruments, material, equipment and surfaces should follow immediately.

Rooms for aseptic endoscopic examinations should not be directly accessible via the corridor but via the preparation room.

Ideally, an endoscopic unit includes the following rooms:

Waiting room, with sufficient space for patients to sit or lie
Patient toilet
Reception and organization
Examination rooms
Clean storage room for sterile objects, material and drugs
Examination room for endoscopy and aseptic operations
Room for cleaning equipment, cleaning agents and disinfectants
Staff changing room and toilet

As in the surgical department the wall surfaces and floors should allow easy cleaning and disinfection.

The cleaning, disinfection, maintenance and storage of the valuable and sometimes extremely sensitive endoscopes is of great importance. It is thus necessary to have built-in washing tables with working tops made of chrome-nickel steel and sinks of sufficient size (60 × 40 cm rather than the frequently too small sinks of 40 × 40 cm). These should be combined with the cleaning and disinfection equipment, which has been developed together with endoscope manufacturers. A washing and disinfection machine is also recommended for used instruments and utensils prior to their preparation, wrapping and sterilization.

Drawers with a width of 1.20 m are provided for the storage of endoscopes. High cabinets with pull-out vertical segments on roller bearings onto which the endoscopes can be hung are also being used more and more frequently. Special holders and plastic tubes into which the endoscope is inserted before it is hung up protect the endoscope from being damaged. If mounted to the wall of the cleaning and working area, these holders and plastic tubes, which are then filled with disinfectant, also serve as a means of disinfection and, if left for 4 hours, as a means of cold sterilization.

Meanwhile, examination tables with table columns anchored in the floor and electrically movable, radiotranslucent tops have also proved worthwhile in the endoscopic unit. In contrast to the movable tables, they need no projecting substructure necessary to ensure stability, which means that the position of the examining doctor is more advantageous and thus not tiring. At the press of a button, the height of the column can be regulated, and the table tops shifted and tilted longitudinally and transversely on the column. In this way the patient's position can be greatly altered as is necessary for a laparoscopy. The same easy access is applicable to the x-ray image intensifier.

Conclusion

The guidelines should stimulate and supplement discussion about planning and reorganization. However, the cooperation of the hospital personnel with the hospital architects, specialist planners for medical technology and specialist engineers is necessary for the coordination of the various hospital departments, for the creation of detailed concepts for functional, constructive measures, and for equipment and technology.

Handling of Equipment in the Operative Field

Independent of the competence and responsibility of the specialists, the handling and control of the instruments and equipment used in the operating field is part of the work of the surgical staff. Due to the size, variety, and sometimes complicated handling of these instruments, the risk of accidents involving patients and staff has increased during recent years, along with the demands regarding training, technical comprehension, and knowledge of the safety regulations concerned. It is thus not surprising that more and more hospitals are employing specially trained hospital engineers for the control and handling of technically complicated instruments and equipment.

Medical Furniture

When purchasing mobile furniture, it is important to check that it has smooth surfaces which permit easy cleaning and are resistant to corrosion and disinfectants. Where great demands are placed on the equipment, rust-resistant stainless steel has proved worthwhile, whereas, where less strain is likely, sheet steel coated with modern lacquers (e.g., DD-lacquer) suffices. Due to disturbing reflections and its more difficult maintenance, chrome-nickel steel should be dull rather than polished. Mobile furniture should have ball-bearing rollers, thread proof, which, however, are more expensive than disk wheels with a rod axle, but run easier and are characterized by much higher reliability and longer life.

The furniture around an operating table should be designed so as to exclude electrostatic sparks according to the regulations concerning risks of explosion. Electrostatic charge with the risk of sparks is prevented by the electric conductivity of the furniture (e.g., conductive bases, studs and rollers) if they are standing on a floor that is conductive and connected to a means for potential equilibration. Regular cleaning, disinfection, maintenance of the furniture and performance tests are the basic conditions for a germ-free environment in the operating theater.

Operating Table

Technical progress in the construction of operating tables has made it possible for modern high-quality tables to meet the medical, technical and infection control demands of an operating field.

The high technical standard of mobile operating tables is to be seen in the electromotive or electrohydraulic drives with miniature modules that permit easy replacement. These are supplied from built-in rechargeable batteries and they can perform several weeks of operations independently of the main supply. Due to the connection of the table to a button control located in a small hand control box, all necessary positions, e.g., flexed table top for bile or renal operations, can be achieved at the press of a button. All segments of the operating table top, which are manually removable and radiotranslucent, are connected, without seams, to the electroconductive pads and can be anatomically adapted to the patient due to their repartition and adjustability. This keeps the strain on the patient to a minimum (cf. type Maquet "Heidelberger S"). The upper section of the operating table mainly consists of smooth segments of chrome-nickel steel. The casing of the column and the base which is of the same material, should be easily removable for maintenance and repair. Also, the ball-bearing rollers, which should be electrically conductive and allow the movement of the table in longitudinal and transverse directions, are accessible from above for cleaning and inspection.

An even greater range of possibilities is offered by an operating table with a column that is firmly anchored in the floor of the operating room, along with different tops that are interchangeable and thus suitable for various operations. This has proved very useful in many medium-sized and large surgical departments. These table tops are easily movable and can be transported on carts. This simplifies transport over longer distances, and the changing of the table tops between patient transfer room, anesthesia induction room, operating room,

exit room and back to patient transfer room and also save the floor due to their weight, which is low compared with other mobile operating tables. The large, accessible rollers are easy to clean and disinfect. The column of the operating table is positioned in relation to the equipment, which is mounted at fixed points on the ceiling, e.g., anesthesia support, operating lighting etc. It has no projecting T-base, is arranged eccentrically outside the operating field, and can be controlled by a wireless remote control system. There is thus available floor space under the table top for the feet of the surgical team, allowing unhindered access for the x-ray image intensifier for intraoperative radioscopy.

At the press of a button, the individual segments of the table can be adjusted for various operations and anatomically adapted to the patient. Since all table tops are suitable for the standard table column, necessary rearrangement for other operations can be carried out easily and is less expensive than the purchase of comparable mobile operating tables (cf. type Maquet 1120).

Apart from regular cleaning and disinfection as a precondition for aseptic work, function tests on the operating table should also include the electrical grounding, either via the conductive floor or via a direct connection to the device for potential equilibration.

Electromedical Instruments

The handling of electromedical instruments in the operating theater, such as electrosurgical instruments, aspirators, anesthetic devices, operating light with operating satellite lamp is difficult in contrast to that of medical furniture. Due to their construction, these devices frequently do not possess the closed, even surfaces that make cleaning and disinfection easy. Due to the risks to patients and staff caused by equipment that produces, transforms, stores, conducts, or uses electrical power, this equipment must be handled, checked and repaired in strict accordance with the operating instructions. Maintenance contracts with the supplier are advisable if the hospital does not have an adequately trained and specialized staff for this purpose. It is particularly necessary to be acquainted with and to adhere to the standards, guidelines and regulations concerning protection against fire and explosion (literature references are given at the end of this book).

Risk of Fire, Explosion, and Burns in the Operative Field

All combustible materials are explosive when evenly distributed in a certain ratio to air or even oxygen. Air-gas or air-vapor compounds developed from combustible liquids are even more explosive. The fine atomization and the compound ratio are decisive here, too: with a too low proportion of substances in the air, combustion and explosion are excluded; with a too high proportion of substances in the air, the existing oxygen suffices for ignition, but not, however, for combustion and explosion.

Burns and explosions arise when combustible materials, oxygen and a source of ignition occur simultaneously.

In the operating room there is an increased risk of fire and explosion if combustible anesthetic air compounds or easily volatilizing and combustible skin cleaning agents or disinfectants are used. Ignition can occur due to the formation of sparks when electrosurgical devices are used, or as a consequence of electrostatic charges. In recent years, however, the situation has changed considerably, since now anesthetic gases are used that may be combustible but that are not explosive when mixed with air. Also, combustible skin cleaning agents, degreasing agents and disinfectants are either used in small quantities only, or have been replaced entirely by incombustible or slightly combustible material (e.g., Merfen, Kodan, etc.). It is therefore not surprising that the number of fires and explosions in the operating room has been reduced by more than 90% as a consequence of new developments. Furthermore, every fifth accident due to fire or explosion used to be fatal, whereas today every 20th accident is fatal.

In contrast to this figure, accidents influenced directly by electricity are increasing (from 1965–1975 "electrical" accidents increased by about 50%). Due to the various, sometimes complicated electrical equipment in modern operating rooms, problems and incorrect use are certainly more frequent than they were. For this reason, the following guidelines describe sources of risk and appropriate measures for the prevention of accidents. Furthermore it is advisable to refer to the leaflet "Protection of Fire and Explosion in the Operating field" issued by the Berufsgenossenschaft für Gesundheitsdienst und Wohlfahrtspflege (Trade Fellowship for Health Care and Charity), which was republished in 1985 and which takes into account not only the present requirements, but also the stage of negotiations regarding guidelines, regulations and rules that are to be reviewed.

Anesthetics

The protective measures against the formation of explosive anesthetics air-compounds include:

Use of "closed medical gas systems" for anesthesia in the operating area, which protect the surgical team from health injuries (see also regulations on occupational diseases)

Prevention or restriction of combustible and explosive anesthetic gas compounds

If these are inevitable, they should be restricted to the necessary quantities or concentrations

The rendering of gases inert, i. e., addition of gaseous substances, such as carbon dioxide or nitrogen, in order to prevent the formation of explosive gas compounds

Check for leakages in the medical gas systems

Safe collection and disposal of exhaled anesthetic gases for the sake of both patients and staff

Aspiration of vapors of analgesics or air compounds via the room air control systems

Endogenous Gases

In the patient's stomach and intestines physiologic fermentation processes can develop gases in which the proportion of methane or hydrogen can create inflammable gas compounds when mixed with air. This also applies to transurethral resections, during which inflammable vapor and gas compounds can occur in the bladder. To prevent this, the patient should be given the necessary diet well before operation. Stomach, intestines and bladder must also be absolutely empty.

Further protective measures include:
Not using electrosurgical equipment until the endogenous gases have escaped and been dissipated
The use of inert gases for rinsing if the use of electrosurgical equipment is inevitable

Skin Cleansers, Degreasing Agents, and Disinfectants

At the beginning of the operation, the operating field is frequently cleaned and disinfected with alcoholic agents. There is thus a risk that residues of liquid and vapors remaining in the air may catch fire due to sparks during the use of electrosurgical equipment or after electrostatic charges. This can cause skin burns. Unfortunately, the colorless flames can hardly be recognized in the light of the operation lamp. However, these agents vaporize within 10 seconds on the skin's surface and the room air control unit removes the vapors so that the operation can resume after a short delay.

Residues of liquid remaining under cloths, in skinfolds, or under the patient's body, which are often overlooked and are, however, dangerous. To prevent this, the patient is to be dried with sterile material with a high absorptive capacity, and if necessary, electrosurgery should be avoided.

Swabs, Dressing Materials, Parts Made of Rubber and Plastic

An atmosphere that is enriched with oxygen is able to make many materials burn more quickly and more explosively than air, sometimes with a colorless flame which can

hardly be recognized in the light of the operation lamp. Materials such as gauze, cotton swabs and covering cloths are in a position to store oxygen and must not be put near the active electrode of the high-frequency surgical unit due to the risk of explosive combustion.

Electrosurgical Equipment

Once the risk of explosion of anesthetic gases is for the most part eliminated, there are more opportunities for the application of electrosurgical equipment. However, the number of accidents and the risk of accidents due to the direct influence of electricity have thus also increased.

In this book it is sufficient to describe the principle of electrosurgery. Readers who are interested in the theory behind it should refer to *Allgemeine und spezielle Elektrochirurgie* by H. von Seemen, published in 1932 by Springer Verlag, Berlin.

According to Joule's law (Joule-Lenz law), heat is developed when current flows through a conductor. The heat developed is proportional to the current density: high-current density – high heat development; low-current density – low heat development. This principle can be used for medical purposes by developing high-current density only whey desired, e.g., for therapeutic purposes and coagulation during operations. Otherwise, it can be used to achieve good current distribution, i.e., low-current density. Correspondingly, certain high-voltage and high-frequency alternating currents are conducted through the patient's body, which is connected to the electrosurgical equipment via a flexible inactive disk electrode at the cable, thus forming a "large electrode" (neutral electrode) with low-current density. The complementary pole is the active or operating electrode, which is different according to each special case. This electrode is also connected to the electrosurgical unit via a cable at the handle or control handle, which can be sterilized. When the equipment is on, the circuit is closed as soon as the operating electrode in the operating field is set on the patient's body. A high current density is developed underneath the active electrode due to its small surface area and, depending on the tension, frequency and type of current, this causes heating, which can boil or coagulate tissue. It is now easy to understand how undesired burns, at temperatures of at least + 50 °C, can develop outside the operating field if high-current concentration occurs at other parts of the body. The following describes some of the main causes and their prevention.

Risk of Burns due to Disturbances in the Current Flow

The current flow via the neutral electrode applied to the patient is disturbed if:

- The cable is broken or not connected to the equipment or if the plugs are defective
- The neutral electrode is insufficiently applied, not applied at all, or displaced during a change in the patient's position
- The neutral electrode is too far away from the operating field so that the current either only partly passes away through the neutral electrode, or not at all, or that on its way to the neutral electrode it develops too high current densities in other parts, e.g., in areas of skin contact between the legs, arms, and trunk
- The neutral electrode has too high a transition resistance due to insufficient conductivity caused by oxidation, inadequately distributed jelly, dirt, or mechanical damages
- Liquids with good conductivity, such as saline solution, sweat and blood, get between the neutral electrode and the patient's skin, causing current concentrations to develop in these wet areas

Protective measures:

Regardless of the regular maintenance and inspection of the high-frequency equipment by a specialist, the following must be checked prior to the operation and the application of the neutral electrode:

- Whether the cable is intact and plugged in
- Whether the plug contact conducts perfectly

– Whether the neutral electrode is in good condition, clean, without oxidation (shiny), and the jelly is uniformly distributed if a neutral electrode is being used with jelly

The area of skin intended for application of the neutral electrode is to be shaved, cleaned, degreased and disinfected in order to reduce skin transition resistance on the total surface.

The neutral electrode, which, according to VDE 0750, is considered large enough for adults with a surface of 180 cm^2, should be applied to the patient's body with its total surface. It should not be applied on areas of the body with projecting bones or on bones that are directly under the skin, or on areas too hairy, injured, or scarred. It is imperative that the neutral electrode be applied near the operative field on one of the patient's upper arms or upper legs. Figure 2 shows the operative field as a dotted surface. The hatched area on the arms and legs shows the suitable position of the neutral electrode.

As can be seen from the illustrations, the current should flow for a short distance between the active or operating electrode and the neutral electrode longitudinally or diagonally to the body, but not transversely. The latter is particularly applicable to the thorax area, where the patient's heart is within the current's path. Unfortunately, nonobservance of these instructions in order to achieve adequate positioning of the neutral electrode is a frequent cause of burns with serious consequences. Since metal elements in the patient's body can affect the distribution of current, bone nails and screws and replacement of joints (endoprosthesis) must be taken into account. To prevent current from flowing from the active electrode to the neutral electrode via areas of skin contact where burns may develop, dry insulating cloths are to be laid between legs, arms, and the trunk and skinfolds.

During the operation, it is necessary to check whether the neutral electrode is in a correct position – especially after changing the patient's position – and whether fluid has accumulated between the skin and the electrode.

Too High Powered Electrosurgical Equipment

The selection of the type of current (modulated, unmodulated, or mixed), the power of

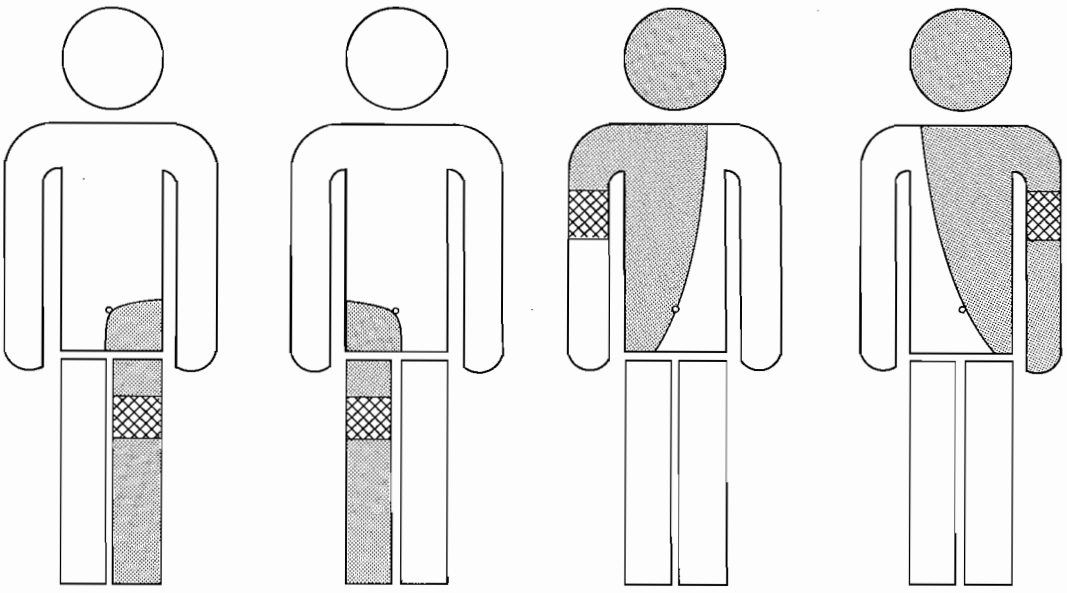

Fig. 2 Electrode adequately positioned for the respective operating field.

performance, the electrodes, and the coagulation and cutting speed is the task of an experienced surgeon. Should the power setting turn out to be no longer sufficient during the operation, it is necessary to ensure the perfect positioning of the neutral electrode, the conductivity of the wires and plug contacts, and, in particular, whether these are discontinued.

The risk of burns arises suddenly if the performance of the electrosurgical equipment is increased and a disturbance is not recognized.

Foot and Manual Switches for Electrodes

During the operation care is to be taken that conductive liquid does not penetrate the manual or foot switch, since this can close the circuit and switch on the unit. Thus, an undesired flow of high-frequency current can develop that can cause burns, particularly when the active electrode comes into contact with the patient's skin via blood-soaked covering cloths or moist sheets. Therefore the active electrode should be placed on a dry cloth where it can easily be seen.

Undesired Direct or Indirect Contact with the Ground Wire

If the patient is in contact with the grounding or electrically conductive metal elements during the use of electrosurgical equipment, high-frequency electrical current can flow in these areas with a high density. This can cause burns, particularly when the neutral electrode is not applied with its entire surface. Sources of risk include:

- Accessory rails on the sides of the operating table
- Accessories, such as headrest, anesthesia screen, armrests, and leg supports, if the padding is defective or becomes displaced so that the skin comes in contact with the metal
- Medical equipment, such as the infusion stand, instrument cart

For this reason, care is always to be taken that the patient has no contact with these metal elements and that he does not come into contact with them after a change of position.

Electrothermic lesions may also be caused by the resectoscope, which similar to high-frequency equipment is needed for coagulation and cutting. During transurethral operations, as a result of irregular spreading of a lubricant, or urethral strictures (extreme narrowing of the urethra), particularly intensive contact can occur with high-current density between the shaft of the resectoscope and the urethra, causing subsequent burns. To prevent this, only resectoscopes with an insulated and nonconductive shaft are to be used. This insulation, however, prevents current from flowing from possibly capacitively, charged metal elements inside the equipment via the patient's body to the neutral electrode. If the current travels via the eye piece of the resectoscope to the surgeon's face and body, which are connected with the ground conductor, burns can occur in the contact area (e.g., in the eye area).

A similar risk of burns occurs if electrically conductive anesthetic tubes are lying on the patient and the high-frequency current flows via the grounded anesthetic apparatus directly to the ground conductor rather than to the neutral electrode. The same applies to the grounded black (according to DIN 1340) ECG electrode if, as seen from the operative field, it is applied to the patient in front of the neutral electrode and the high-frequency current flows to the ground conductor via the ECG electrode. Due to the surface of this electrode, which in most cases is much smaller, serious burns can develop in the area of skin contact. Therefore the grounded black ECG electrode must always be connected to the neutral electrode.

The active electrode of the electrosurgical equipment must not be used near the ECG electrodes. If there is not a minimum distance of 150 mm, burns in the areas of skin contact of the ECG electrodes can occur, since due to the low resistance of the tissue lying between them, there is a strong high-frequency current flowing via coupling capacities.

Apart from the risks of burns due to direct contact with the ground conductor, just described, there are further sources of risk due to indirect contact, e.g., by bridging an existing insulation. Conductive coverings of the operating table are provided with a certain conductive resistance so that electrostatic charges can flow away via the grounded operating table. For the circuit necessary for the application of electrosurgery, an additional insulating sheet is needed between the patient and the padding lying on the operating table (e.g., antistatic dry cloths). If there is no insulating sheet available or if the padding of the operating table conducts too well – due to rubber sheets of a material that does not meet the requirements, damage in the padding, or worn padding – or if the insulating sheet becomes moist from absorption of liquid residue, such as sweat, amniotic fluid, urine, blood, saline solution or disinfectant, a current transition can occur to the grounded operating table. For the patient, this means the risk of large, deep burns.

It is important to ensure that the patient is lying on dry sheets which should not be too thin, and that liquids are completely absorbed immediately, so as not to moisten the sheet or possibly accumulate underneath the patient's body.

Small Parts of the Body

During application of high-frequency surgery, high-current densities can occur in small parts of the body, causing increased heating of tissue and thus a risk of burns. Especially when surgical instruments, such as metal clips, hooks, etc., are touched with the active electrode, this extends its range of effectiveness to the whole contact area of the skin and the surgical instrument. This can cause burns fairly rapidly. The bipolar electrosurgery technique can be required to prevent such undesired coagulation.

Undesired Current Flows due to Inductive or Capacitive Current Transitions

Whereas direct current can flow via electrical conductors only, high-frequency current can also flow through nonconductors, e.g., air. Such flows of current increase with the frequency of the high-frequency current. If wires of electrosurgery monitoring devices (pulse, temperature, etc.) are close to or above each other, induction can cause undesired current flows of considerable intensity, which are not only in a position to disturb the monitors, but can also cause burns. Therefore wires should not be looped, parallel, or close to each other. In particular, they must not come into contact with the patients.

A high-frequency circuit develops capacities (capacitor effect) against grounding, e.g., between ECG wires and their shields (coupling capacity), between high-frequency wires and the patient's body if these wires are very close to the patient, or between the patient and the operating table, the insulating sheet of the operating table being a dielectric.

Due to the low resistance in the case of very high frequencies, this can cause a high-frequency current flow to the ground conductor. According to estimations, the capacitive resistance between the patient and the grounded operating table is some hundred ohms. If a neutral electrode is wrongly placed (e.g., too far away from the operative area), its resistance can be higher, causing the high-frequency current, which follows the path of least resistance, to flow via the apparently nonconductive sheet on the operating table to the ground. The necessary protective measures are the same as those described on pp. 29 to 30.

Burns of Internal Organs

Undesired burns of internal organs due to too high current, improper use of the technique, or special anatomic circumstances constitute a further risk. The causes are the same as for skin burns, even if they occur or are recognized less frequently. High-frequency current can, for instance, travel an organ lengthwise to an area of smaller cross-section. Here, the current density increases, leading to heating of tissue, even causing burns.

Electric Heating Pads

Depending on the type and duration of an operation, the patient is at risk of hypothermia if there is no adequate thermal insulation, if the speed of air due to the room air control unit is too high or the air temperature is too low, or if the infusion solution is not warmed or if the body temperature decreases as a consequence of drugs or anesthetics (e.g., halothane) administered.

Heating pads can effectively prevent hypothermia, but, in the case of inadequate electric pads, errors or improper temperature settings, there is a risk of burns. Even if the specifications of heating pads for operating tables have not as yet been officially defined, they should nevertheless meet the following requirements:

- Limitation of the maximum heat admission
- Multiple channel temperature regulation
- Sufficient number of unbreakable temperature sensors, particularly for pads for small children

For reasons of safety, simple electric pads for home use must not be used, since they do not meet these requirements. This does not only apply to their use in the operating room but also to the warming of incubators and beds for infants and small children.

Even in apparently ideal circumstances, burns can occur. The heating pad supplies the patient with heat, which is partly stored and partly carried away by the blood circulation. Should the heat not be correctly carried away, e.g., in the case of disturbed circulation or pressure from outside being exerted on the blood vessels, the heat can accumulate, causing burns on the skin surface. These can easily be recognized as red patches and burn blisters in the surrounding contact area of the heating pad with the skin and should be analyzed. They can be prevented by a sufficient number of temperature sensors (cf. type "Thermomaquet" with up to eight sensors), which avoid local heat accumulation.

Pseudoburns

From their outward appearance pseudoburns are often difficult to distinguish from burns caused by overheating. They are not visible until after the operation and are caused by acid or pressure. They occur frequently and their cause is rarely recognized. According to American studies pseudoburns occur in both corpulent and thin patients in exposed areas, such as coccygeal region or the shoulder blades. An acute risk of necrosis arises when the outside pressure exceeds the arterial pressure.

Acid Burns Due to Disinfectants

If disinfectant residue accumulates underneath the patient and is allowed to act on the patient's skin during the operation, skin irritations can occur, with redness, formation of blisters, and even necrosis. Nevertheless, it is difficult in practice to find the real reason for this, since often enough various factors have to be taken into account – the use of electrosurgical equipment, heating pads, disturbed circulation, mechanical pressure, etc. Any of these could be responsible, and, with regard to their coincidence and frequency, there are still no reliable data. If disinfectants are used carefully, liquid residue is immediately removed and the patient is positioned on dry absorptive sheets, these accidents can be prevented.

Necroses Caused by Mechanical Action

In the case of prolonged periods of lying in an unchanged position, the patient is at risk of skin lesions. These are caused by poorly nourished tissue, since anesthetics and muscle relaxants can relax the tissue to such an extent that the arterial pressure is lower than the outer pressure of the body weight and the blood supply is disturbed. Further reasons are contusions of the tissue after changing the patient's position or application of incision or dressing foil. The consequence can be decubitus ulcer or even necrosis, especially in areas with only thin skin tissue over the bones. These include:

- Heels, sacrum, elbow, shoulder blades, and occiput when the patient is in a supine position
- Heels, sacrum, elbow and occiput when the patient is in a sitting position
- Hip, toes, and knee when the patient is in a lateral position
- Pelvis, shoulder, and head when the patient is in a prone position

If the patient is in Trendelenburg's position on the operating table, pressure increases in the lower areas.

Both overweight and underweight patients are equally affected by such skin lesions; in overweight patients the affected areas are greater, with less serious sores, whereas in underweight patients the areas are smaller with, however, more serious sores.

To prevent this, the following measures are advisable:

- Short duration of operation, since after 2 hours at least the tissue is damaged
- Replacement of older and worn padding on the operating table with new ones of sufficient thickness and softness
- Careful adaptation of the individual segments of the operating table top to the patient's body, if necessary, using additional padding
- Avoidance of skin contusions and formation of folds in the padding on the operating table when the patient's position is changed

Risks Caused by Undesired Electrical Current Flows in Combination with Electrosurgery Techniques

Undesired electrical currents can cause not only burns, but also endanger the patient in other ways. This can be direct, e.g., if undesired current flows through the patient's heart causing ventricular fibrillation, or indirect, if undesired current causes disturbances in the monitoring devices.

Pacemakers

When electrosurgical equipment is used, problems or even irreversible damage to the pacemaker must be expected. These can cause ventricular fibrillation in the patient. This risk is particularly great in the case of high-frequency currents that flow either directly across the heart in the thorax portion with the implanted pacemaker and leads, or via an introduced heart catheter, to the ground conductor. In this case the cardiologist should be consulted and the electrosurgical equipment switched off as soon as the heart rhythm changes.

Disturbances in the Monitoring Devices

Monitors for pulse, ECG, temperature, EEG, blood pressure, etc., can be disturbed by high-frequency currents and in certain circumstances even damaged. The inductive or capacitive transitions of current described on pp. 30 to 31 must also be taken into account. These devices are thus to be protected against such risks during production and should be equipped with interference filters, so that vital information can be safely transferred and evaluated even during use of the electrosurgical device.

Conclusions: Burns; Undesired Electrical Current Flows in Electrosurgery Techniques

These guidelines should shed light on the frequent uncertainties regarding the causes and risks of accidents in the operating room. At the same time, they show that cooperation with specialized engineers is necessary in view of the various technical problems, to which there are often as yet no reliable solutions. The protective measures recommended are in particular those that can be carried out within the realm of the surgical-technical staff.

Preoperative Preparation of the Patient

Preoperative preparation starts on the ward, where the patient is washed. For reasons of hygiene, showers are recommended rather than baths if the entire body is to be washed. For the same reasons, clean sheets are to be put on the patient's bed. Before the operation, jewelry, valuable objects, documents, spectacles, watches, hair clasps, dentures, etc., are to be removed and kept under lock and key on the ward. The patient's stomach, intestines and bladder should be emptied. Before transport of the patient into the operating room, the operative field is to be shaved using sterile shaving foam or disinfecting soap and disposable razors. After shaving and initial skin disinfection, the area should be covered with a sterile cloth.

After preparation on the ward, the patient is brought into the surgical department with the following documents:

Radiographs
Temperature chart
Case history
Operative permit
Anesthetic report
Accompanying documents concerning preparations and smear (cf. pp. 10 to 11"The Patients").

After his arrival in the surgical department, the patient's identity must be carefully checked to avoid confusion with another patient. His documents are also to be checked thoroughly in order to exclude the possibility of operation on the wrong side, should the operation concern one of a pair of organs.

During further preparation of the patient in the anesthesia induction room, the surgical-technical staff should cooperate closely with the anesthesiologist. In view of the importance placed on the patient's position for the anesthetic and the operation, the general advice presented on pp. 34 to 35 ("Positioning of the Patient) is followed. Here, priority is given to the guidelines for disinfection and sterile covering of the operative field in the operating room after the preanesthetic stage of anesthesia.

The area to be disinfected should be of such a size that the incision can be enlarged should this become necessary. It is advisable to begin the sterile covering at a distance of 25 cm from the incision. The disinfectant is either sprayed or rubbed onto the skin with a cotton applicator, which reinforces its effect (cf. section pp. 4 to 5 "Operations"). After an exposure time of 2 minutes, the operative field should be disinfected again. After another exposure time, disinfectant residue is carefully wiped away with sterile swabs in order to prevent skin lesions (cf. also pp. 30 to 31 "Undesired Direct or Indirect Contact with the Ground Wire" and pp. 31 to 32 "Acid Burns Due to Disinfectants"). If incision foil is used, this will then stick better. The patient's body is covered except for the operative field. The sterile cloths may also be touched at the edges, ends, or from above. If textile covering cloths are used, several layers are needed to exclude the risk of the patient's being endangered by humidity or the conveyance of microorganisms. The cloths are fixed with clips or sewn on in the case of intraoperative radioscopy. Disposable covering cloths are water resistant but permeable to air and are supplied in sterile packages. Since they do not absorb humidity, special care is to be taken when using these. Otherwise, they have a number of advantages, although their expense cannot be neglected. Gloves are to be changed after covering.

Positioning of the Patient

The anesthesiologist, the surgeon and the surgical-technical staff should work together to achieve optimum positioning of the patient for the induction of anesthesia and the operation. First, the specialists form an opinion of the patient's general condition in order to decide to what extent the patient can cope with the strain of his position on the operating table before the nursing staff actually begins the positioning of the patient. Continuous coordination and observation concerning the patient and his positioning are obviously necessary.

The patient's age, weight, constitution

(i.e., the sum of his natural characteristics and his disposition), his current state of health – heart, lung, circulation, metabolism, nervous system, muscles, prestrain on skin tissue, e.g., due to metabolic disturbance, obesity, rheumatic arthritis, cardiac and vessel insufficiencies, disturbed circulation – have a considerable influence on procedures. They must therefore be taken into account, since each position means additional strain on the patient.

The administration of anesthetics and muscle relaxants can have a strengthening influence on breathing, blood supply, and nerves. During the anesthesia, the patient does not feel any pain caused by pressure or stretching. Neither can he react to them due to the lack of protective reflexes and reduced muscle tone (from the Greek, a normal state of tension of the muscles due to the influence of nerves).

If in critical circumstances the patient is at risk of being hurt even when correctly positioned (cf. p. 32), simple changes in position, such as the following, need special care:

- Lower position of the head with the risk of obstruction of breathing and blood circulation by the pressure of abdominal organs
- High position of the upper body with the risk of ischemia (bloodlessness), especially with the head turned sideways
- Abdominal position with the risk of eye damage

The induction of the anesthesia begins in the induction room while the patient is in a supine position. The final positioning for the operation is performed in the operating room when the patient is deeply anesthetized with relaxed muscles. This keeps the strain on the patient at a minimum and makes intervention easier should problems arise during transport to the operation room. The neutral electrode (cf. pp. 27 to 29) should, if possible, be applied near the operative field on an upper arm or upper leg (burns in these areas are less serious). The electrode is to be fixed with wide straps or bands so that its entire surface is touching the skin without, however, causing pressure sores. The skin in the area of the neutral electrode must be shaved, degreased and disinfected beforehand in order to reduce the skin transition resistance. If the patient has poor blood circulation, the area should be massaged or brushed.

For insufflation anesthesia, the patient's head should be positioned anteriorly in order to extend the trachea for insertion of the tube. This can be performed with an adjustable headrest or a padded neck roll. As soon as the tube is in the correct position, the head is returned to its original position, the patient being supine.

The patient's arm intended for intravenous induction of anesthesia and infusion must lie flat with its total length on a well-padded armrest (if necessary, elongate the armrest with a padded Cramer's splint). The splint should be steplessly adjustable in all directions in order to keep the strain on the arm to a minimum and to suit the anesthesiologist. Even pressure caused by the edges of the padding on the armrest or the operating table can cause damage, e.g., paralysis of the nervus radialis or ulnaris, especially when muscle relaxants are administered. It is equally dangerous to overstretch the arm (paralysis of plexus). This applies to an abduction over an angle of more than 90° as well as to a lowering of the arm. In rare cases there is a risk of overstretching the elbow. The best way is to place the arm in a supine position (palm upward), slightly angled and raised into a position just slightly higher than the horizontal level. The other arm can be positioned in various ways according to the kind of operation, e.g., if the patient is in supine position, laterally to the body or elevated on the anesthesia screen. If the arm is placed laterally to the body it should be laid on a suitable padding (length 40 cm) and secured with a well-padded hand strap in order to prevent pressure sores. If the arm is elevated, a suitable anesthesia screen should be used in the form of an angled splint with one open side with a horizontal rail for the fixation of two padded hand straps or a padded arm board. This secures the arm firmly and

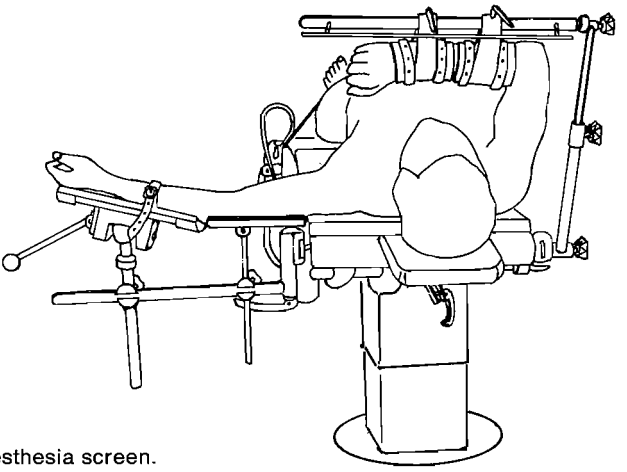

Fig. 3 Arm raised and secured on the anesthesia screen.

prevents pressure sores. In this position care is to be taken that the patient's shoulder is not elevated and that his arm is not overstretched (cf. Fig. 3). Generally, care is always to be taken that no one leans against the patient's arm or supports himself on it.

The same care is to be taken with regard to the patient's legs, to avoid pressure on the leg nerves or veins. The experienced surgeon will certainly not position the patient with crossed legs, although the semicircular pad that is positioned with the best of intention beneath the hollow of the knees can surprisingly cause pressure sores, especially when leg straps are applied above the patella. Leg plates, which are themselves tiltable and which are often found on modern operating tables, can be well adapted to the legs so that the surface pressure is distributed over a sufficient area. At the same time, it is possible to obtain a suitable operating position. If leg holders are used for gynecologic or urologic operations, there is an increased risk of pressure sores and strain, which can be caused, for example, by overstretching the legs, which are relaxed during anesthesia, by the pressure due to improperly adjusted leg holders and leg belts, by the edges of the leg plate padding, or the pressure of the legs against the leg holder bars.

The positioning of the trunk requires the same care and attention as that of the arms and legs. More detailed information is given on p. 32 "Necroses Caused by Mechanical Actions", making further explanation here superfluous.

When the patient has reached the stage of deep anesthetization, he is transported to the operating room. Positioning is carried out at the operating table with relaxed muscles. Then the operative field is disinfected and the patient covered with sterile cloths.

2 Abdominal Surgery

Appendectomy

Figure 4 shows the patient in a supine position. The surface of the operating table is slightly flexed in the area of the hypogastric region so that the operative field is lifted and thus taut. The tension of the operative field can be increased by slightly lowering the legs. If the patient is corpulent, the surface is slightly tilted on the surgeon's instruction.

The patient's legs are to be strapped about 6 inches above the patella, whereby the wide padded straps must not be tied too tightly. The foldable leg plates or, in the case of anatomically different legs, pads serve as a support for the knee joints. These pads are also to be laid between the patient's legs and under his heels in order to avoid burns or pressure sores. The neutral electrode is applied on the outer side of the extremity near the operative area and fixed to it so that it is in good contact with its entire surface without, however, causing any pressure sores (cf. Fig. 2 and pp. 34 to 35).

The patient's arm intended for the infusion must lie flat with its full length on the well-padded armrest. Even the pressure caused by the edges of the armrest and operating table can be harmful, e. g., causing paralysis of the nervus radialis or of the nervus ulnaris, particularly when muscle relaxants are administered. Should the armrest be too short, a padded Cramer's splint may be used to bridge the gap. It is equally dangerous to overstretch the arm (paralysis of the plexus), which applies to an abduction of more than 90° as well as to the lowering of the arm. The risk of overstretching the bend of the elbow is less likely. It is best to keep the arm in a supine position (palm upward), slightly bent and raised into a position just slightly higher than the horizontal level.

The other arm is placed laterally to the body on a padded cushion of about 40 cm length and 20 cm width and secured with a padded hand strap in order to prevent blood congestion, pressure sores or the hand's slipping.

The patient's head is to be supported at the neck with a flat crescent-shaped pad if the headrest or plate is not used in the case of small patients.

To close the wound, the flexed surface is returned to its original position and the tightness of the operative area is reduced, which is made easier by lifting the leg plates.

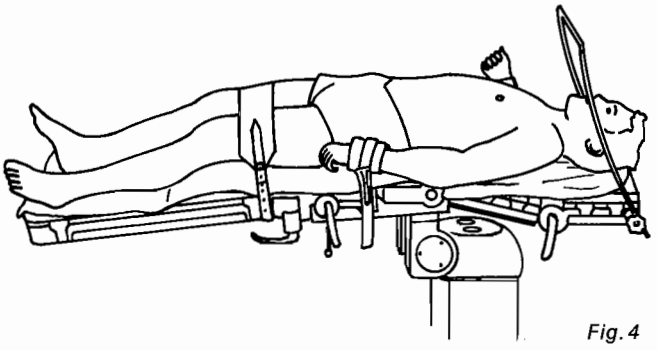

Fig. 4 Appendectomy.

Care is to be taken that this is not exaggerated, since it would make it more difficult to close the wound due to the possible skinfolds.

Herniotomy

The positioning of the patient is similar to that for an appendectomy, except that, in this case, the pelvic area is flexed.

Gallbladder Operations

The prepared, anesthetized patient is laid on the operating table in a supine position, making sure that the flexed and thus most elevated point of the surface lies beneath the gallbladder, i.e., level with the upper abdominal area. To flex the surface, the dorsal and pelvic plates are tilted until the operative area is lifted, and thus taut; the separate pelvic plates, adjusted to form a hollow, are a more suitable fit for the patient's buttocks. The other segments of the surface, the foldable leg plates and the upper section of the dorsal plate, can likewise be adjusted to suit the anatomic characteristics. The lowered, inclined position of the patient's head during this procedure can be compensated for by tilting the total surface toward the foot end. Depending on the patient's size, his head is positioned on the upper section of the dorsal plate or on an additionally mounted head plate. The slight inclination of the surface to the right is only to be increased on the surgeon's instruction, should this be necessary in order to obtain a better radiographic picture of the bile ducts. To take this picture, the film cassette and holder can be mounted either beneath the radiotranslucent surface or directly onto the x-ray image intensifier with a special cassette holder. After completion of the radiographic study, the surface, which was previously inclined to the right, is returned to its original position to continue the operation (cf. Fig. 5, 6).

The patient's legs are to be strapped

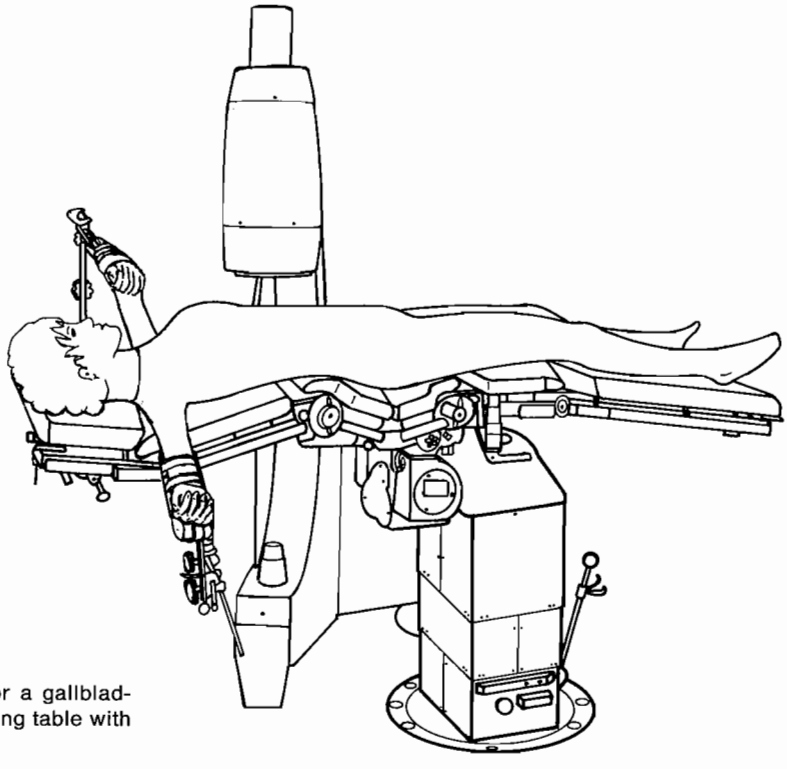

Fig. 5 Patient's position for a gallbladder operation on an operating table with an x-ray image intensifier.

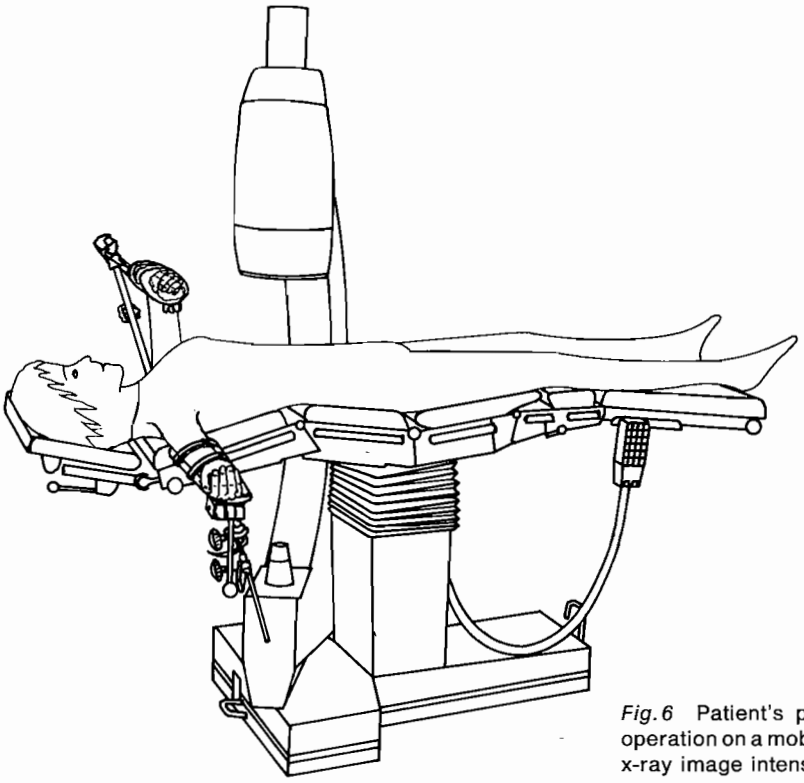

Fig. 6 Patient's position for a gallbladder operation on a mobile operating table with an x-ray image intensifier.

about 6 inches above the patella, using wide padded straps, which must not be tied too tightly. The foldable leg plates or, in the case of anatomically different legs, pads serve as a support for the knee joints. These pads are also to be laid between the patient's legs and under his heels in order to avoid burns or pressure sores. The neutral electrode is applied on the outer side of the extremity near the operative area and fixed to it so that it is in good contact with its entire surface without, however, causing pressure sores (cf. Fig. 2 and pp. 34 to 35).

The patient's arm intended for the infusion must lie flat with its full length on the well-padded armrest. Even the pressure caused by the edges of the armrest and operating table can be harmful, e. g., causing a paralysis of the nervus radialis or of the nervus ulnaris, particularly when muscle relaxants are administered. Should the armrest be too short, a padded Cramer's splint may be used to bridge the gap. It is equally dangerous to overstretch the arm (paralysis of the plexus), which applies to an abduction of more than 90° as well as to the lowering of the arm. The risk of overstretching the bend of the elbow is less likely. It is best to keep the arm in a supine position (palm upward), slightly bent and raised into a position just slightly higher than the horizontal level. The other arm is raised on an appropriate anesthesia screen – in the form of an angled splint that is open on one side with a horizontal splint to hold two padded hand straps or a padded arm board – in order to fasten the arm without running the risk of pressure sores. It is important that the patient's shoulder is not in a raised position and that his arm is not overstretched (cf. Fig. 3).

To close the wound, the flexed surface of the table is returned to its original position and the dorsal and pelvic plates lifted so that the operative field becomes less tight.

The total surface can be lowered at the

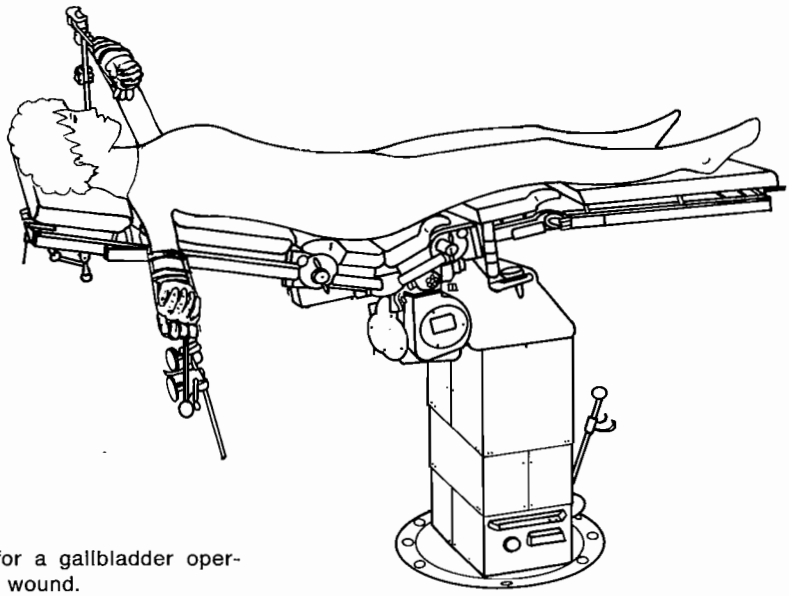

Fig. 7 Patient's position for a gallbladder operation for the closure of the wound.

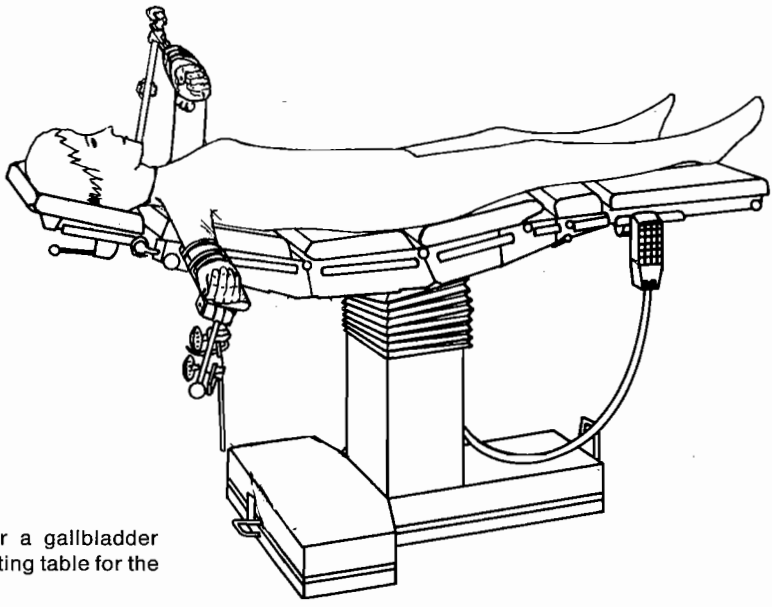

Fig. 8 Patient's position for a gallbladder operation on a mobile operating table for the closure of the wound.

head end in order to compensate for the previously lowered, inclined position of the feet (cf. Fig. 7, 8).

Gastric Resections

The prepared, anesthetized patient is laid on the operating table in the normal supine position. By slightly lowering the dorsal plate, the operative field is lifted, and thus taut, in the epigastric region. Depending on the patient's size, his head is positioned on the sightly elevated upper section of the dorsal plate or on an additionally mounted head plate (cf. Fig. 9).

The patient's legs are to be strapped

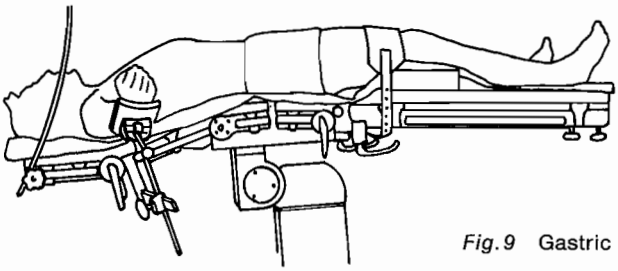

Fig. 9 Gastric resection.

about 6 inches above the patella using wide padded straps, which must not be tied too tightly. The foldable leg plates or, in the case of anatomically different legs, pads serve as a support for the knee joints. These pads are also to be laid between the patient's legs and under his heels in order to avoid burns or pressure sores. The neutral electrode is applied on the outer side of the extremity near the operative field and fixed to it so that it is in good contact with its entire surface without, however, causing pressure sores (cf. Fig. 2 and pp. 34 to 35).

The patient's arm intended for the infusion must lie flat with its full length on the well-padded armrest. Even the pressure caused by the edges of the armrest and operating table can be harmful, e. g., causing a paralysis of the nervus radialis or of the nervus ulnaris, particularly when muscle relaxants are administered. Should the armrest be too short, a padded Cramer's splint may be used to bridge the gap. It is also dangerous to overstretch the arm (paralysis of the plexus), which applies to an abduction of more than 90° as well as to the lowering of the arm. The risk of overstretching the bend of the elbow is less likely. It is best to keep the arm in a supine position (palm upward), slightly bent and raised into a position just slightly higher than the horizontal level. The other arm is placed laterally to the body on a padded cushion of about 40 cm length and 20 cm width and strapped with a padded hand strap in order to prevent blood congestion, pressure sores, or the hand's slipping. To close the wound unhindered, the dorsal plate is elevated to such an extent that the tightness of the operative field is reduced without, however, forming skinfolds.

Spleen Operations

The prepared, anesthetized patient is placed in the dorsal position on the operating table so that the left surface of the body in the thorax region is a few centimeters above the supporting surface. Since the patient is lying relaxed on the edge of the padding, thus increasing the risk of pressure sores, a flat pad must be placed between the thorax and the surface; the pad also improves the patient's position for the operation. As shown in Figure 10, the slightly S-shaped surface fits the patient's figure well and lifts the operative field, making it taut. The surface is tilted to the right on the surgeon's instruction (cf. Fig. 10).

Depending on the patient's size, his head is positioned on the slightly elevated upper section of the dorsal plate or on an additionally mounted head plate. The patient's legs are to be strapped about 6 inches above the patella using wide padded straps, which must not be tied too tightly. The foldable leg plates or, in the case of anatomically different legs, pads serve as a support for the knee joints. These pads are also to be laid between the patient's legs and under his heels in order to avoid burns or pressure sores. The neutral electrode is applied on the outer side of the extremity near the operative field and fixed to it so that it is in good contact with its entire surface without, however, causing pressure sores (cf. Fig. 2 and pp. 34 to 35).

The patient's arm intended for the infusion must lie flat with its full length on the well-padded armrest. Even the pressure caused by the edges of the armrest and operating table can be harmful (e. g., a paralysis of the nervus radialis or of the nervus ulnaris) particularly when muscle

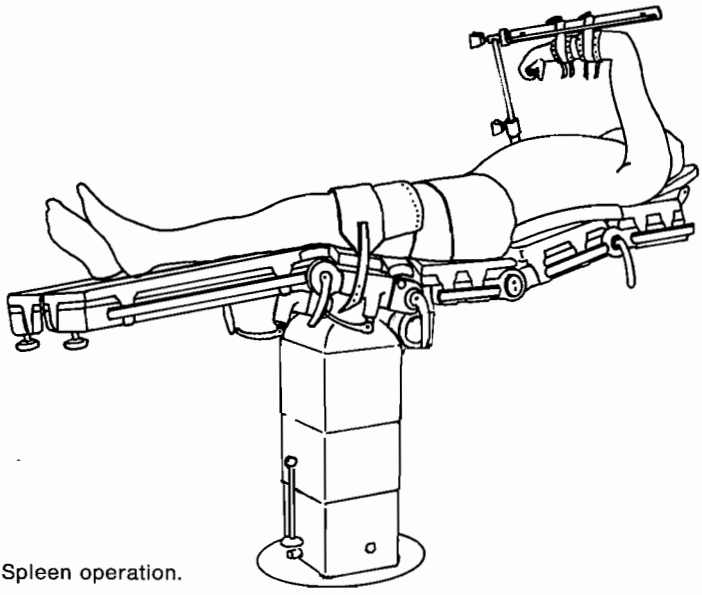

Fig. 10 Spleen operation.

relaxants are administered. Should the armrest be too short, a padded Cramer's splint may be used to bridge the gap. It is also dangerous to overstretch the arm (paralysis of the plexus), which applies to an abduction of more than 90° as well as for the lowering of the arm. The risk of overstretching the bend of the elbow is less likely. It is best to keep the arm in a supine position (palm upward), slightly bent and raised into a position just slightly higher than the horizontal level.

The other arm is raised on an appropriate anesthesia screen, – in the form of an angled splint that is open on one side with a horizontal splint to hold two padded hand straps or a padded arm board – in order to fasten the arm without the risk of pressure sores. It is important that the patient's shoulder is not in a raised position and that his arm is not overstretched (cf. Fig. 3).

To close the wound unhindered, the dorsal plate is elevated to such an extent that the tightness of the operative field is reduced without, however, forming skinfolds.

Kidney Operations

Prior to moving the prepared, anesthetized patient from the supine to the lateral position, his documents (radiographs, history) must be checked in order to avoid confusion about which kidney is being operated on. When this has been done, and only then, the patient is positioned with his back toward the surgeon near the edge of the surface on his sound side, so that the most elevated part of the surface is flexed between the costal arch and the iliac crest. By lowering the dorsal and leg plates on the surgeon's instruction, the operative field can be flexed and is thus taut. In this position the thorax and pelvic regions must always be in contact with the surface. For patients with a broad pelvis, pelvic plates that are transversely split and adjustable can be used.

The lateral supports mounted at both sides of the thorax protect the patient due to the various possibilities of adjustment. This keeps the strain on the patient at a minimum. Pads between the body and the supports are only rarely needed. In practice the lateral position is frequently achieved by slightly turning the thorax and pelvis toward each other, whereby only two lateral supports are necessary. These are diagonally arranged at the front of the thorax and at the buttocks.

By elevating the upper part of the dorsal plate, a sheath is formed into which the arm

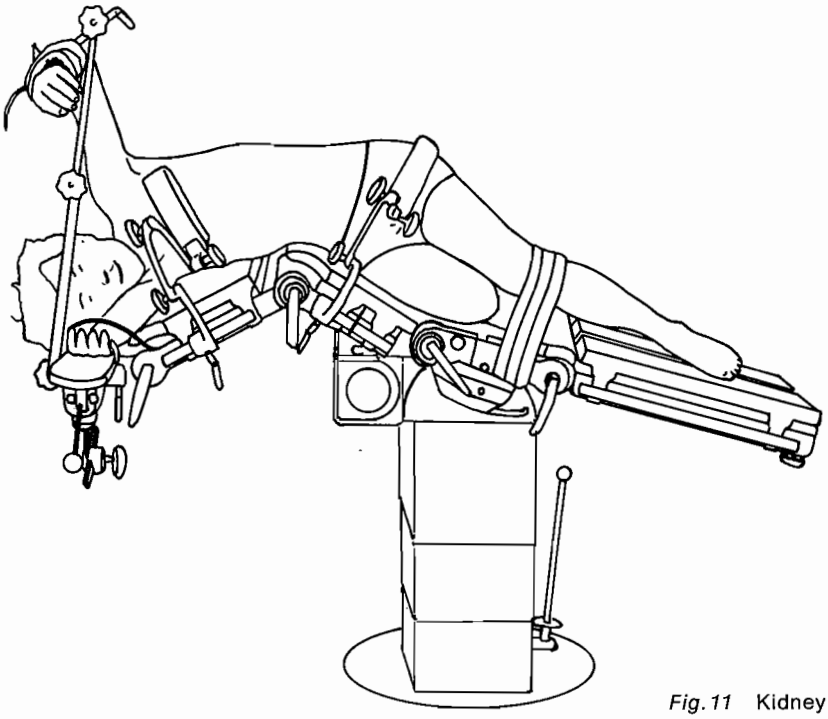

Fig. 11 Kidney operation.

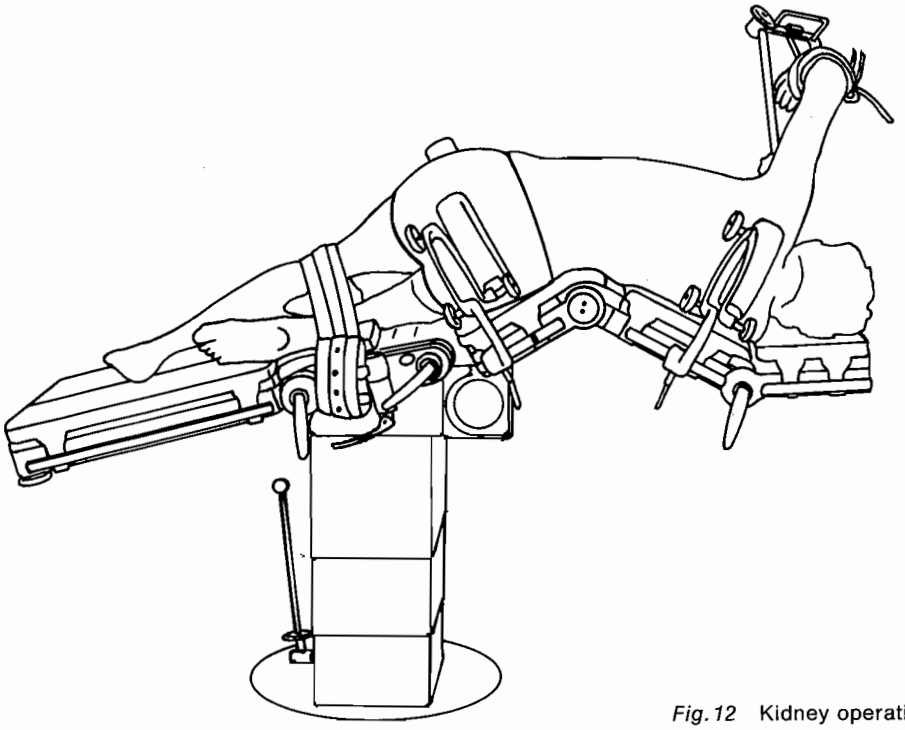

Fig. 12 Kidney operation.

intended for the infusion can be placed. It is then free of pressure and is easily accessible. Together with the arm support, this forms a continuous padded surface for the entire arm. Even the pressure caused by the edges of the armrest and of the operating table can be harmful, e.g., causing a paralysis of the nervus radialis or of the nervus ulnaris, particularly when muscle relaxants are administered. The patient's head is laterally turned on the upper section of the dorsal plate or on an additionally mounted adjustable head plate. It is advisable to raise the other arm on an appropriate anesthesia screen – in the form of an angled splint that is open on one side, with a horizontal splint to hold two padded hand straps or a padded arm board – in order to fasten the arm without, however, abducting the arm by more than 90° or stretching it behind the patient's back. The neutral electrode is applied on the outer side of the extremity near the operative field and fixed to it so that it is in good contact with its entire surface without, however, causing pressure sores (cf. Fig. 2 and pp. 34 to 35). The bottom leg is bent and drawn up to the body on the table surface. The top leg is extended. A pad is placed between the two legs before they are fastened with a wide strap. The lower section of the leg plates, which are themselves tiltable can be adjusted to correct the patient's position.

Figure 13 shows the positioning of the patient for a kidney operation on the operating table with an x-ray image amplifier.

Inclination of the entire operating table, which can arise during positioning for the operation, can be compensated for by tilting the foot or the head end. To close the wound, the flexed surface of the table is returned to its original position and the dorsal and pelvic plates lifted so that the operative field becomes less tight.

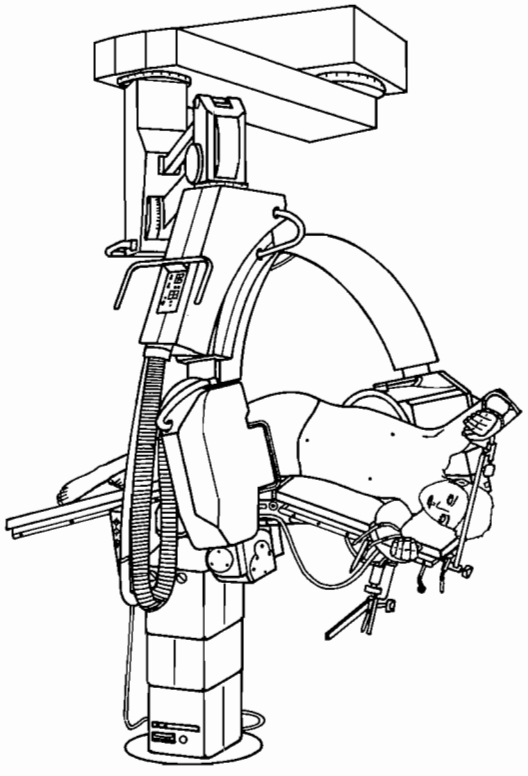

Fig. 13 Kidney operation with x-ray image amplifier mounted on ceiling holder.

Rectal Operation

For this operation three methods of positioning are possible:

Patient in dorsal position with elevated legs (Quenu)

Patient in dorsal position with change to the prone position (Hollenbach) or vice versa (K. H. Bauer)

Patient in lateral position with drawn up thighs

Patient in Supine Position with Elevated Legs (Quenu)

The prepared, anesthetized patient is placed in a supine position on the operating table so that the coccyx is on the very edge of the surface. The legs, spread out to the sides, are positioned slightly bent with the lower legs on Goepel leg holders instead of leg plates. The sheath of the leg holders must support the patient, with the bed beneath the knee joints so that pressure sores cannot develop. The lower legs are secured with wide straps. By slightly lowering the leg holders, the operative field becomes taut. During the

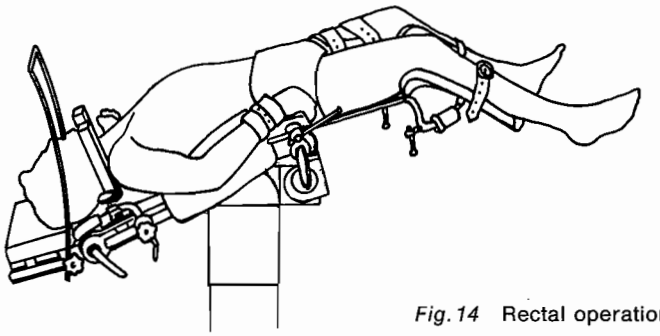

Fig. 14 Rectal operation.

operation, the entire surface is lowered at the head end on the surgeon's instruction (Fig. 14) so that the movable parts of the internal organs are displaced to the epigastric area. The lowered position of the head (Trendelenburg) is no longer necessary.

The shoulder supports, which are mounted before the operation, should prevent the patient's slipping, in particular during the second part of the operation. Since bent shoulder supports can cause pressure sores, due to their inadaptability to the different sizes of the patients, straight, broad, well-padded shoulder supports should be used only.

The patient's arm intended for the infusion must lie flat with its full length on the well-padded armrest. Even the pressure caused by the edges of the armrest and operating table can be harmful, e. g., causing a paralysis of the nervus radialis or of the nervus ulnaris, particularly when muscle relaxants are administered. Should the armrest be too short, a padded Cramer's splint may be used to bridge the gap. It is equally dangerous to overstretch the arm (paralysis of the plexus), which applies to an abduction of more than 90° as well as to the lowering of the arm. The risk of overstretching the bend of the elbow is less likely. It is best to keep the arm in a supine position (palm upward), slightly bent and raised into a position just slightly higher than the horizontal level. The other arm is placed laterally to the body on a padded cushion of about 40 cm length and 20 cm width and secured with a padded hand strap in order to prevent blood congestion, pressure sores, or the hand's slipping. It is advisable to raise the other arm on an appropriate anesthesia screen – in the form of an angled splint, which is open on one side with a horizontal splint to hold two padded hand straps or a padded arm board – in order to fasten the arm and to prevent possible pressure sores. Care is to be taken that neither the patient's shoulder is lifted nor the arm overstretched (cf. Fig. 3).

The neutral electrode is applied on the outer side of the extremity near the operat-

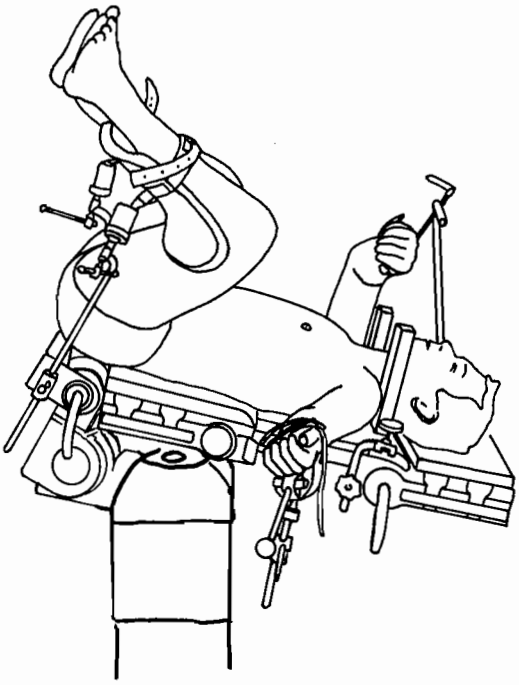

Fig. 15 Operation on the rectum with the patient in supine position with elevated legs.

ing field and fixed to it so that it is in good contact with its entire surface without, however, causing pressure sores (cf. Fig. 2 and pp. 34 to 35).

During the second part of the operation, the patient's legs – still astride – are raised extremely close to the body, for the sacral intervention. The pelvis should be slightly elevated. In order to achieve a suitably free pelvic position, the buttocks are pushed slightly beyond the edge of the surface (cf. Fig. 15). Possible changes in the patient's position for the closure of the wound are carried out on the surgeon's instruction. After the operation, the patient should be covered with warmed sheets and moved into a preheated bed in order to prevent hypothermia.

Patient in Supine Position with Change to the Prone Position (Hollenbach) or Vice Versa (K. H. Bauer)

As already described on pp. 43 to 45, the patient is first placed in a supine position with his legs apart and slightly bent. Then the legs are raised toward the body, with a slightly elevated pelvis.

For the change of the patient's position to the prone position, the patient is rolled over the arm, which is lying beside the body. During this procedure, the arm intended for infusion is to be moved, still bent, through the air. The patient is now lying with the iliac crest on the padded pelvic section of the table and is kneeling in the lower leg supports of the leg plates or in the sheaths of the leg holders (Figs. 16, 17). The plates of the pelvic section of the table are lowered to make the abdomen free, where the movable parts of the organs (intestinal loops) are displaced; the surgeon thus has a better view and easier access to the deeper section of the small pelvis. Figure 18 shows another kind of free abdomen using a rectal unit instead of leg plates.

The patient's head is on its side on the surface, and the arms are spread – the forearm at an angle of about 120° to the upper arms – on the arm supports. In this position, too, the arms must lie flat and not be overstretched in order to prevent para-

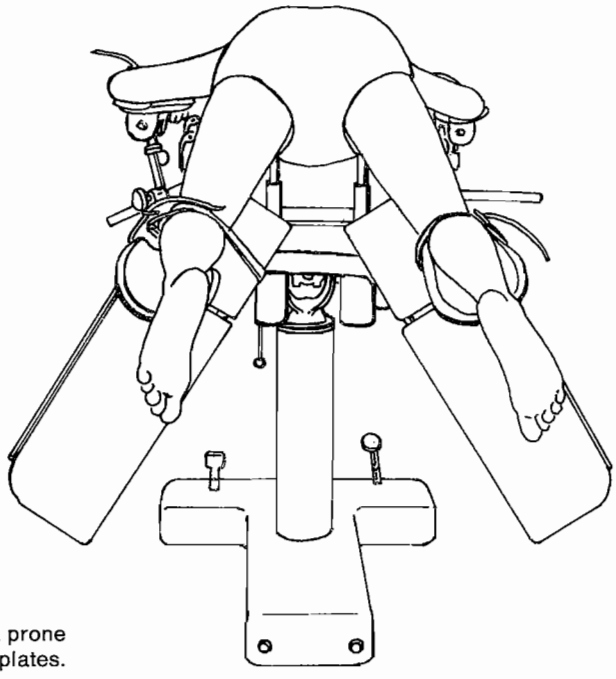

Fig. 16 Rectal operation. The patient is in a prone position, with lower leg supports on the leg plates.

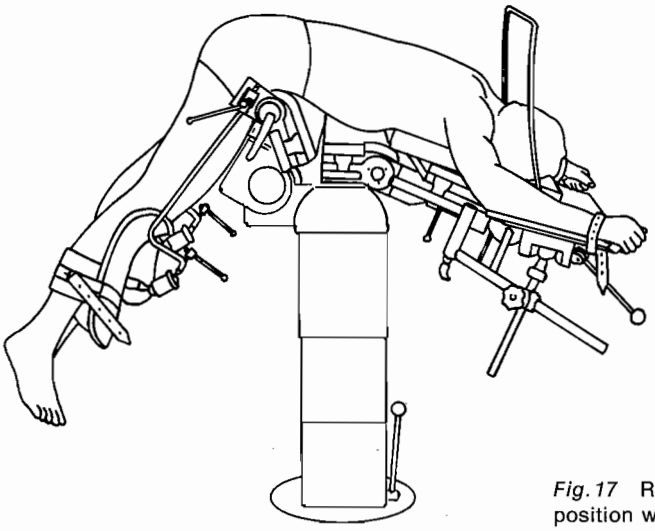

Fig. 17 Rectal operation. The patient is in a prone position with leg supports.

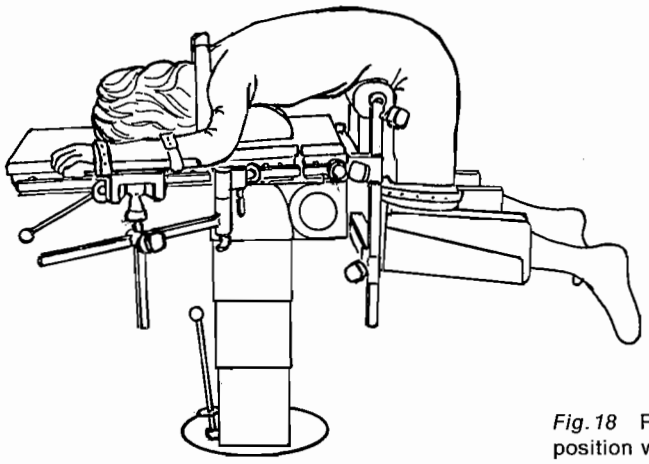

Fig. 18 Rectal operation. The patient is in a prone position with rectal device.

lyses of ulnaris, radialis, and plexus. On the surgeon's instruction, the entire surface can be inclined toward the head end. After the operation, the patient is turned back to the supine position, covered with warmed sheets, and quickly transferred into a preheated bed.

Patient in Lateral Position with Drawn Up Thighs

As already described on pp. 43 to 45, the patient is in a supine position for the first part of the operation. During the second part, the patient is turned onto his side so that he is lying with his back near the edge of the surface. To achieve better access, the leg plate near the buttocks is removed. The long section of the other leg plate, which can be itself tilted, is folded down. The legs are drawn up extremely close to the body on the surface and the short section of the leg plate (Fig. 19). Pads should be placed between the legs.

An adjustable lateral support mounted at the patient's back (Fig. 20) helps support him without putting too much strain on him.

The patient's arm intended for the infu-

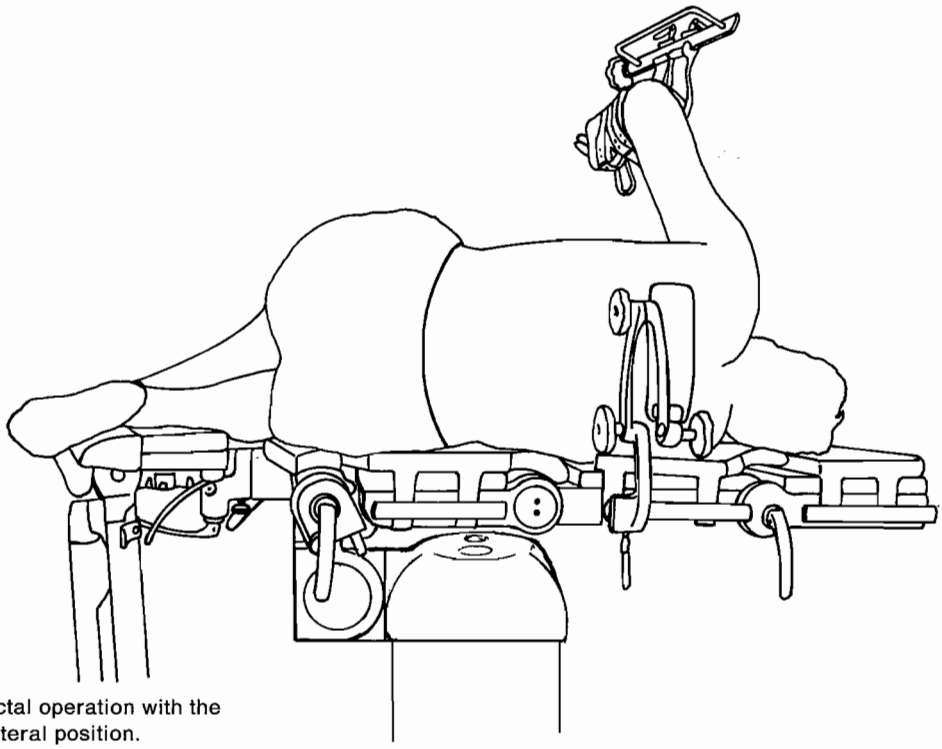

Fig. 19 Rectal operation with the patient in lateral position.

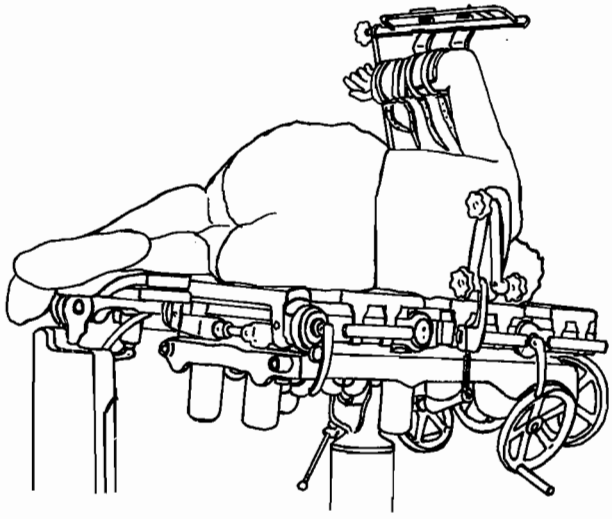

Fig. 20 Rectal operation with the patient in lateral position on a mobile operating table.

sion must lie flat with its full length on the well-padded armrest or additionally mounted arm support. There should be no pressure on the arm, since even the pressure caused by the edges of the armrest and operating table can be harmful, e.g., causing a paralysis of the nervus radialis or of the nervus ulnaris, particularly when muscle relaxants are administered. The other arm, which is raised on an anesthesia screen as

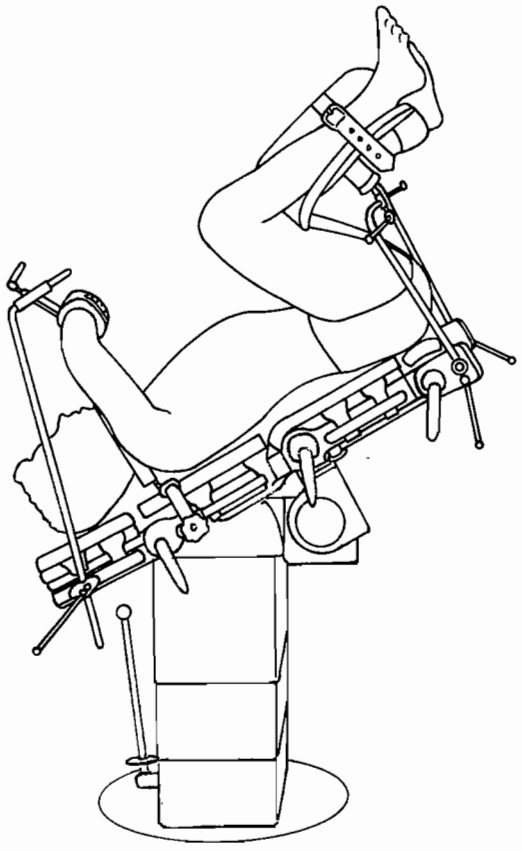

Fig. 21 Hemorrhoidectomy.

described on pp. 43 to 45, must neither be abducted by more than 90° nor overstretched behind the patient's back. After the operation, the same procedure is to be performed as described on pp. 43 to 46.

Hemorrhoidectomy Gynecologic Operation: Vaginal Operation

The prepared, anesthetized patient is placed in a supine position on the operating table so that the buttocks are slightly over the edge of the surface. The widely spread legs are elevated and drawn up extremely close to the body, with the lower legs lying in the leg-supporting sheaths and secured with wide straps. The legs should be free from pressure. The neutral electrode is applied on the outer side of the extremity near the operative field and fixed to it so that it is in good contact with its entire surface without, however, causing pressure sores (cf. Fig. 2 and pp. 34 to 35).

The patient's arm intended for the infusion must lie flat with its full length on the well-padded armrest. Even the pressure caused by the edges of the armrest and

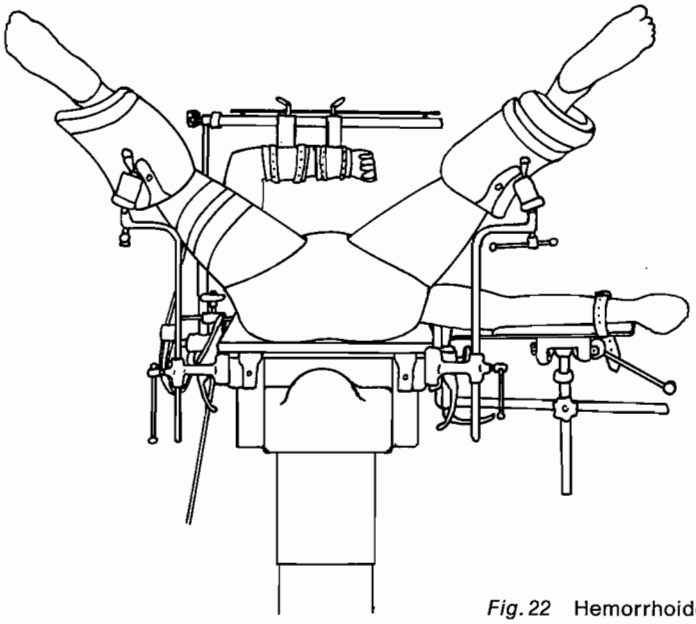

Fig. 22 Hemorrhoidectomy, or gynecologic operation.

operating table can be harmful, e.g., causing a paralysis of the nervus radialis or of the nervus ulnaris, particularly when muscle relaxants are administered. Should the armrest be too short, a padded Cramer's splint may be used to bridge the gap. It is equally dangerous to overstretch the arm (paralysis of the plexus), which applies to an abduction of more than 90° as well as to the lowering of the arm. The risk of overstretching the bend of the elbow is less likely. It is best to keep the arm in a supine position (palm upward), slightly bent and raised into a position just slightly higher than the horizontal level. It is advisable to raise the other arm on an appropriate anesthesia screen – in the form of an angled splint that is open on one side with a horizontal splint to hold two padded hand straps or a padded arm board – in order to fasten the arm. Care is to be taken, however, that neither the patient's shoulder is elevated nor the arm overstretched (cf. Fig. 3).

The shoulder supports, which are mounted before the operation, should prevent the patient's slipping, in particular during the second part of the operation. Since bent shoulder supports can cause pressure sores due to their inadaptability to the different sizes of the patients, straight, broad, well-padded shoulder supports should be used only.

At the beginning of the operation, the surface is inclined toward the head end. Other changes in the patient's position (e.g., for closure of the wound) are carried out on the surgeon's instruction.

For a gynecologic operation (Fig. 23) the elevated legs are not so widely spread and are bent toward the body. Special gynecologic operating tables or table tops that have a folding pelvic plate render possible vaginal and abdominal operations in one process without requiring a change of the patient's position.

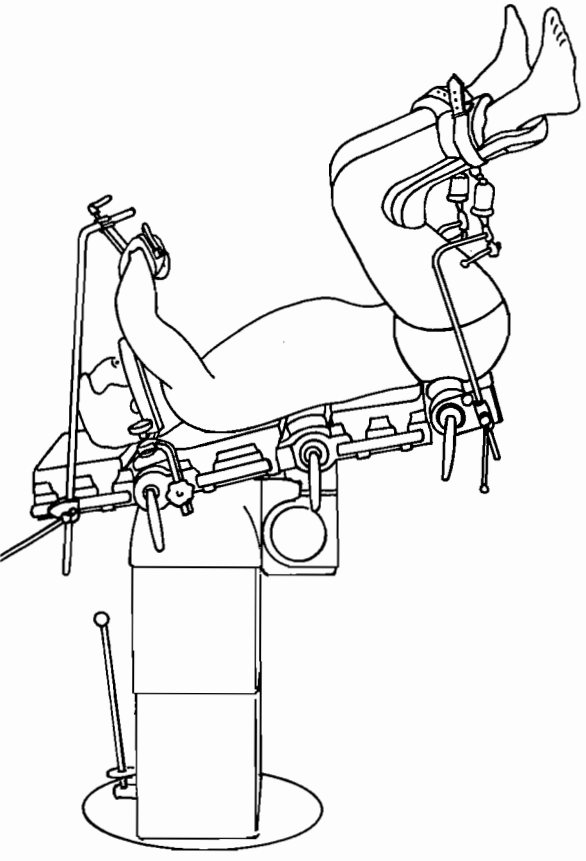

Fig. 23 Gynecologic operation.

Vesical Operations (According to Freyer) – Prostatectomy (According to Millin) Gynecologic Operation: Abdominal Operations

The prepared, anesthetized patient is placed in a supine position on the operating table so that the coccyx is on the very edge of the surface. The legs, spread out to the sides, are positioned slightly bent with the lower leg on the Goepel leg holders instead of leg plates. The sheaths of the leg holders must support the patient without causing any pressure, especially in the bend. The lower legs are secured with wide straps. A slight inclination of the entire supporting surface and a simultaneous lowering of the leg holders raise the operative field, which is then tightened. During the operation, the entire surface is inclined toward the head end on the surgeon's instruction

(Trendelenburg's position), so that the movable parts of the internal organs are displaced to the epigastric region (Fig. 24). The shoulder supports, which are mounted before the operation, should prevent the patient's slipping, in particular during the second part of the operation. Since bent shoulder supports can in most cases cause pressure sores due to their inadaptability to the different figures of the patients, straight, broad, well-padded shoulder supports should be used only.

The neutral electrode is applied on the outer side of the extremity near the operative field and fixed to it so that it is in good contact with its entire surface without, however, causing pressure sores (cf. Fig. 2 and pp. 34 to 35).

The patient's arm intended for the infusion must lie flat with its full length on the well-padded armrest. Even the pressure caused by the edges of the armrest and of the operating table can be harmful, e. g., causing a paralysis of the nervus radialis or of the nervus ulnaris, particularly when muscle relaxants are administered. Should the armrest be too short, a padded Cramer's splint may be used to bridge the gap.

It is equally dangerous to overstretch the arm (paralysis of the plexus), which applies to an abduction of more than 90° as well as to the lowering of the arm. The risk of overstretching the bend of the elbow is less likely. It is best to keep the arm in a supine position (palm upward), slightly bent and raised into a position just slightly higher than the horizontal level. It is advisable to raise the other arm on an appropriate anesthesia screen – in the form of an angled splint that is open on one side with a horizontal splint to hold two padded hand straps or a padded arm board – in order to fasten the arm. Care is to be taken, however, that neither the patient's shoulder is elevated nor his arm overstretched (cf. Fig. 3). For the closure of the wound, Trendelenburg's position is no longer necessary and the legs can be raised until the tightness of the operative field is reduced.

Transurethral Operations

Apart from standard operating tables, special operating tables are being used increasingly for urologic transurethral operations. These tables are equipped with electromotors that allow a longitudinal shifting of the table for radioscopy. Also, they are equipped with a tiltable, removable funnel with a tissue sieve, splash protection and drainage tube as well as Goepel leg holders, wedge-shaped dorsal pads and an adjustable dorsal plate. Since this operation is similar to the gynecologic operation (cf. pp. 49 to 50

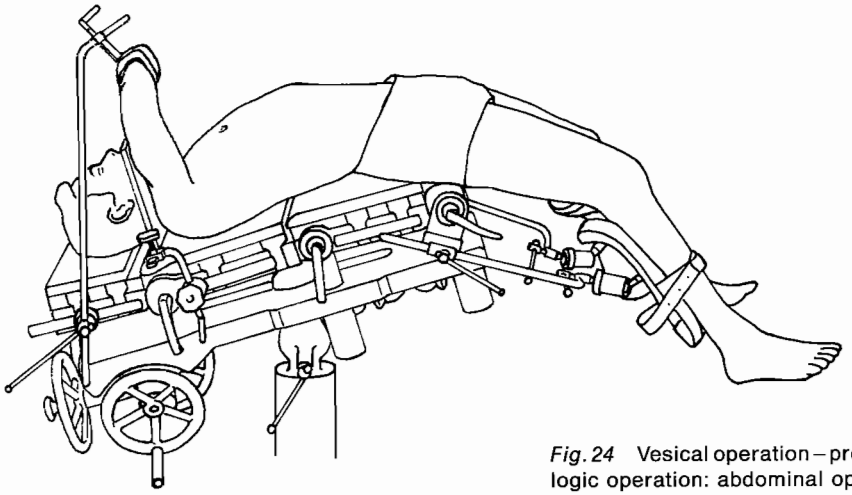

Fig. 24 Vesical operation – prostatectomy; gynecologic operation: abdominal operation.

and Fig. 23), further description is superfluous.

Percutaneous Renal Stone Surgery (Nephrolitholapaxy) with the Patient in Prone Position

To render radioscopy possible in the renal and vesical region, including the renal duct, it is advisable to use a surface that can be moved longitudinally on the table column (cf. type Maquet) which, apart from this, is suitable for urologic operations with the patient in supine position (endovesical and transurethral operations).

The prepared, anesthetized patient is laid in a prone position on the operating table so that the operative field is easily accessible for the surgeon and for work with the x-ray image amplifier. The pressure on the abdominal region can be reduced by placing flat pads between the patient and the supporting surface. These should be on a level with the sternum and the iliac crest on the side to be operated on.

The patient's head is turned to the side on the head plate of the operating table. His arms are spread – the forearms bent with an obtuse angle of 120° toward the upper arm – and laid on the arm supports that are mounted on the operating table. The arms must lie flat on this support and should not be overstretched in order to prevent paralyses of ulnaris, radialis, and plexus. The neutral electrode is applied on the outer side of the extremity near the operative field and fixed to it so that it is in good contact with its entire surface without, however, causing pressure sores. The patient's legs must also lie flat over their total surface, without being exposed to pressure. The lower legs are secured with wide straps, and the instep is supported by a crescent-shaped pad. Other changes in the patient's position or adjustments in the position of the surface (e.g., tilting, inclination, and longitudinal shifting) are performed on the surgeon's instruction.

3 Throat Surgery

Goiter Operations

Due to the fact that the blood circulation of the thyroid, which is rich in blood vessels, must be reduced, the following positioning is necessary for the operation. Ganglionic blockers should be used. Care must be taken that the patient's throat region is the most elevated region of the patient's body on the operating table.

Goiter Operations with the Patient in Supine Position

As can be seen in Figure 25, the S-shaped surface fits the patient's figure well. This is achieved using flexible dorsal, pelvic and leg plates.

The prepared, anesthetized patient is placed in a supine position on the operating table so that his shoulders are level with the edges of the surface. The upper section of the dorsal plate is lifted and the head leaned back against the headrest, to such an extent that the operative field is elevated. The neutral electrode is applied on the outer side of the extremity near the operative field and fixed to it so that it is in good contact with its entire surface without, however, causing pressure sores (cf. Fig. 2 and pp. 34 to 35). The patient's arm intended for the infusion must lie flat with its full length on the well-padded armrest. Even the pressure caused by the edges of the armrest and operating table can be harmful, e. g., causing paralysis of the nervus radialis or of the nervus ulnaris, particularly when muscle relaxants are administered. Should the armrest be too short, a padded Cramer's splint may be used to bridge the gap.

It is equally dangerous to overstretch the arm (paralysis of the plexus), which applies to an abduction of more than 90° as well as to the lowering of the arm. The risk of overstretching the bend of the elbow is less likely. It is best to keep the arm in a supine position (palm upward), slightly bent and raised into a position just slightly higher than the horizontal level.

The other arm is placed alongside the body on a padded cushion of about 40 cm length and 20 cm width and secured with a padded hand strap in order to prevent blood congestion, pressure sores or the hand's slipping.

The patient's legs are to be fastened about 6 inches above the patella using wide

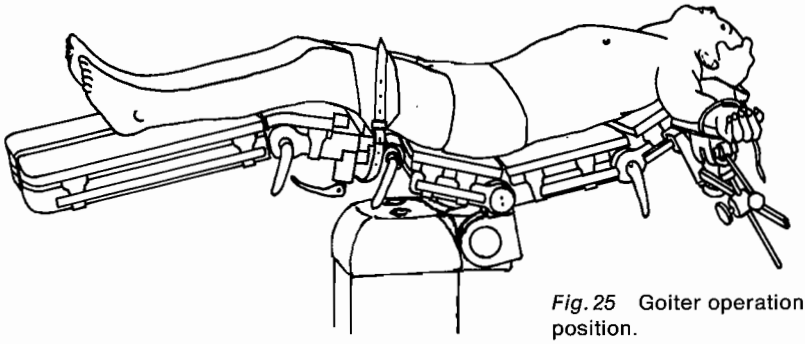

Fig. 25 Goiter operation with the patient in supine position.

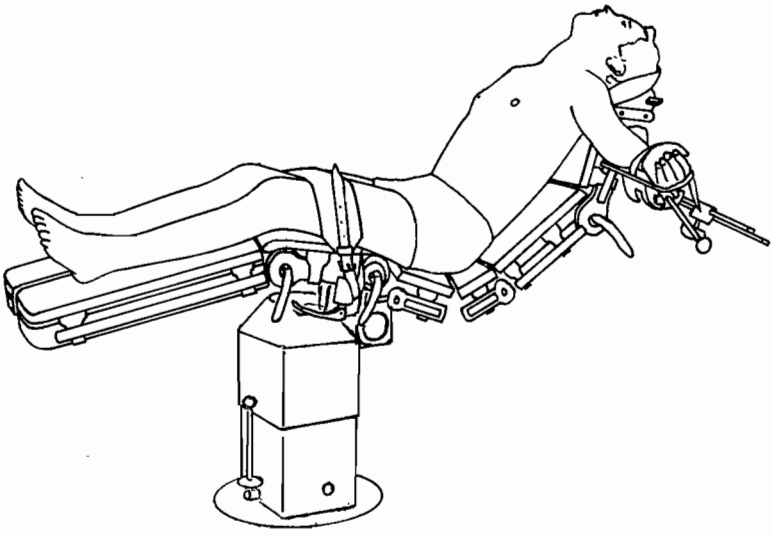

Fig. 26 Goiter operation in semi-sitting position.

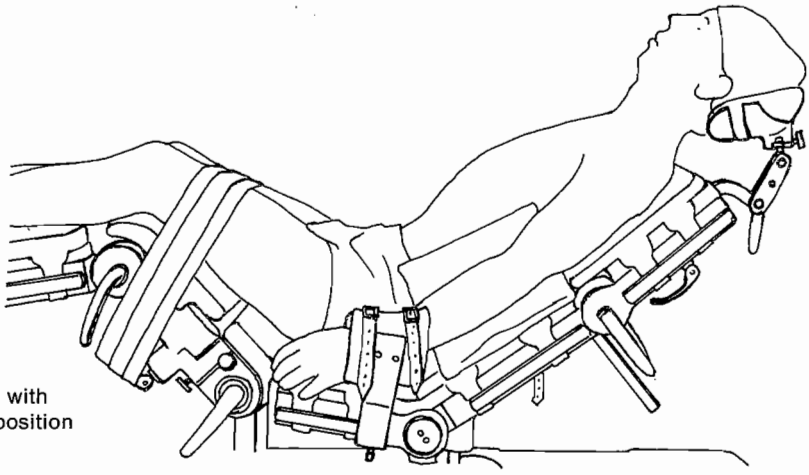

Fig. 27 Goiter operation with patient in a semi-sitting position for wound closure.

padded straps, which must not be tied too tightly, especially if one of the veins of the leg is being used for an infusion. Pads between the patient's legs and under the heels prevent burns and pressure sores. For the closure of the wound, the patient's head is raised in order to reduce the tightness of the operative field.

Goiter Operations in Semi-sitting Position

The principle of the patient's positioning is similar to that described on p. 52. However, as shown in Figure 26, the dorsal plate is higher.

Figure 27 shows the patient in a semi-sitting position for the closure of the wound.

4 Operations on Thorax, Positioning for Heart Surgery and Gastric Operation (Transthoracic Operation), Thoracoplasty, Pneumonectomy, and Rib Resection, Breast Operation

Operations with the Patient in Supine Position

The prepared, anesthetized patient is placed in the normal supine position on the operating table so that the dorsal plate, which is slightly flexed, lies under the thoracic region, thus elevating and tightening the operative field. Further changes in position, e.g., lateral inclination of the surface, are carried out on the surgeon's instruction. The positioning of the patient's legs and arms is the same as for the appendectomy on p. 36, Figure 4, or gallbladder operation, on pp. 37 to 39, Figure 5.

Operations with the Patient in Lateral Position

The patient is prepared and anesthetized in the supine position. Before he is moved into the lateral position, his documents (radiographs, history) must be examined in order to prevent positioning on the wrong side. Only then should the patient be placed onto his sound side in the center of the surface with his back toward the surgeon so that the most elevated part of the flexed surface is beneath the thorax. It is important that the thorax and the pelvic area are in good contact with the surface.

The adjustable lateral supports brace the patient without putting too much strain on him and hold him in such a way that additional pads are only rarely needed. The lateral supports mounted in the shoulder and coccyx regions (Figs. 28, 29) illustrate only one of the many techniques, the choice of which is usually made by the surgeon and anesthesiologist.

By elevating the upper section of the dorsal plate, a mold is formed in which the arm intended for the infusion can be placed so that it is easily accessible and free from pressure. Together with the arm support, a continuous padded surface is formed for the entire arm. Even the pressure caused by the edges of the padding can be harmful, e.g., causing paralysis of the nervus radialis or nervus ulnaris, particularly when muscle relaxants are administered. The patient's head is turned to the side on the upper section of the dorsal plate or on an additionally mounted adjustable head plate.

If, as can be seen in Figure 29, the other arm lies ahead in a relaxed position, care is to be taken that it is padded, if necessary, and that it is free from pressure, which can be caused by accessories, the accessory rail of the operating table, or the edges of the pads. It is advisable to raise the other arm on an appropriate anesthesia screen – in the form of an angled splint that is open on one side, with a horizontal splint to hold two padded hand straps or a padded arm board – in order to fasten the arm. The arm should neither be abducted by more than 90° nor be overstretched behind the patient's back. The neutral electrode is passed behind the patient's back. The neutral electrode is applied on the outer side of the extremity near the operative field and fixed to it so that it is in good contact with its entire surface without, however, causing pressure sores (cf. Fig. 2 and pp. 34 to 35).

The bottom leg lies flexed and drawn up toward the body on the table, the top leg remains stretched. A pad is placed between the legs before securing them with a wide belt. The lower section of the flexible leg plates can be adjusted to change the patient's position. A further technique for positioning the patient without putting too much strain on him is possible using a dorsal plate with a

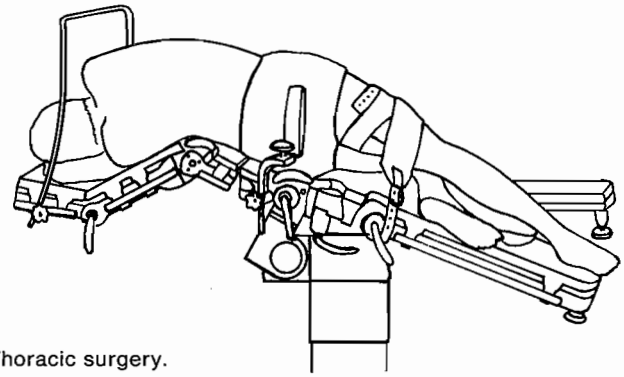

Fig. 28 Thoracic surgery.

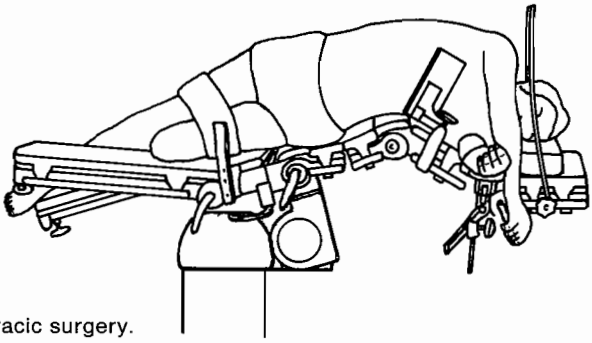

Fig. 29 Thoracic surgery.

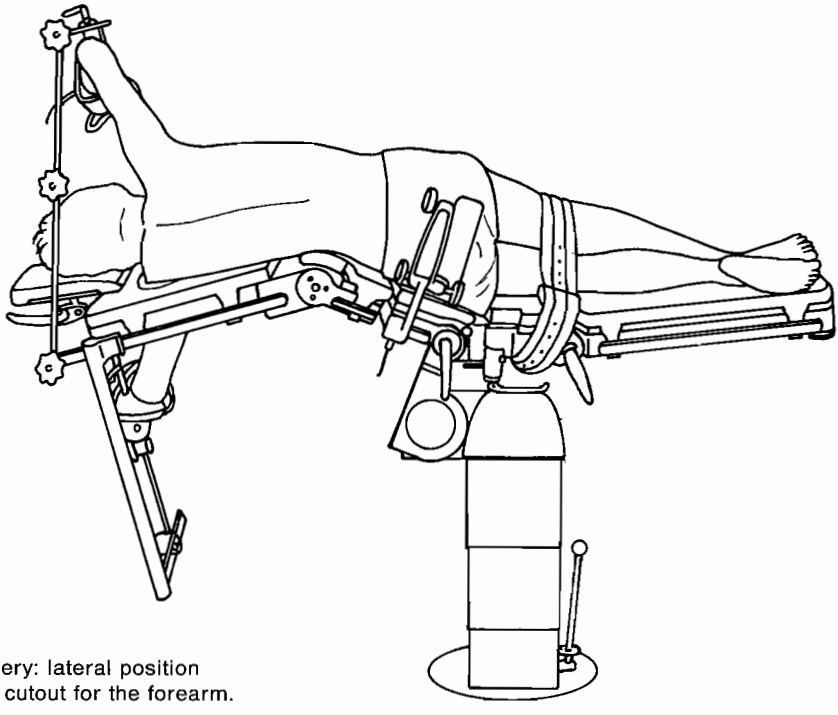

Fig. 30 Throacic surgery: lateral position on a dorsal plate with cutout for the forearm.

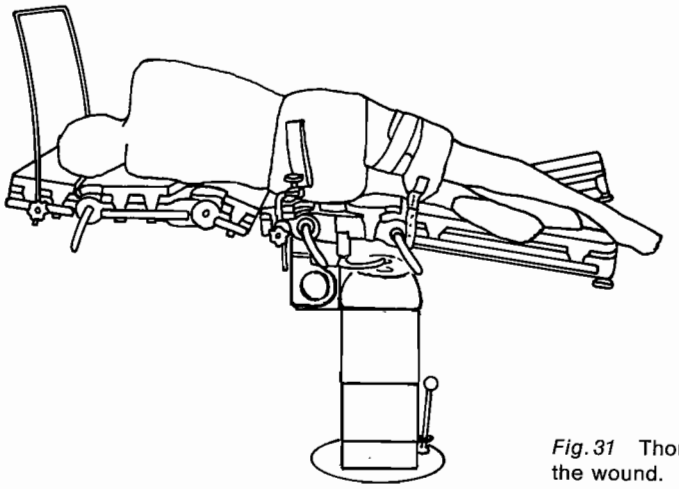

Fig. 31 Thoracic surgery: position for closure of the wound.

circular cutout through which the arm, which would otherwise be on the supporting surface, can be placed. The arm is thus proteced from the risk of pressure sores and is safely positioned on an armrest, making it easily accessible. The armrest is fixed to the sliding rail of the operating table using an adapter (Fig. 30). The operative field can be tightened by lowering the dorsal plate. Inclined positions, which can occur during this procedure, can be compensated for by an inclination of the entire surface toward the foot end.

At the beginning of the operation, the surface can be inclined laterally following the surgeon's incision and then returned to the original position. A similar technique is used for the closure of the wound in layers, for which the flexed position of the table is no longer necessary. This requires the readjustment of the anesthesia screen to make sure that it does not swing into the operative field (Fig. 31).

Operations of Patients in Sitting Position (e.g., Rib Resection)

Prior to the operation, the dorsal plate of the surface is raised into an almost vertical position and the upper section lowered into a horizontal position. As can be seen in Figure 32, the flexible leg plates can be

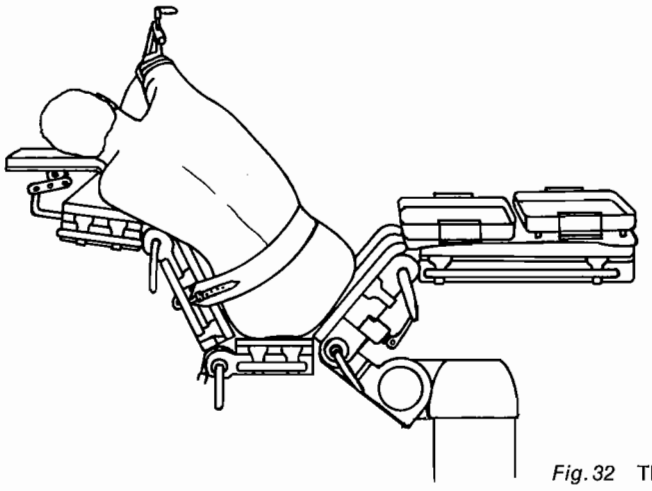

Fig. 32 Thoracic surgery – patient in sitting position.

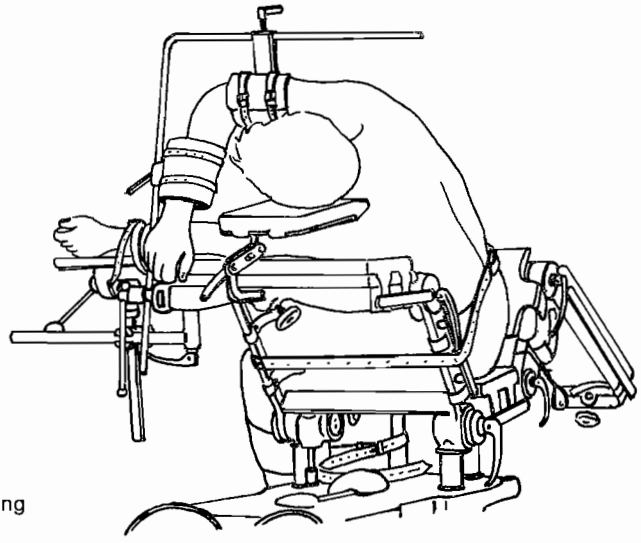

Fig. 33 Thoracic surgery – patient in sitting position: positioning of head and arm.

similarly adjusted to support the patient and, at the same time, to from a surface for instrument trays.

An adjustable head plate is mounted on the upper section of the dorsal plate, and, similarly, opposite the operative field, an armrest and an anesthesia screen in the form of an angled splint which is open on one side and adjustable. The patient is put on the table so that his buttocks and his back are on the very edge of the surface. The upper part of the body leans slightly bent against the dorsal rest. Pads ensure that the body is free from pressure. The patient is secured with a wide belt. His head is turned to the side on the head plate. The arm intended for infusion lies on the upper section of the dorsal plate, and should be free from pressure. Together with the arm support, a continuous padded surface is formed for the entire arm, since even the pressure caused by the edges of the padding can be harmful, e.g., causing a paralysis of the nervus radialis or of the nervus ulnaris, particularly when muscle relaxants are administered. If the other arm is positioned freely toward the front, particular care is to be taken that it is padded and that it is free of pressure which can be caused by accessories, the sliding rail of the operating table, or the edges of the pads. It is advisable, as can be seen in Figure 33, to raise the arm bent on the anesthesia screen and to secure it with two padded hand straps, always taking care that the arm is neither abducted by more than 90° nor overstretched behind the patient's back.

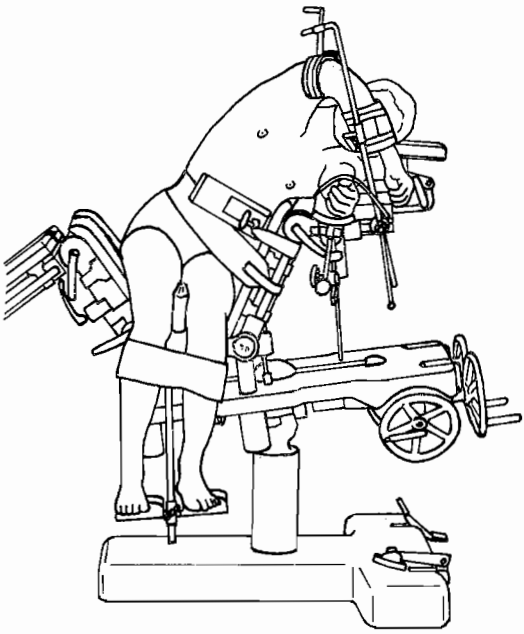

Fig. 34 Thoracic surgery – patient in sitting position.

The neutral electrode is applied on the outer side of the extremity near the operative field and fixed to it so that it is in good contact with its entire surface without, however, causing pressure sores (cf. Fig. 2 and pp. 34 to 35). The foot plates support the patient's legs so that the thighs are free of pressure caused by the edges of the surface or the padding of the operating table (Fig. 34).

The lateral support which, as demonstrated in Figure 34, serves as a thoracic support, compensates for the pressure caused by the surgeon most effectively if it is mounted in the upper section of the chest.

For easier access, the leg plates can also be removed if the patient's size allows this (Fig. 35).

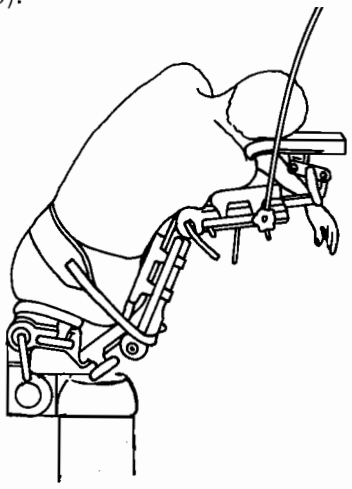

Fig. 35 Thoracic surgery – patient in sitting position without leg plates.

Changes in the patient's position during or after the operation are carried out on the surgeon's instruction.

Breast Operations

The prepared, anesthetized patient is placed on the operating table in the normal supine position so that the side of the thorax that is to be operated on extends about 3–4 cm beyond the surface. Since the patient is relaxed, a flat pad must be placed between the thorax and the surface to avoid the increased risk of pressure sores. This pad also improves the position for the operation. For the operation in the axilla, the surface is slightly inclined toward the sound side of the body. A lateral support on the sound side of the thorax prevents the patient's slipping. Due to its adjustment into an S-shape, the surface is anatomically adapted to the different patients. In addition, the upper section of the slightly raised dorsal plate is lowered to such an extent that the operative field is elevated due to its being slightly flexed in the shoulder blade area (Fig. 36).

The arm lying opposite the operative field is intended for infusion. Both the patient's arms , which are abducted by nearly 90°, must lie flat with their full length on the well-padded armrests. Even the pressure caused by the edges of the armrest and operating table can be harmful, e.g., causing a paralysis of the nervus radialis or of the nervus ulnaris, particularly when muscle relaxants are ad-

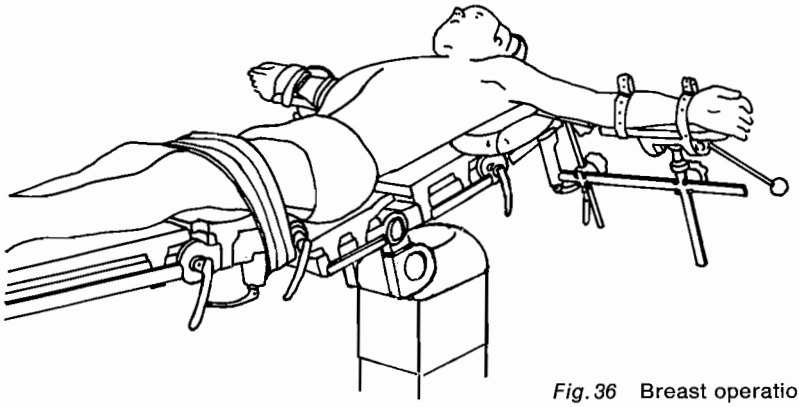

Fig. 36 Breast operation.

ministered. Should the armrests be too short, padded Cramer's splints may be used to bridge the gap.

It is equally dangerous to overstretch the arm (paralysis of the plexus), which applies to an abduction of more than 90° as well as to the lowering of the arm. The risk of overstretching the bend of the elbow is less likely. It is best to keep the arm in a supine position (palm upward), slightly bent and raised into a position just slightly higher than the horizontal level. The patient's head is supported by an adjustable head plate that is mounted on the dorsal plate. The neutral electrode is applied on the outer side of the extremity near the operative field and fixed to it so that it is in good contact with its entire surface without, however, causing pressure sores (cf. Fig. 2 and pp. 35 to 36). The patient's legs are to be secured about 6 inches above the patella using wide padded straps, which must not be tied too tightly. The knee joints are supported with flexible leg plates or, in the case of anatomically different legs, with pads. Additionally, pads are laid under the heels in order to prevent burns or pressure sores. Changes in the patient's position during the operation, e. g., tilting, are performed on the surgeon's instruction.

5 Surgery on the Apparatus of Locomotion

Vertebral Operations

The special requisites for the patient's positioning for a vertebral operation include the following: on the one hand the patient's back must be elevated, thus clearly bent and tight, but, on the other hand, the thorax and abdominal regions must be free from pressure caused by the weight of the body. In practice there are various positions, some of which are achieved by special positioning of the patient (e.g., knee-elbow squatting position called "hare position"), others by special equipment and special padding. The experienced surgeon will nearly always come to a reasonable compromise concerning the requirements just described. Figures 37 and 38 were not chosen due to any preference: Figure 37 was chosen because this position can easily be achieved without using special equipment. Figure 38, however, describes a position that uses ad-

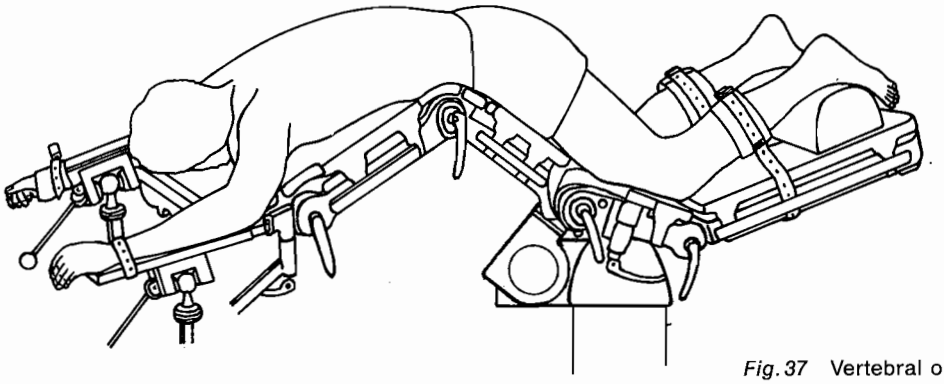

Fig. 37 Vertebral operation.

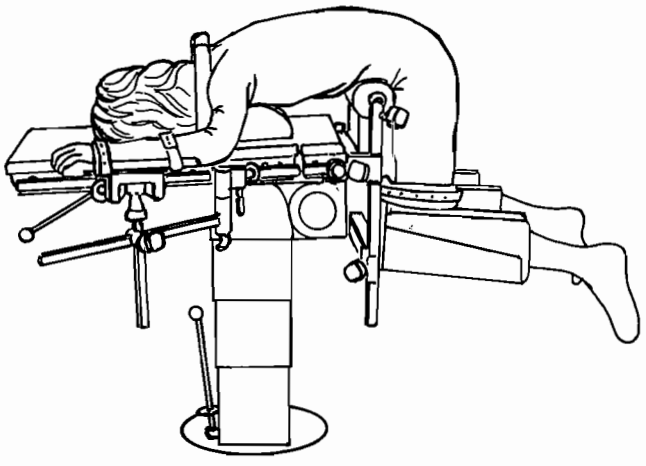

Fig. 38 Vertebral operation with special positioning equipment.

ditional equipment, which can also be used for other surgical operations (e.g., rectal operations).

The prepared, anesthetized patient is placed on the operating table in a prone position so that the most elevated and flexed section of the supporting surface is as near to the pelvic crest as possible. A flat pad positioned on a level with the sternum between the thorax and the supporting surface reduces the pressure on the abdominal region. The patient's head is turned to the side on the slightly elevated section of the dorsal plate, arms are spread – the forearms bent toward the upper arms at an angle of about 120° – on the mounted arm supports. The arms must lie flat and not be overstretched in order to prevent paralysis of ulnaris, radialis, and plexus. The neutral electrode is applied on the outer side of the extremity near the operative field and fixed to it so that it is in good contact with its entire surface without, however, causing pressure sores. The legs are placed with the knees in the flex joints of the leg plates: the lower legs are secured with wide belts, and the instep is supported by a crescent-shaped pad. Other changes in the patient's position or adjustments in the position of the supporting surface (e.g., removal of flexion for wound closure) or adjustment of the inclination by lowering the head section or the foot section of the supporting surface are carried out on the surgeon's instruction.

Figure 38 also shows the patient in prone position but with additional positioning equipment comprising adjustable, padded lateral pelvic supports and adjustable, padded lower leg supports in the form of shells. Adjusted to fit the patient's figure, it is possible to achieve suitable positioning with a free abdomen.

Shoulder supports, which are mounted on the accessory rails of the operating table brace the patient and secure him. The dorsal plate can easily be lowered if the bend of the back and the tightness of the operative field has to be increased. The patient's head and his arms are positioned as described previously. Further changes in position are carried out on the surgeon's instruction.

Figure 39 shows the previously mentioned knee-elbow squatting position called "hare position."

Figure 40 shows a position for a vertebral operation as has been practiced for many years in the Orthopedic Department of the Krankenhaus der Augustinerinnen in Cologne, Germany, and that was described by Chief Surgeon Dr. D. Schöllner (cf. Therapiewoche 33, 3748–3749 [1983]: Orthopädie, Verlag G. Braun, Karlsruhe). This position keeps the strain on the patient at a minimum. The patient is positioned favorably, with his center of gravity in its natural position. His buttocks are supported by an adjustable, well-padded, round positioning frame. Padded supports secure him at the sides. With his legs astride and a pad under his chest, it is possible to leave the

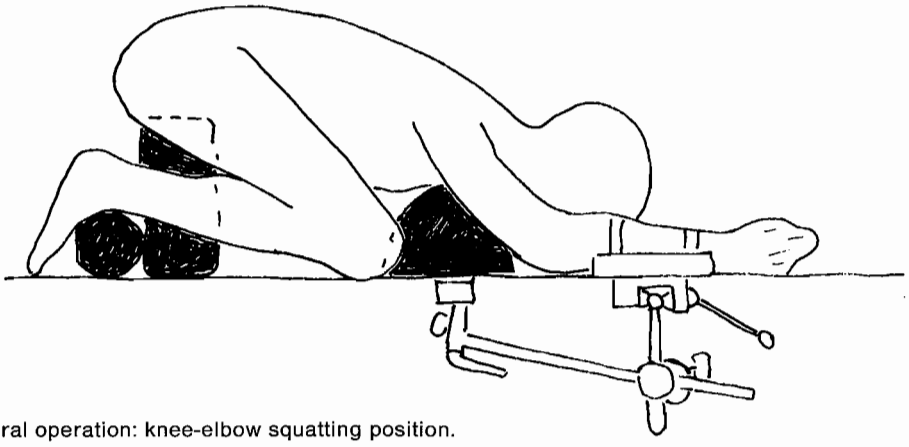

Fig. 39 Vertebral operation: knee-elbow squatting position.

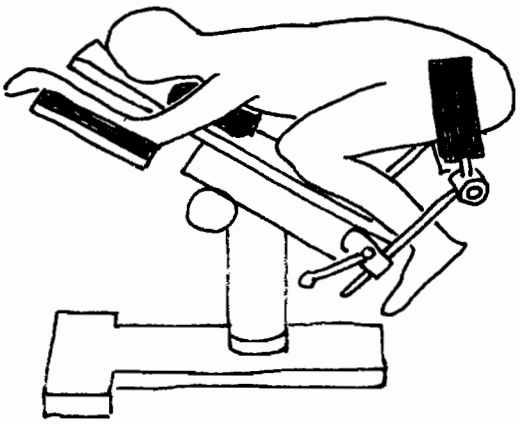

Fig. 40 Vertebral operation with special positioning equipment.

abdomen free. The flexion of the knee joints (not more than 120°) can be adjusted exactly with the positioning frame. The ankle joints are relaxed. His head is turned sideways on the supporting surface, his arms are placed on two armrests at the sides of the operating table.

Hip Operations (e.g., Total Endoprosthesis)

The prepared, anesthetized patient is placed on the operating table in normal supine position with the hip to be operated on slightly projecting over the edge of the supporting surface. Care must be taken that the projecting skin tissue is protected from the risk of pressure sores caused by the edges of the pads or even of the supporting surface. Since this position does not normally involve anything special, illustrations are not necessary. For further details, e.g., regarding positioning of the arms, refer to pp. 34 to 35 "Positioning of the Patient."

Positioning for Surgical Treatment of Fractures (Osteosynthesis)

There are various techniques of surgical treatment of fractures (osteosynthesis), including

- Intramedullary nailings
- Plates and screws of the AO (Association for Osteosynthesis)
- Kirschner's wire traction strapping for the surgical treatment of malleolar, knee, and elbow factures, etc.,

which are applied on the surgeon's instruction singly or in combination. All these surgical techniques are based on the principle of invasive reposition, adjustment carried out according to the impression formed either by the naked eye, or by the x-ray image intensifier and the fixation of the fragments. There are, however, differences with regard to the prerequisites for the patient's positioning: pp. 63 to 85 describe the positions that require the following simultaneously:

- The positioning of the patient, which puts minimum strain on him
- Maintenance of aseptic environment
- The unhindered access of the surgeon to the operative field
- Well-measured and uniform traction
- Unhindered x-ray

Neck of Femur Operation

The prepared, anesthetized patient is positioned on the extension plate in dorsal position so that the pelvic plate freely supports the buttocks without developing pressure sores. The eccentrically arranged well-padded countertraction bar is in good, firm contact with the patient's crotch. The legs are to be kept parallel and symmetrical and spread as far as is necessary for the operation involving an x-ray image intensifier, taking the patient's condition into account. The patient's feet, beginning with the affected leg, are secured using padded foot straps or gauze, so that the soles of the feet lie flat and firmly on the foot plates even under extensive traction. The ankle joints should be relaxed.

The extension bars are adjusted according to the length of the patient's legs and must be outside the path of x-rays and allow unhindered radioscopy at a swing of the C-arm fluoroscopic mobile unit in two levels

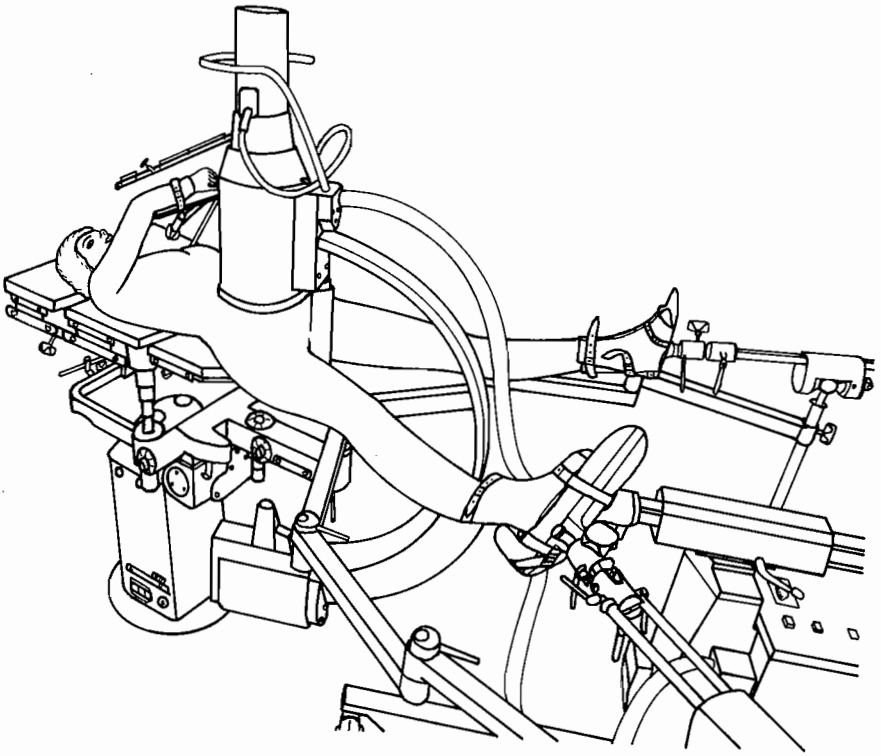

Fig. 41 Neck of femur operation – x-ray image intensifier for anteroposterior radioscopy.

perpendicular to each other (anteroposterior and axial). Figure 41 demonstrates the patient's position with the x-ray image intensifier for anteroposterior radioscopy positioned between his legs. The neutral electrode is applied on the outer side of the extremity near the operative field and fixed to it so that it is in good contact with its entire surface without, however, causing pressure sores (cf. Fig. 2 and pp. 34 to 35).

Figures 42 and 43 show the patient's position with an x-ray image intensifier mounted on the side of the operating table for anteroposterior and axial radioscopy.

The patient's arm intended for the infusion must lie flat with its full length on the well-padded armrest. Even the pressure caused by the edges of the armrest and of the operating table can be harmful, e.g., causing paralysis of the nervus radialis or nervus ulnaris, particularly when muscle relaxants are administered. Should the armrest be too short, a padded Cramer's splint may be used to bridge the gap. It is equally dangerous to overstretch the arm (paralysis of the plexus), which applies to an abduction of more than 90° as well as to a lowering of the arm. The risk of overstretching the bend of the elbow is less likely. It is best to keep the arm in a supine position (palm upward), slightly bent and raised into a position just slightly higher than the horizontal level. The other arm is raised on an appropriate anesthesia screen – in the form of an angled splint that is open on one side with a horizontal splint to hold two padded hand straps or a padded arm board – in order to fasten the arm without running the risk of pressure sores. It is important that the patient's shoulder is not elevated and that his arm is not overstretched (cf. Fig. 3).

Figure 44 illustrates the position for anteroposterior and axial radioscopy using two x-ray image intensifiers with fixed settings. One of these is brought into position from the side opposite the operative

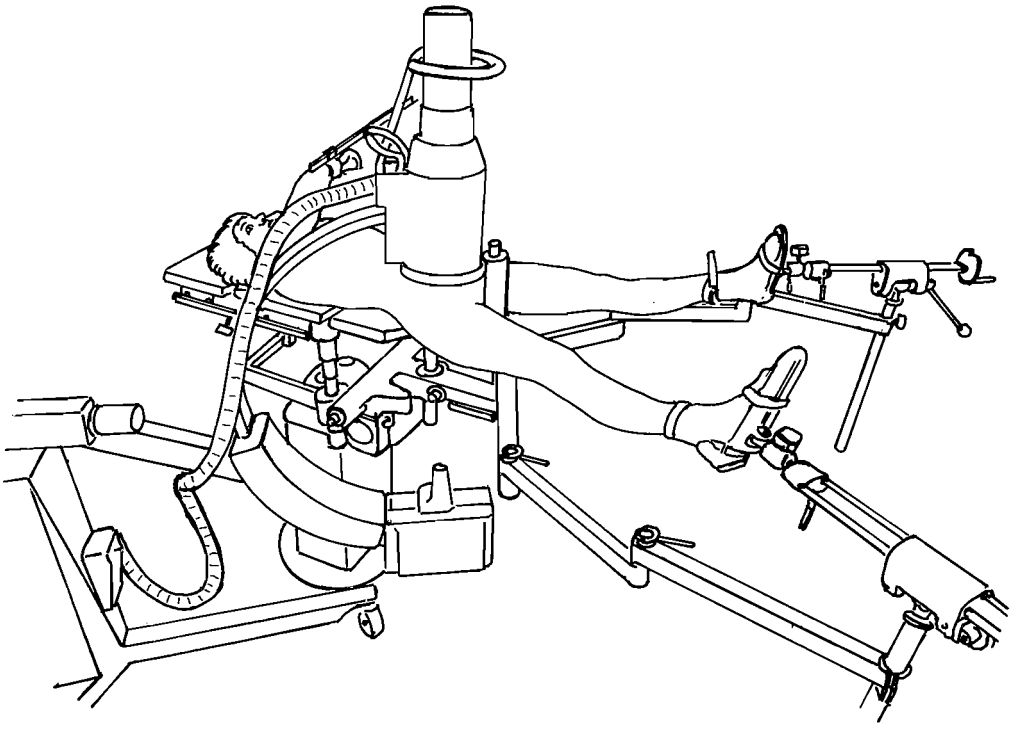

Fig. 42 Operation on the neck of the femur – x-ray image intensifier for anteroposterior radioscopy.

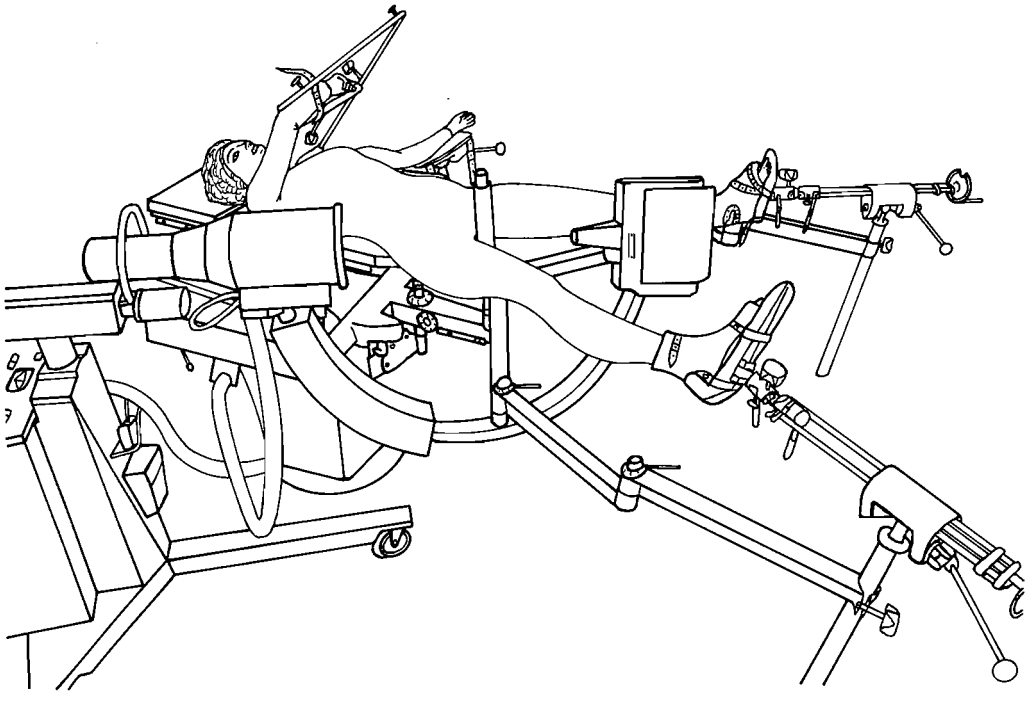

Fig. 43 Neck of femur operation – x-ray image intensifier for axial radioscopy.

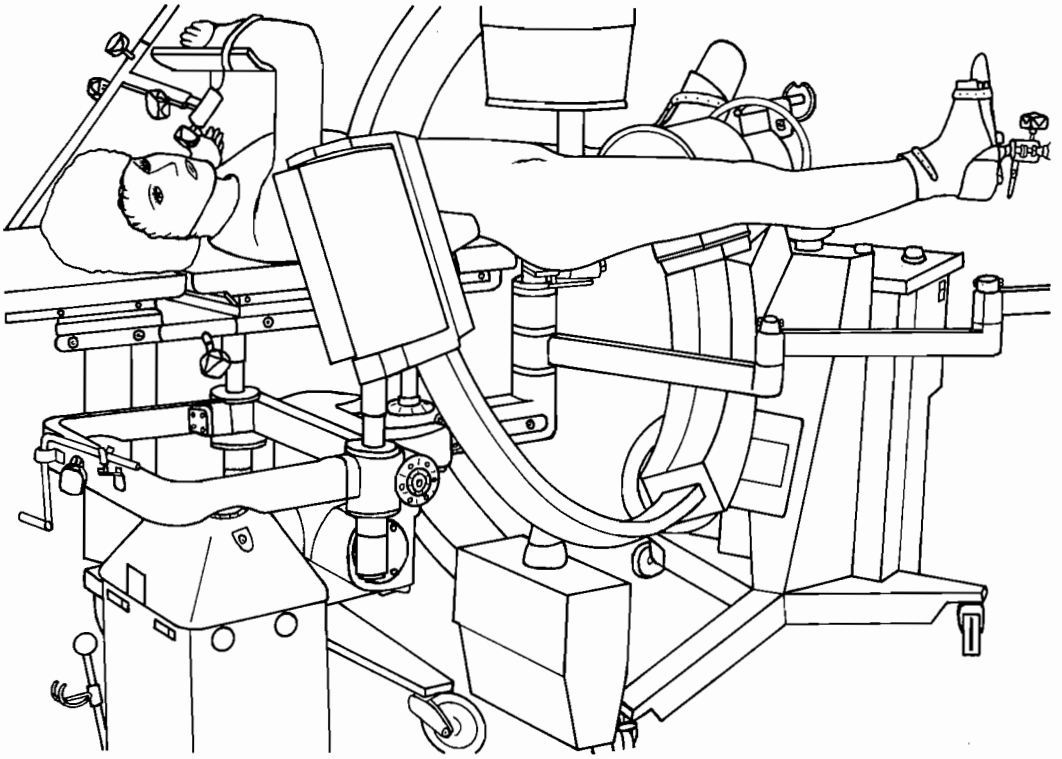

Fig. 44 Neck of femur operation – illustration of two firmly mounted x-ray image intensifiers for anteroposterior and axial radioscopy.

field, the other is put between the patient's legs.

Figures 45 and 46 show the patient's position on a mobile extension table for anteroposterior and axial radioscopy with an x-ray image intensifier that can be moved in from the side.

Before the operation is begun, the table top with the patient is raised to the working height of the x-ray image intensifier. The patient's legs are slightly turned to the inside and extended according to the surgeon's instruction. The adjustable extension devices, which allow adjustment in kilogram steps permit uniform and exactly measured extension. Figure 47 shows a mobile extension device that is used together with the operating table. Before this is used, the leg plates of the operating table must be folded down or removed.

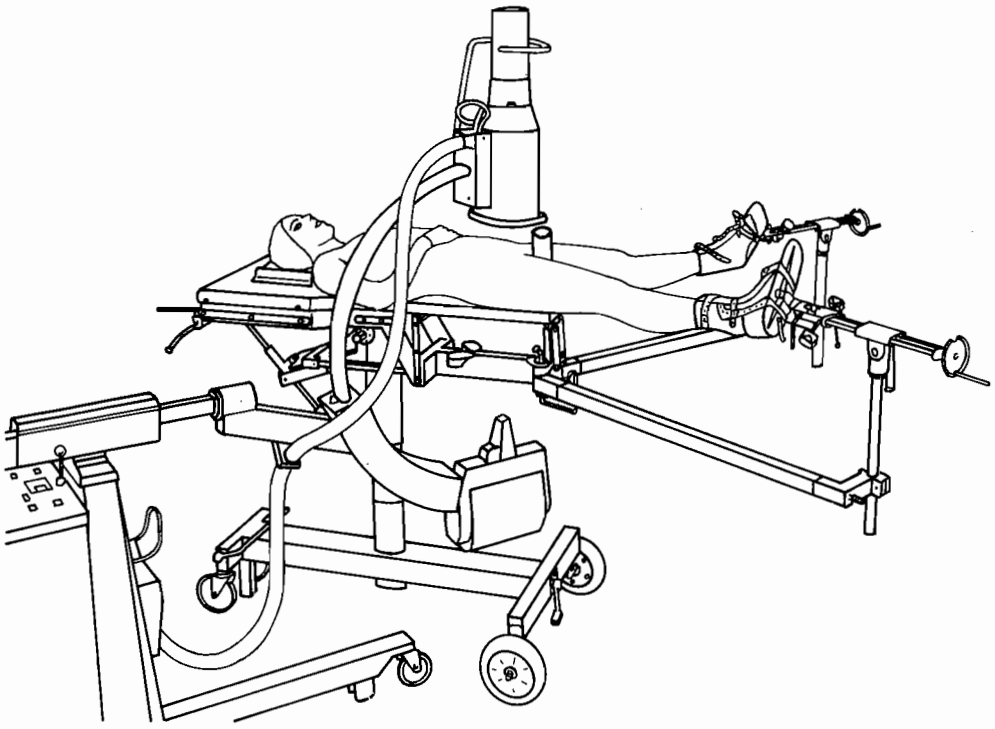

Fig. 45 Neck of femur operation – mobile extension table with x-ray image intensifier for anteroposterior radioscopy.

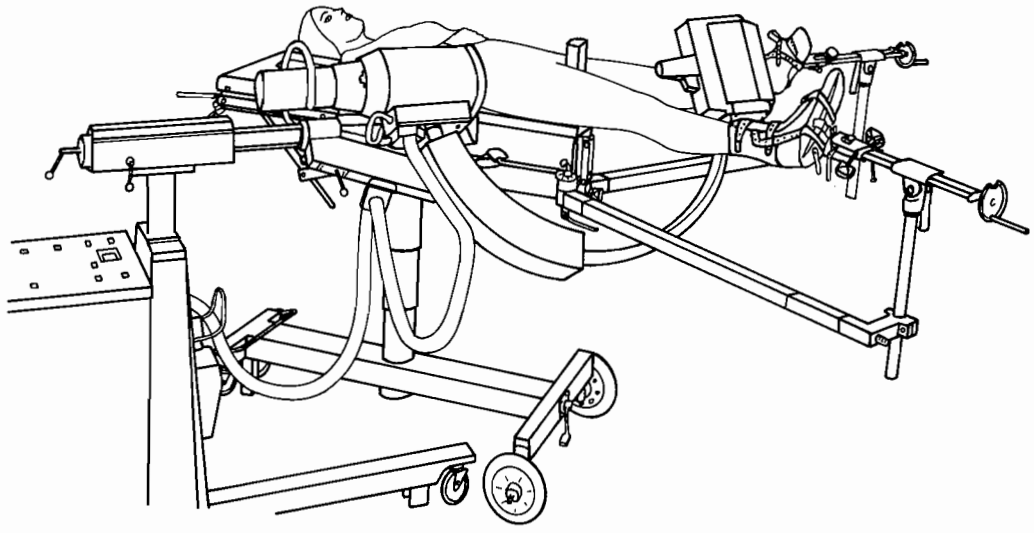

Fig. 46 Neck of femur operation – with x-ray image intensifier for axial radioscopy.

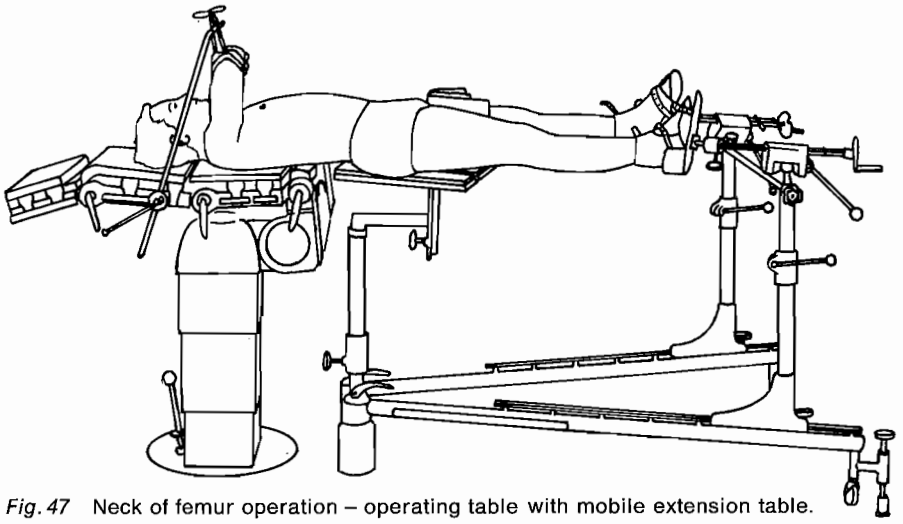

Fig. 47 Neck of femur operation – operating table with mobile extension table.

Femur Operations

Apart from the conventional lateral position, the supine position is also being used increasingly due to modern, adjustable operating tables that keep the strain on the patient at a minimum. These offer better working conditions for the surgeon and are more easily accessible.

Patient in Supine Position

As shown in Figure 48, the patient is in supine position on the extension table with the x-ray image intensifier for anteroposterior radioscopy mounted between the patient's legs. The eccentrically arranged and well-padded countertraction bar is in good, firm contact with the patient's crotch.

Figure 49 shows the same position as Figure 48, but here the x-ray image intensifier is positioned for axial radioscopy.

The neutral electrode is applied on the outer side of the extremity near the operative field and fixed to it so that it is in good contact with its entire surface without, however, causing pressure sores (cf. Fig. 2 and pp. 34 to 35). The patient's arm intended for the infusion must lie flat with its full length on the well-padded armrest. Even the pressure caused by the edges of the armrest and of the operating table can be harmful, e.g., causing a paralysis of the nervus radialis or nervus ulnaris, particularly when muscle relaxants are administered. Should the armrest be too short, a padded Cramer's splint may be used to bridge the gap. It is equally dangerous to overstretch the arm (paralysis of the plexus), which applies to an abduction of more than 90° as well as to the lowering of the arm. The risk of overstretching the bend of the elbow is less likely. It is best to keep the arm in a supine position (palm upward), slightly bent and raised to a position just slightly higher than the horizontal level. The other arm is raised on an appropriate anesthesia screen – in the form of an angled splint that is open on one side with a horizontal splint to hold two padded hand straps or a padded arm board – in order to fasten the arm without running the risk of pressure sores. It is important that the patient's shoulder is not in a raised position and that his arm is not overstretched (cf. Fig. 3).

The leg intended for operation is stretched and secured with a padded foot strap or gauze so that the sole of the foot lies flat and firmly on the foot plate even under extensive traction. The ankle joint should be relaxed.

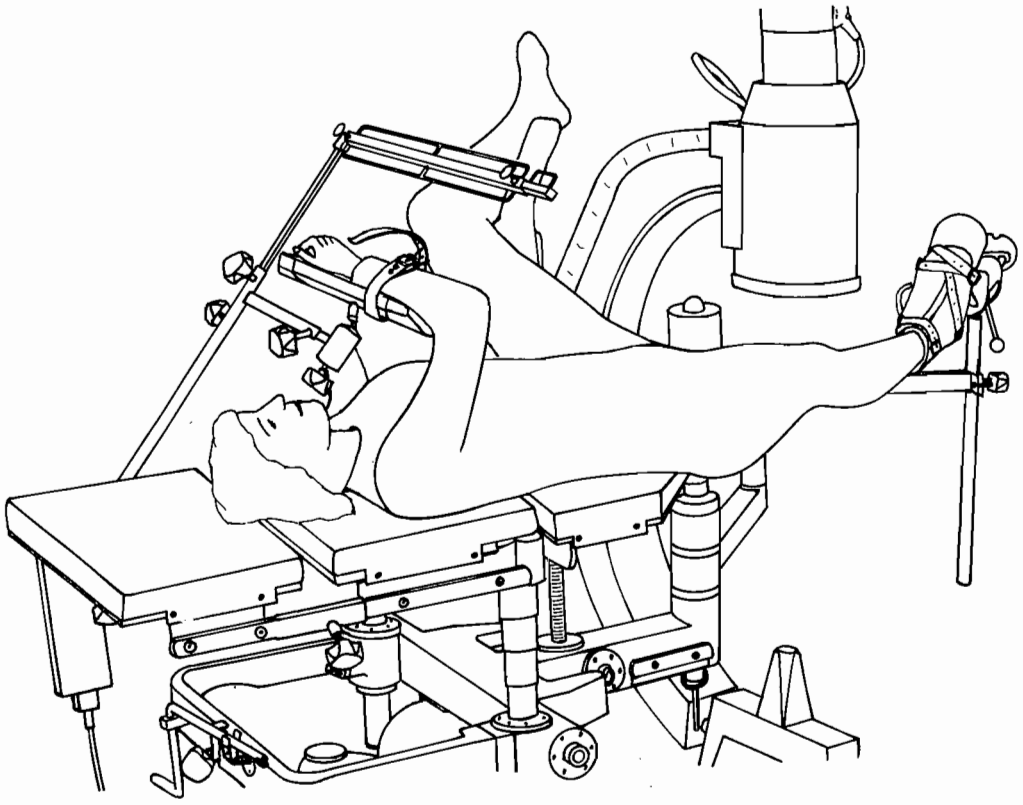

Fig. 48 Femur operation with the patient in supine position – x-ray image intensifier for anteroposterior radioscopy.

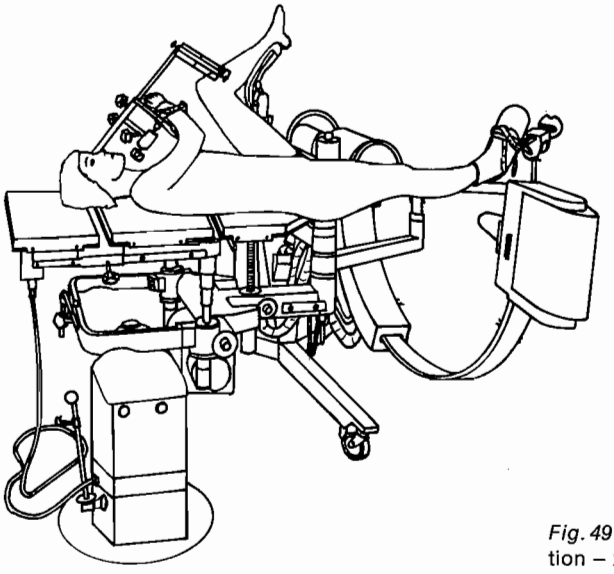

Fig. 49 Femur operation on patient in supine position – x-ray image intensifier for axial radioscopy.

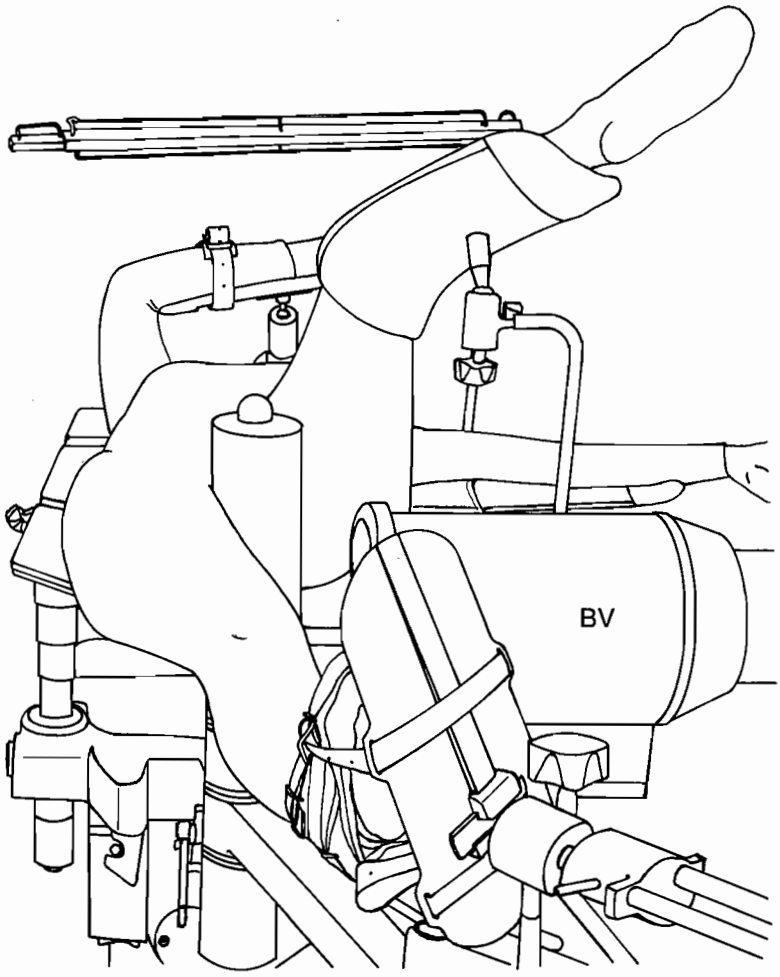

Fig. 50 Femur operation.

Figure 50 shows the patient as seen from the foot end. The affected leg is adducted to such an extent that the trochanter major is pressed toward the outside. The sound leg is slightly bent with the lower leg on a Goepel leg holder, which is mounted on the side of the operating table. For easier access, the second extension bar should be removed. The x-ray image intensifier, which in Figure 50 is shown between the extended leg and the stretched arm, is ready for axial radioscopy. Another positioning technique for the sound leg is demonstrated in Figure 51. The x-ray image intensifier is moved in from the side opposite the operative field for anteroposterior radioscopy.

The extension bar, which is adjusted according to the length of the patient's leg, must be outside the path of x-rays and allow unhindered radioscopy in two levels perpendicular to each other (anteroposterior and axial). Before the operation is begun, the table top with the patient is raised to the working height of the x-ray image intensifier. Adduction and extension of the affected leg are carried out on the surgeon's instruction. The adjustable extension devices that are adjustable in kilogram steps permit uniform, exactly measured extension. Lateral inclination of the table top and its lowering toward the foot end make the surgeon's work easier. Figures 52 and 53

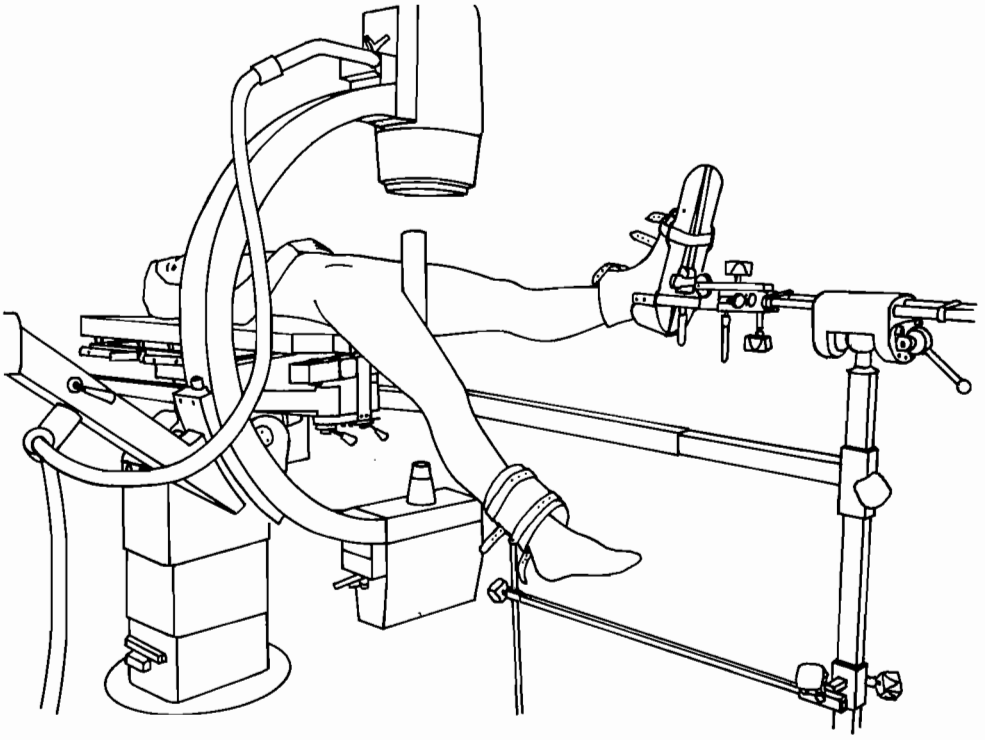

Fig. 51 Femur operation – x-ray image intensifier opposite the operative field for anteroposterior radioscopy.

show the patient in supine position on a mobile extension table. The x-ray image intensifier has been moved in for anteroposterior radioscopy.

The affected leg is demonstrated with bent knee and indicated supracondylar wire extension (Fig. 53) and the x-ray image intensifier for axial radioscopy.

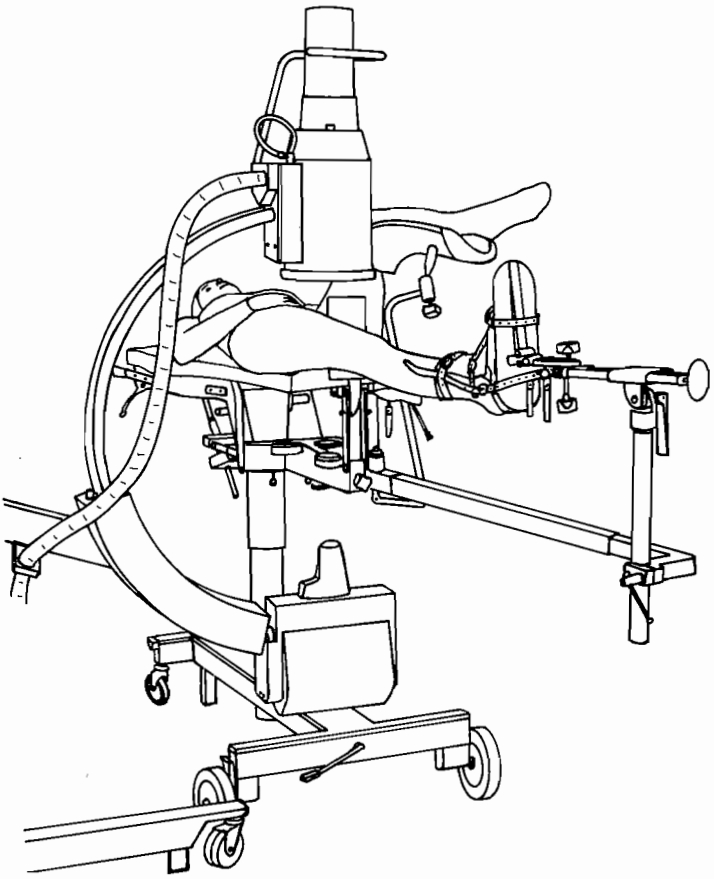

Fig. 52 Femur operation – mobile extension table, image intensifier for anteroposterior radioscopy.

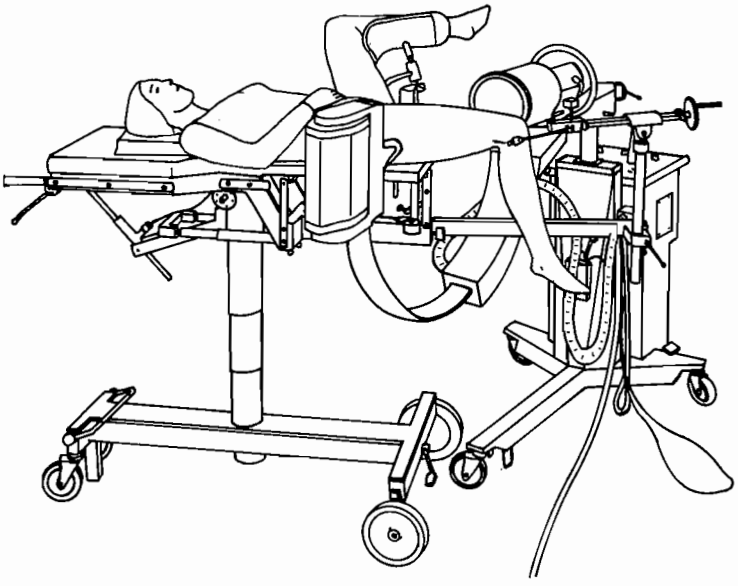

Fig. 53 Femur operation – mobile extension table, x-ray image intensifier for axial radioscopy.

Lateral Position of the Patient

The prepared, anesthetized patient is positioned on the sound side of the body so that the padded countertraction bar, which can be adjusted in height, is in good, firm contact with the patient's crotch. The leg to be operated on is secured above the countertraction bar with a padded foot strap or gauze so that the sole of the foot is flat and firmly positioned on the foot plate even under extensive traction. The ankle joints are relaxed. The extension bar is adjusted according to the length of the patient's legs and must be outside the path of x-rays and allow unhindered radioscopy at a swing of the C-arm x-ray image intensifier in two levels perpendicular to each other (anteroposterior and axial). Figure 54 shows the patient's position for anteroposterior radioscopy. The x-ray image intensifier has been moved in from the operative field.

The sound leg is abducted and the knee is flexed, with the lower leg in the padded sheath of the Goepel leg holder, which is mounted on the operating table (Fig. 55). This also prevents the patient's side from bending too much, which could lead to pressure sores caused by the edges of the padding on the operating table or even by the table top. The padded countertraction bar, which is adjustable in height should be adjusted, only to the extent that it lies against the patient but that, otherwise, the patient is flat on his side on the supporting surface. Additionally mounted lateral supports in the region of the thorax brace the patient without putting too much strain on him.

The neutral electrode is applied on the outer side of the extremity near the operative field and fixed to it so that it is in good contact with its entire surface without, however, causing pressure sores (cf. Fig. 2 and pp. 34 to 35).

Figure 56 demonstrates the patient in lateral position for axial radioscopy using the x-ray image intensifier.

The patient's head is turned sideways and supported by a pad on the table top. The patient's arm intended for the infusion must lie flat with its full length on the well-padded armrest. Even the pressure caused by the edges of the armrest and of the operating table can be harmful, e.g., causing a paralysis of the nervus radialis or nervus ulnaris, particularly when muscle relaxants are administered. Should the armrest be too short,

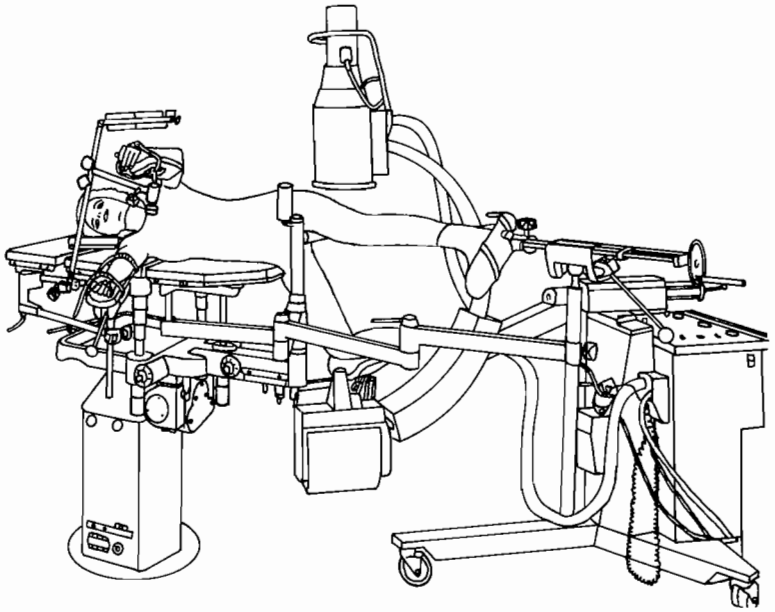

Fig. 54 Femur operation – patient in lateral position with the x-ray image intensifier for anteroposterior radioscopy.

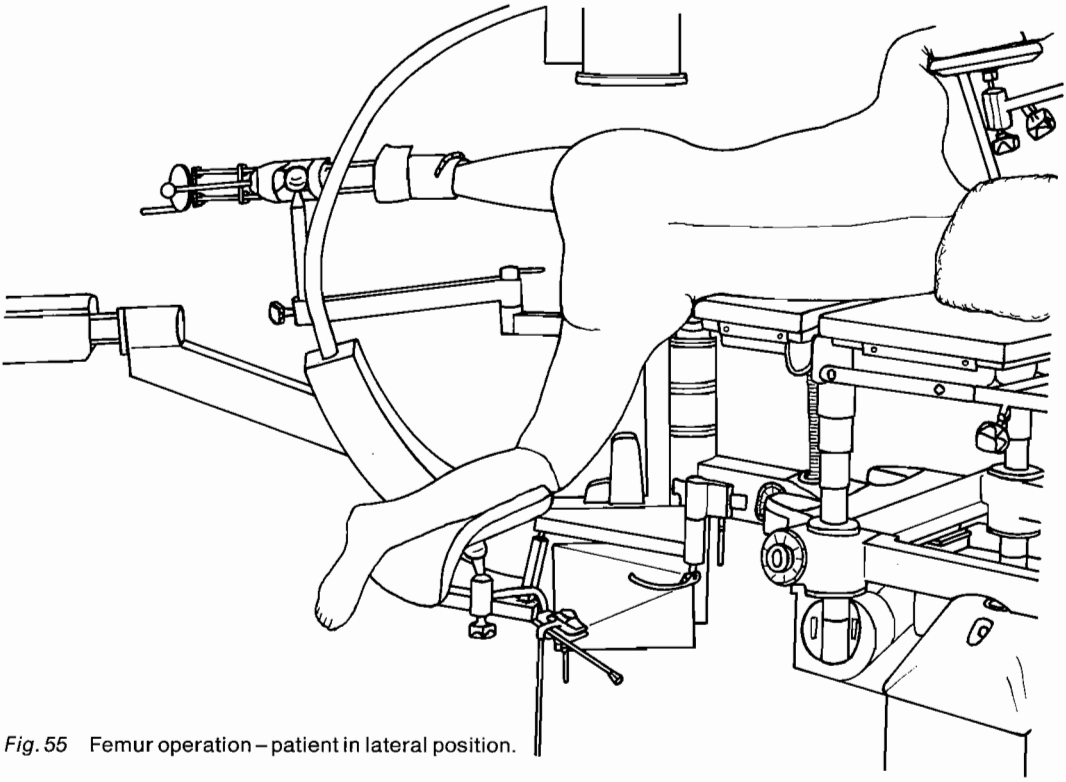

Fig. 55 Femur operation – patient in lateral position.

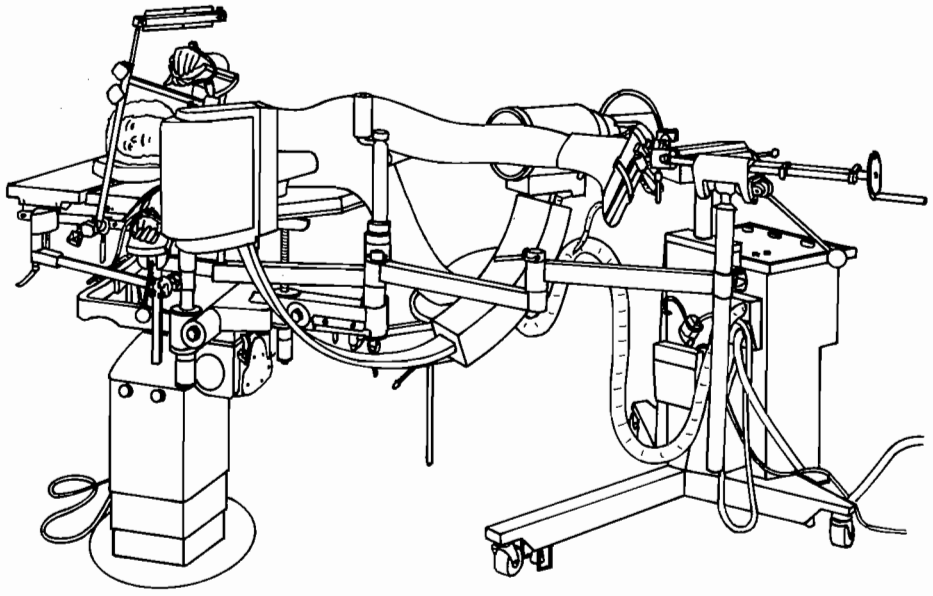

Fig. 56 Femur operation – patient in lateral position with the x-ray image intensifier for axial radioscopy.

a padded Cramer's splint may be used to bridge the gap.

It is equally dangerous to overstretch the arm (paralysis of the plexus), which applies to an abduction of more than 90° as well as to the lowering of the arm. The risk of overstretching the bend of the elbow is less likely. It is best to keep the arm in a supine position (palm upward), slightly bent and raised to a position just slightly higher than the horizontal level. The other arm is raised on an appropriate anesthesia screen – in the form of an angled splint, which is open on one side with a horizontal splint to hold two padded hand straps or a padded arm board – in order to fasten the arm without running the risk of pressure sores. It is important that the patient's shoulder is not elevated and that his arm is not overstretched (cf. Fig. 3).

Figure 57 shows the patient in lateral position with his legs astride. These are secured at the feet by means of padded leather straps or gauze. The ankle joints are relaxed. If this positioning technique is applied, care is to be taken that the patient does not develop pressure sores due to the padding or the edge of the table top. Since both extension bars are used for the positioning of the patient, careful adjustment is necessary to make sure that the bars hinder neither the radioscopy nor the C-frame of the x-ray image intensifier when it is swung into position in either of the two levels.

Figure 58 showing the x-ray image intensifier for anteroposterior radioscopy illustrates the patient in lateral position with a supracondylar wire extension for which the two extension bars are used together with a foot plate.

Before the operation is begun, the table top with the patient is raised to working height of the x-ray image intensifier. On the surgeon's instruction, the adjustable, padded vertical piece of the countertraction bar is arranged on the thigh and fixed. Then the thigh is adducted to such an extent that the trochanter major is pressed toward the outside. The extension is performed with an adjustable extension device with an adjustment in kilogram steps. Figure 59 shows the patient in lateral position for axial radioscopy on a mobile extension table with the x-ray image intensifier, which has been moved in from the operating side.

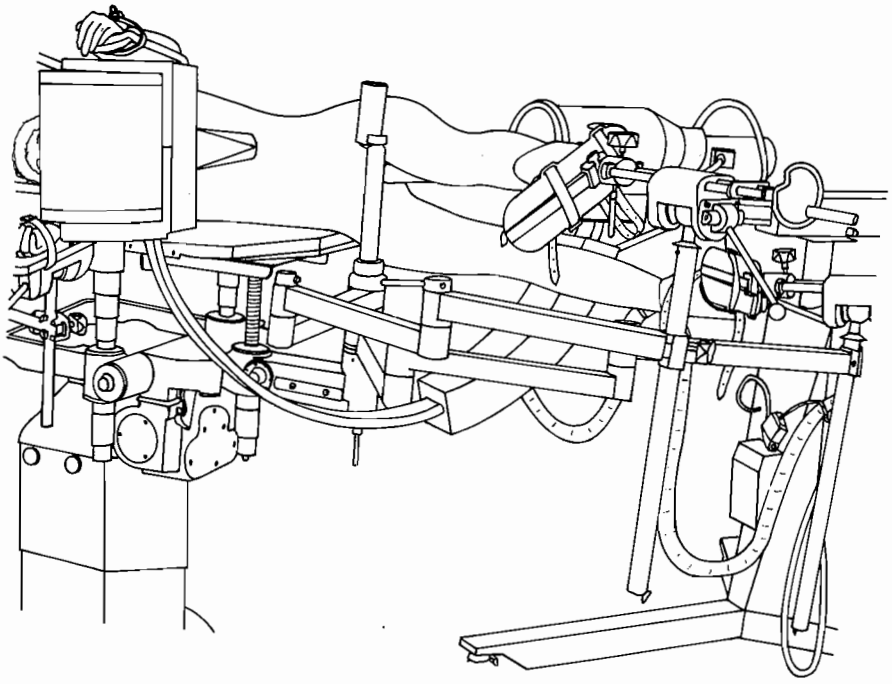

Fig. 57 Femur operation – patient in lateral position, and x-ray image intensifier for axial radioscopy.

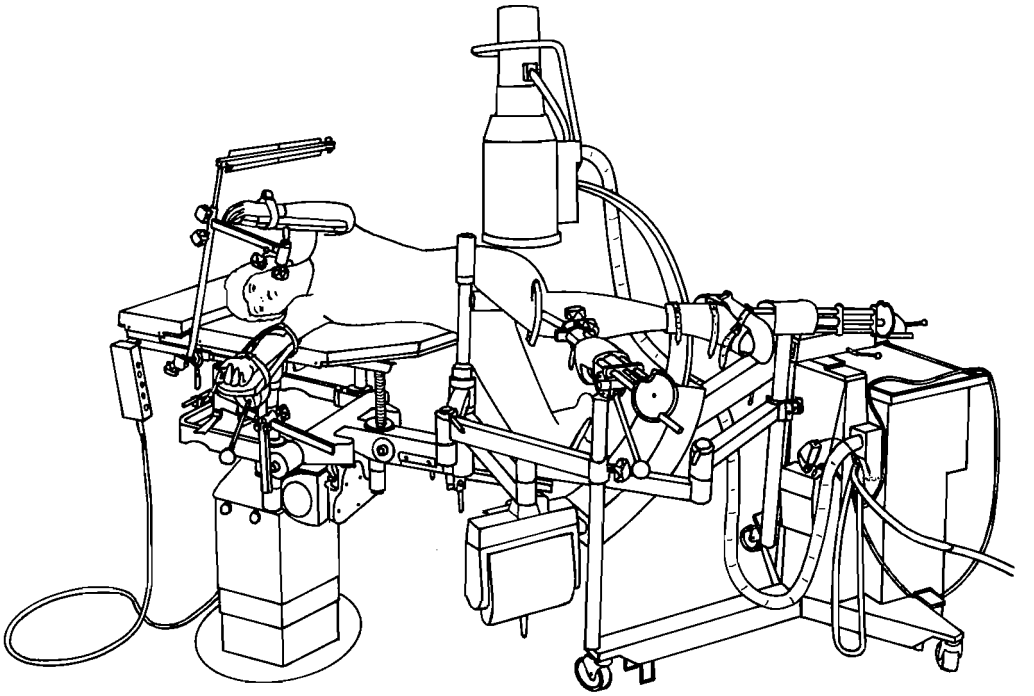

Fig. 58 Femur operation – patient in lateral position with supracondylar wire extension and x-ray image intensifier for anteroposterior radioscopy.

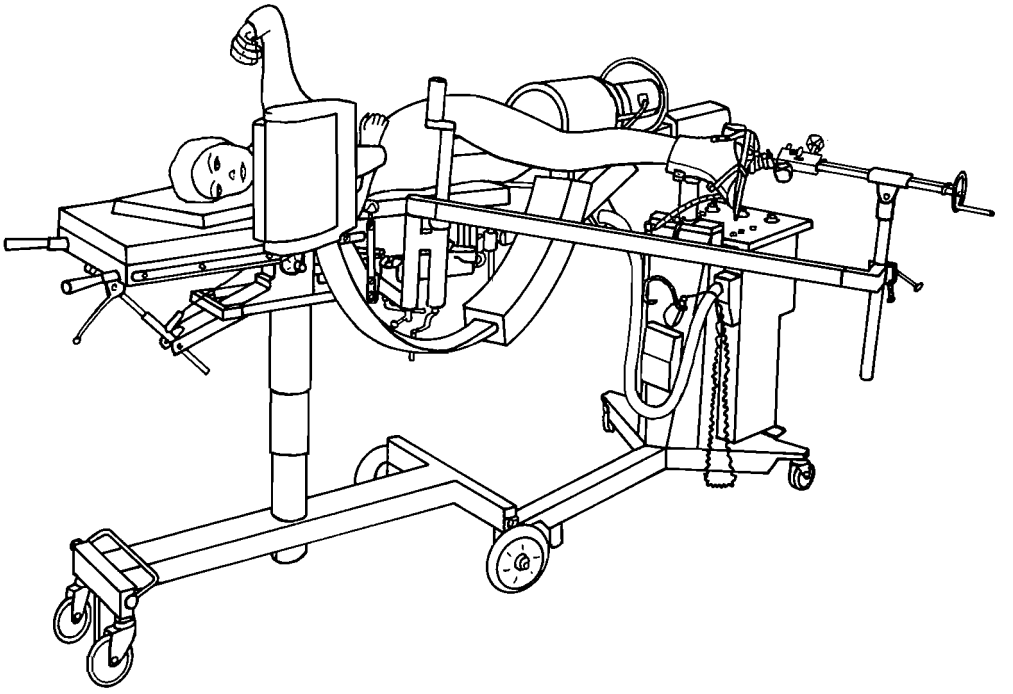

Fig. 59 Femur operation – mobile extension table with the patient in lateral position and x-ray image intensifier for axial radioscopy.

Tibia and Fibula Operation

The prepared, anesthetized patient is placed in supine position on the extension table so that no pressure sores can develop. As shown in Figure 60, the thigh and the lower part of the leg to be operated on are raised by nearly 90° or bent with the countertraction bar evenly and firmly in the hollow of the knee. The thigh is thus prevented from slipping over the counter bar when traction begins. The foot is secured with the ankle joint relaxed, using a padded strap or gauze, so that the sole is in good, firm contact with the foot plate even during traction (Figs. 60 and 61).

The sound leg is abducted and drawn toward the body with the lower leg on the laterally mounted Goepel leg holder. The x-ray image intensifier is arranged on the side opposite the operative field for anteroposterior and axial radioscopy.

The neutral electrode is applied on the outer side of the extremity near the operative field and fixed to it so that it is in good contact with its entire surface without, however, causing pressure sores (cf. Fig. 2 and pp. 34 to 35). The patient's arm intended for the infusion must lie flat with its full length on the well-padded armrest. Even the pressure caused by the edges of the armrest and of the operating table can be harmful, e.g., causing a paralysis of the nervus radialis or nervus ulnaris, particularly when muscle relaxants are administered. Should the armrest be too short, a padded Cramer's splint may be used to bridge the gap. It is equally dangerous to overstretch the arm (paralysis of the plexus), which applies to an abduction of more than 90° as well as to the lowering of the arm. The risk of overstretching the bend of the elbow is less likely. It is best to keep the arm in a supine position (palm upward), slightly bent and raised into a position just slightly higher than the horizontal level. The other arm is raised on an appropriate anesthesia screen – in the form of an angled splint that is open on one side with a horizontal splint to hold two padded hand straps or a padded arm board – in order to fasten the arm without running the risk of pressure sores. It is important

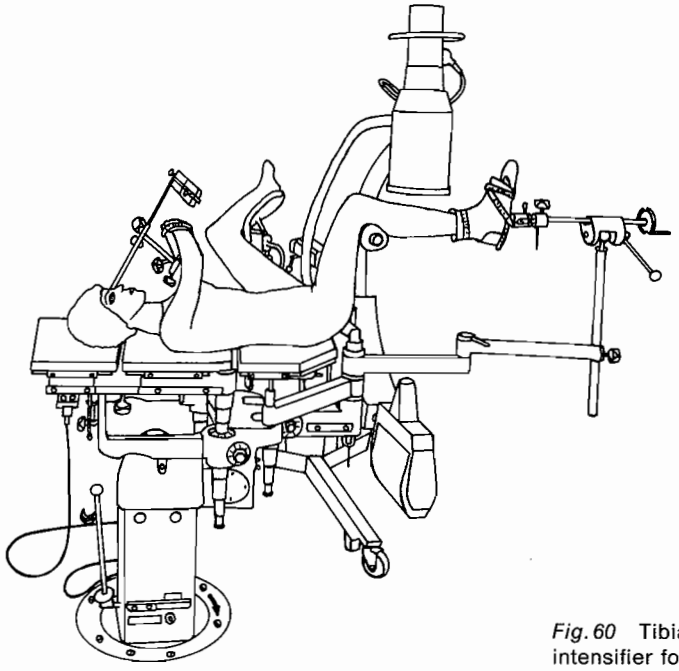

Fig. 60 Tibia and fibula operation – x-ray image intensifier for anteroposterior radioscopy.

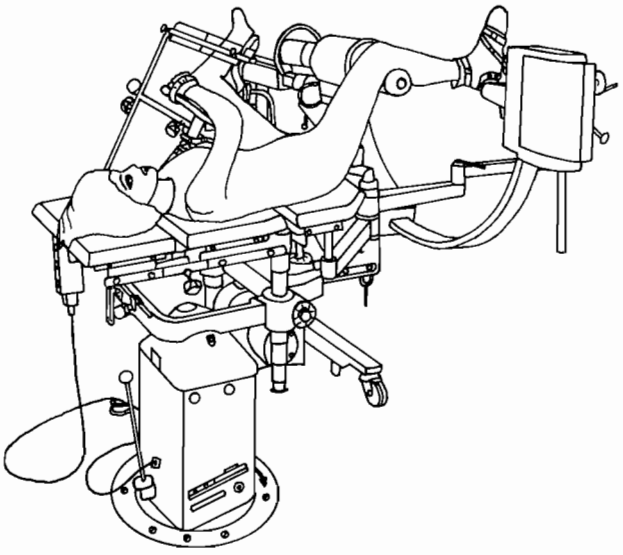

Fig. 61 Tibia and fibula operation – x-ray image intensifier for axial radioscopy.

that the patient's shoulder is not elevated and that his arm is not over stretched (cf. Fig. 3).

The positioning demonstrated in Figure 62 with the x-ray image intensifier for axial radioscopy is another technique for positioning the sound leg, which is secured with a padded cuff at the ankle. The corresponding positioning equipment is fixed to the vertical rod of the extension bar.

Before the operation is begun, the table top with the patient is raised to the working height of the x-ray image intensifier and the extension bar is arranged outside the path of the x-rays so that the C-arm can be swung into both levels (anteroposterior and axial) perpendicular to each other. Since the countertraction bar is adjustable in height, the distance from the table top can be adapted to the respective length of the patient's thigh.

Figure 63 illustrating the x-ray image intensifier for anteroposterior radioscopy demonstrates the position with a mobile extension table.

The extension device, which is adjustable in kilogram steps, allows even, exactly measured traction, which, like other changes in the position, e. g., lowering of the foot end of the table top, is performed on the surgeon's instruction. The patient's head can be placed on a flat padded cushion. The vertical position of the lower leg that is best for the surgeon can easily be arranged, using one of the many methods offered by extension tables today. Nevertheless, this position has become rare, since it hardly permits the use of an x-ray image intensifier for anteroposterior and axial radioscopy.

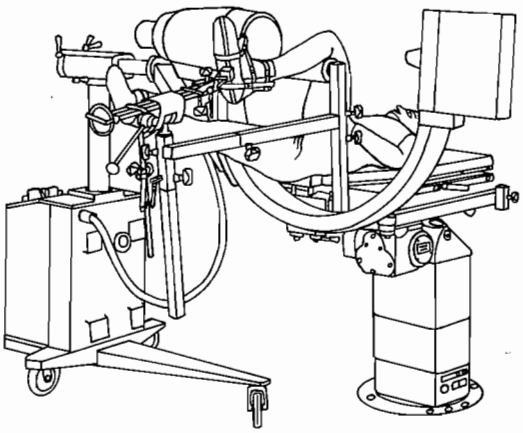

Fig. 62 Tibia and fibula operation – x-ray image intensifier for axial radioscopy.

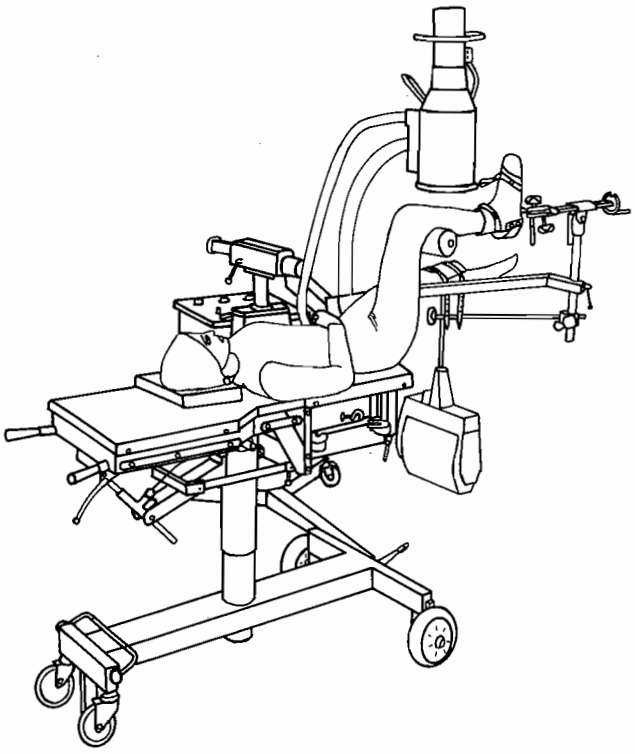

Fig. 63 Tibia and fibula operation – x-ray image intensifier for antero-posterior radioscopy.

Meniscus Operations

Figure 64 shows the prepared, anesthetized patient in supine position on the operating table. The leg to be operated on is slightly elevated and supported at the thigh by a Goepel leg holder so that the lower leg can be bent down, freely moved, and flexed toward the body during operation. The leg holder, directly adjacent to the table top, must form an evenly padded surface for the thigh. For this kind of operation in particular, leg holders in which the section of the sheath at the joint to the table top is less bent, have proved worthwhile.

Figure 65 illustrating the operative field from the foot end also shows the position of the sound leg, which is slightly bent and, for easier access, abducted, with the lower leg fastened to the leg plate. Depending on the size of the patient, his head is positioned on either the slightly elevated section of the dorsal plate or on a headrest that is mounted on the operating table. The neutral electrode is applied on the outer side of the extremity near the operative field and fixed to it so that it is in good contact with its entire surface without, however, causing pressure sores (cf. Fig. 2 and pp. 34 to 35).

Figure 66 demonstrates a modified position using a foldable leg plate. This does not, however, offer the leg lateral support during the operation, as does the sheath of the leg holder.

The patient's arm intended for the infusion must lie flat with its full length on the well-padded armrest. Even the pressure caused by the edges of the armrest and of the operating table can be harmful, e.g., causing a paralysis of the nervus radialis or nervus ulnaris, particularly when muscle relaxants are administered. Should the armrest be too short, a padded Cramer's splint may be used to bridge the gap.

It is equally dangerous to overstretch the arm (paralysis of the plexus) which applies

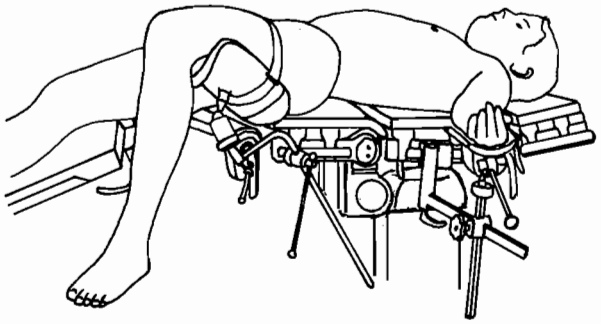

Fig. 64 Meniscus operation.

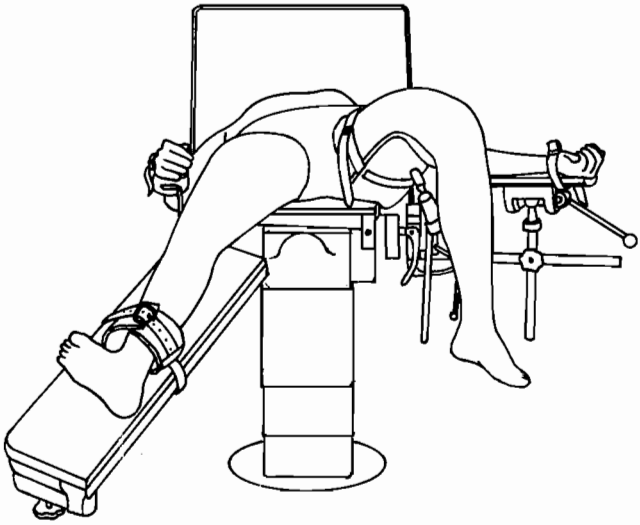

Fig. 65 Meniscus operation.

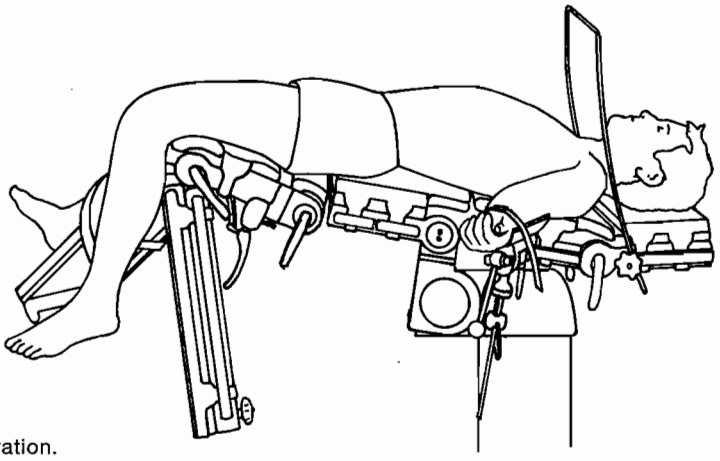

Fig. 66 Meniscus operation.

to an abduction of more than 90° as well as to the lowering of the arm. The risk of overstretching the bend of the elbow is less likely. It is best to keep the arm in a supine position (palm upward), slightly bent and raised to a position just slightly higher than the horizontal level. The other arm is placed laterally to the body on a padded cushion of about 40 cm length and 20 cm width and secured with a padded hand strap in order to prevent blood congestion, pressure sores, or the hand's slipping. Further changes in the patient's position, e.g., slight lowering of the head end of the table top, are carried out on the surgeon's instruction.

Humerus Operations

The operation can be performed either from the patient's shoulder (proximal: near, the part of an extremity that is near to the body) or from the elbow (distal: the part of an extremity that is farther away from the body).

Figure 67 demonstrates the patient's position for an operation using a distal approach with a wire extension through the olecranon attached to the traction device of the extension bar. Instead of this wire extension, a padded arm board is frequently used, whereby the traction is distributed over the entire surface of the forearm, which is strapped to it and bent.

Figure 68 shows the prepared, anesthetized patient in lateral position lying on his sound side. The x-ray image intensifier is parallel to the table top of the operation side for radioscopy in two levels. The countertraction is performed by means of a wide padded leather strap in the armpit, which is fixed to the traction device of the second extension bar behind the patient's back. A lateral support located at the patient's back serves as a useful counterpoint and braces the patient at the same time. See also Figures 69 and 70.

Pads positioned between the thorax and the table top and beneath the head, which is

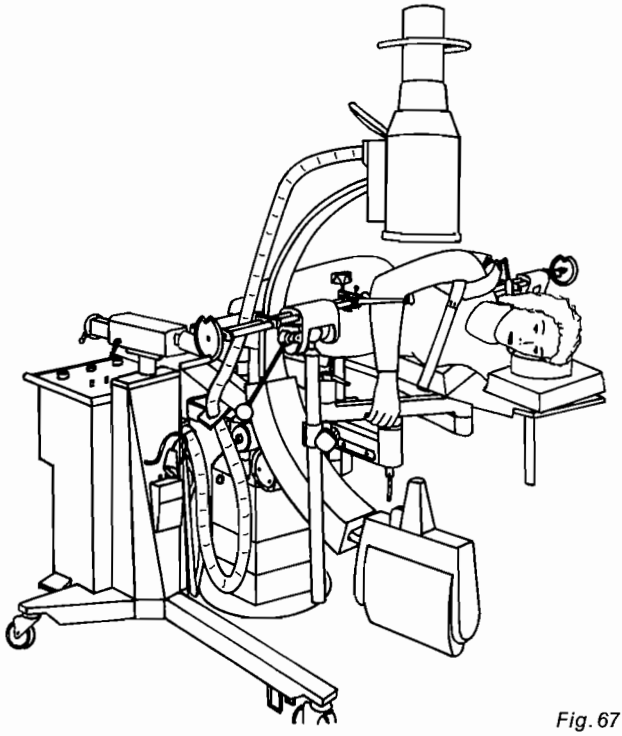

Fig. 67 Humerus operation.

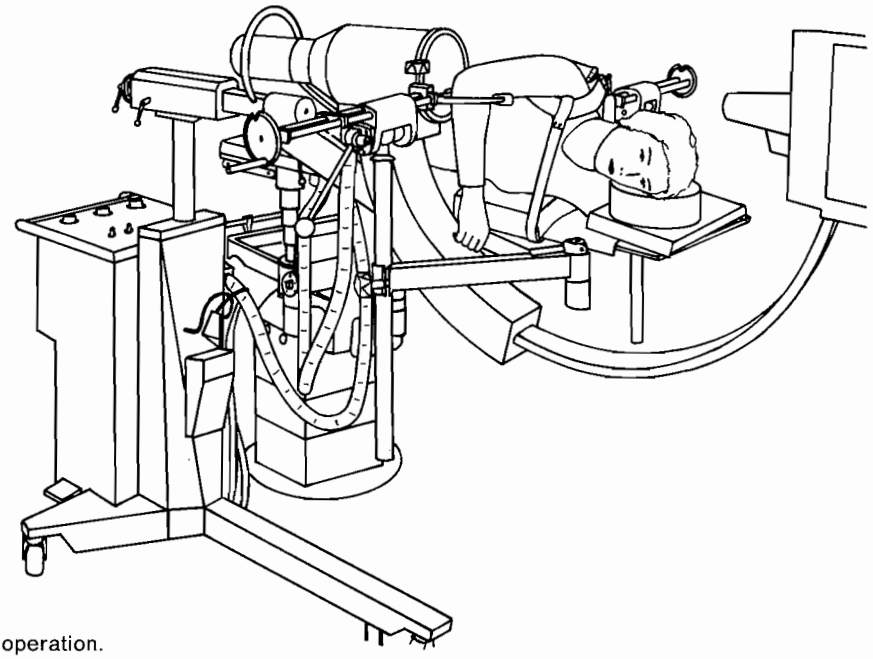

Fig. 68 Humerus operation.

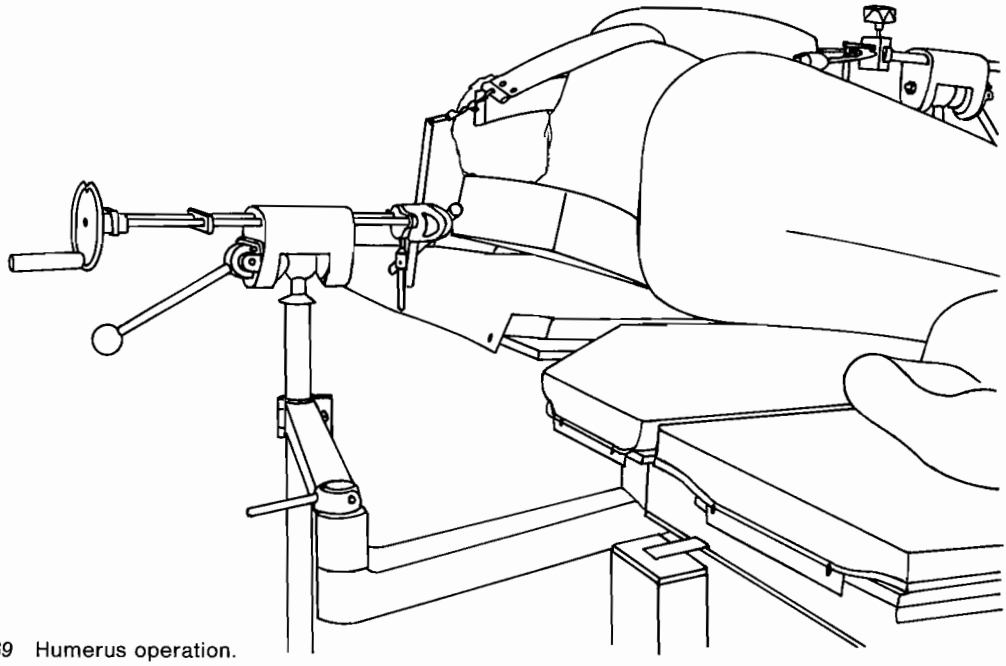

Fig. 69 Humerus operation.

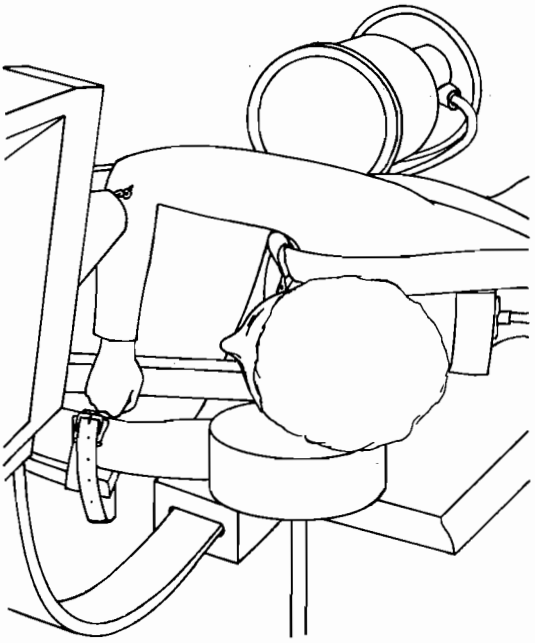

Fig. 70 Humerus operation.

turned sideways, or an adjustable headrest relieve the arm, which is positioned on the table and armrest outside the path of x-rays. The arm should be easily accessible for the anesthesiologist and must lie flat on the continuously padded surface. Even the pressure caused by the edges of the armrest and of the operating table can be harmful, e.g., causing a paralysis of the nervus radialis or nervus ulnaris, particularly when muscle relaxants are administered.

The neutral electrode is applied on the outer side of the extremity near the operative field and fixed to it so that it is in good contact with its entire surface without, however, causing pressure sores (cf. Fig. 2 and pp. 34 to 35).

The bottom leg is bent and drawn toward the body on the supporting surface, the top leg is slightly stretched. A pad is placed between the legs before they are secured with a wide strap. Figures 71 and 72 illustrate the same position on a mobile extension table with an x-ray image intensifier parallel to the table for radioscopy in two levels.

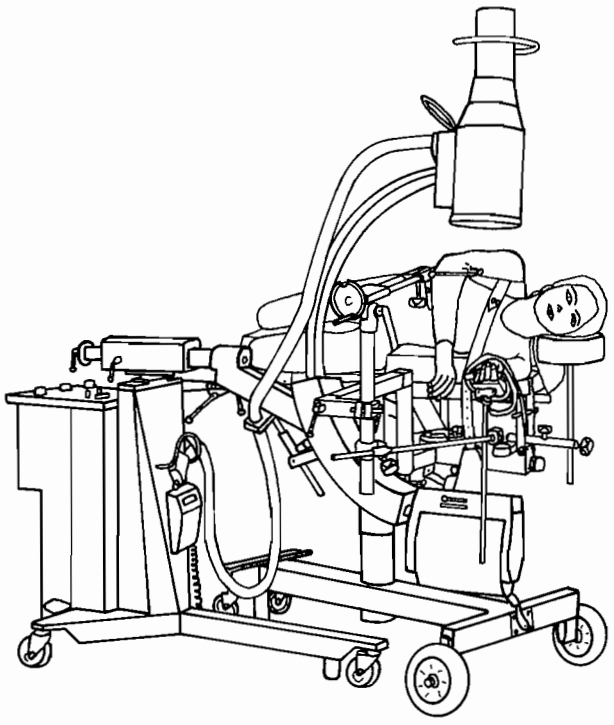

Fig. 71 Humerus operation.

Further adjustments of the position, e.g., height of the extension table and x-ray image intensifier, inclination of the table top and well measured extension traction are carried out on the surgeon's instructions.

Figure 73 shows the position for a proximal operation on a standard operating table.

The prepared, anesthetized patient is placed on the operating table in supine position so that his shoulder and thorax project on the side of the operation over the table top to ensure easy access to the upper arm for radioscopy. A pad lying between the body and the table top prevents pressure sores caused by the edges of the table and pads and elevates the operative field. By elevating the dorsal plate and slightly lowering the head end, the surgeon's access is made easier. The same applies to a slight tilting of the table top toward the sound side and the turning of the patient's head to the side. Lateral devices holding the thorax and the buttocks prevent the patient's slipping during tilting.

The arm to be operated on is slightly abducted and fixed to the extension device – with radiotranslucent padded supports serving as a countersupport in the armpit and in the elbow joint and using a hand strap. (For this purpose the arm board of the armrest can be replaced by the traction unit of the extension table, since the ball head on the vertical bars are standardized.) The neutral electrode is applied on the outer side of the extremity near the operative field and fixed

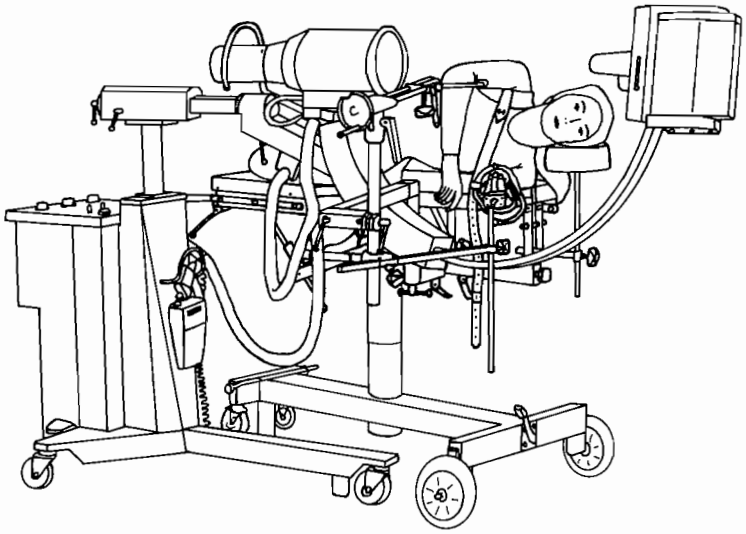

Fig. 72 Humerus operation.

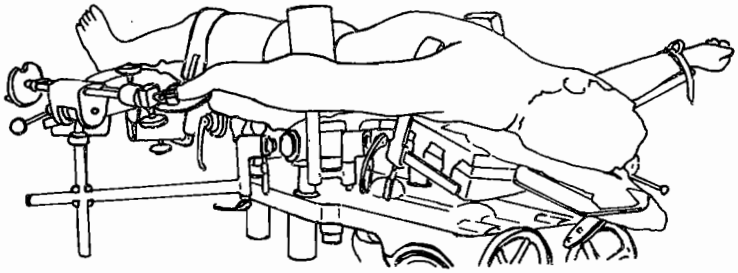

Fig. 73 Humerus operation – patient on a standard operating table.

to it so that it is in good contact with its entire surface without, however, causing pressure sores (cf. Fig. 2 and pp. 34 to 35).

The patient's arm intended for the infusion must lie flat with its full length on the well-padded armrest. Even the pressure caused by the edges of the armrest and of the operating table can be harmful, e. g., causing a paralysis of the nervus radialis or nervus ulnaris, particularly when muscle relaxants are administered. Should the armrest be too short, a padded Cramer's splint may be used to bridge the gap. It is equally dangerous to overstretch the arm (paralysis of the plexus), which applies to an abduction of more than 90° as well as to the lowering of the arm. The risk of overstretching the bend of the elbow is less likely. It is best to keep the arm in a supine position (palm upward), slightly bent and raised to a position just slightly higher than the horizontal level. The patient's legs are to be secured about 6 inches above the patella with wide padded straps, which must not be tied too tightly. The foldable leg plates or, in the case of anatomically different legs, pads serve as a support for the knee joints. These pads are also to be laid between the patient's legs and under his heels in order to avoid burns or pressure sores. Further adjustments and changes in the patient's position for the operation and for radioscopy are carried out on the surgeon's instruction.

For the proximal intramedullary nailing of the upper arm, the patient's position is almost always the same as the one just described (Fig. 73), with, however, a strongly adducted arm that is bent at the elbow joint until the hand of the sound side is on a level with the shoulder joint.

Radius and Cubitus Operations

The prepared, anesthetized patient is in normal dorsal position and, on the side to be operated on, close to the edge of the supporting surface. The arm to be operated on is abducted by almost 90° and the forearm bent by an angle of almost 90°. An adjustable, padded, radiotranslucent support serves as a countersupport in the elbow joint. As shown in Figures 74 and 75, the patient's hand is secured in the hand strap so that the thumb is pointing upward, is free and sticking out, and the hand is bent and flexed. Well-measured, even extension can be performed by means of the traction device with kilogram adjustment, which is fixed to the hand straps. (For this purpose, the arm board of the armrest can be replaced by the traction unit of the extension table, since the ball heads on the vertical bars are standardized.)

The patient's arm intended for the infusion must lie flat with its full length on the well-padded armrest. Even the pressure caused by the edges of the armrest and of the operating table can be harmful, e. g., causing a paralysis of the nervus radialis or nervus ulnaris, particularly when muscle relaxants are administered. Should the armrest be too short, a padded Cramer's splint may be used to bridge the gap. It is equally dangerous to overstretch the arm (paralysis of the plexus), which applies to an abduction of more than 90° as well as to the lowering of the arm. The risk of overstretching the bend of the elbow is less likely. It is best to keep the arm in a supine position (palm upward), slightly bent and raised to a position just slightly higher than the horizontal level. The patient's legs are to be secured about 6 inches above the patella, using wide padded belts, which must not be tied too tightly. The foldable leg plates or, in the case of anatomically different legs, pads serve as a support for the knee joints. These pads are also to be laid between the patient's legs and under his heels in order to avoid burns or pressure sores. The patient's head lies on an adjustable headrest on the operating table. Changes in the patient's position and repositioning is carried out on the surgeon's instruction or by himself.

The positioning of the patient already described can be achieved on all operating tables with relatively few devices. Apart from this, the forearm can be fixed after repositioning in the position necessary for the operation so that both positioning and the operation can be performed by one person.

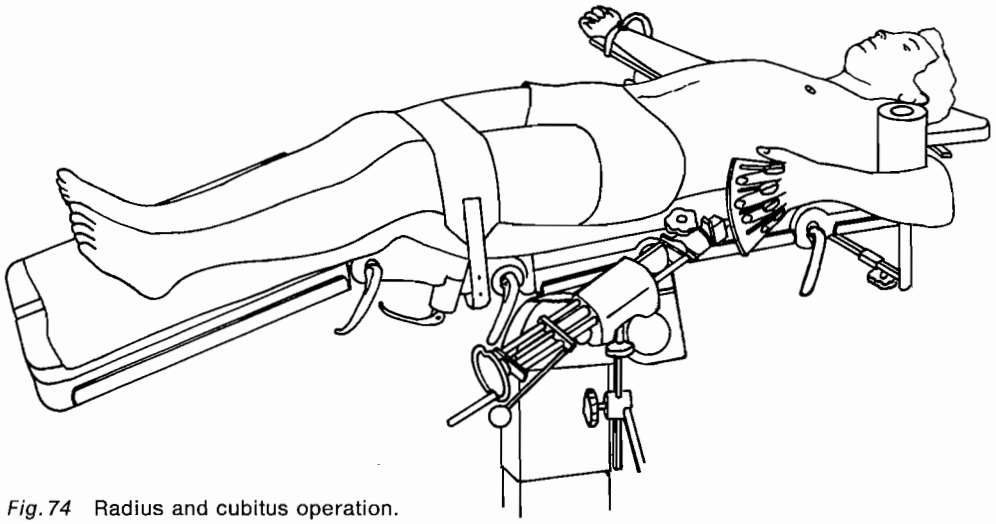

Fig. 74 Radius and cubitus operation.

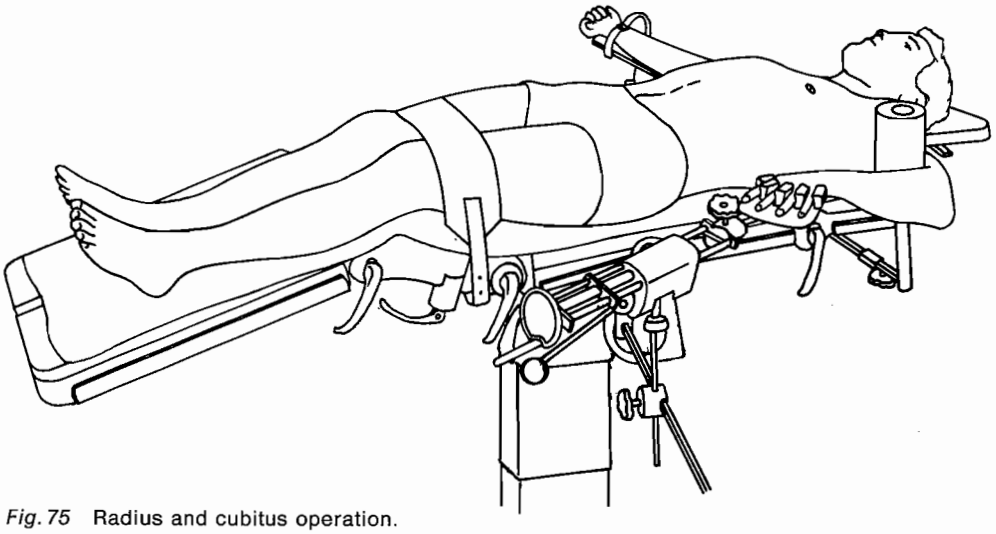

Fig. 75 Radius and cubitus operation.

Another frequently practiced technique of patient positioning for a forearm operation is similar to that described for the upper arm operation with the patient in a lateral position (cf. pp. 79–83). Instead of the wide strap in the armpit, an adjustable, padded, radiotranslucent support serves as a countersupport in the elbow joint. The abducted arm is bent at the elbow joint at an angle of 90° and extended with the traction device via the hand in the hand strap.

A simplified mode of this positioning is also common, whereby an additional radiotranslucent table or supporting board is used at the operating table. The abducted arm, which is bent at the elbow joint, is placed on the additional apparatus and repositioning is carried out by hand.

6 Surgery for Head Injuries

The patient's positioning for operations on the head are dependent on the type and place of the injury. These operations are carried out with the patient in normal supine position with the head in rest position, in normal supine position with the head turned to the side, and in prone position with the head in rest position.

In the case of cranial and cerebral trauma the supine position is recommended with the upper part of the body slightly elevated and the head in rest position to avoid or lessen the risk of an increase in the cerebral pressure.

Positioning in Injuries of the Facial Region

The patient is placed on the operating table in normal supine position. The separately adjustable padded segments of the table top are anatomically adapted to the patient to avoid pressure sores. The upper section of the dorsal plate and the head plate or headrest are raised slightly to elevate the operative field (Fig. 76).

The neutral electrode is applied on the outer side of the extremity near the operative

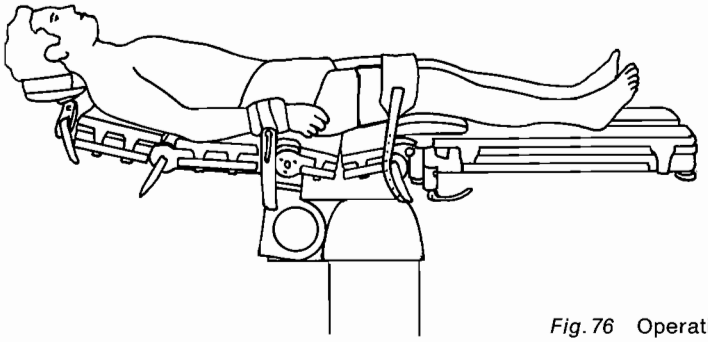

Fig. 76 Operation on the patient's facial region.

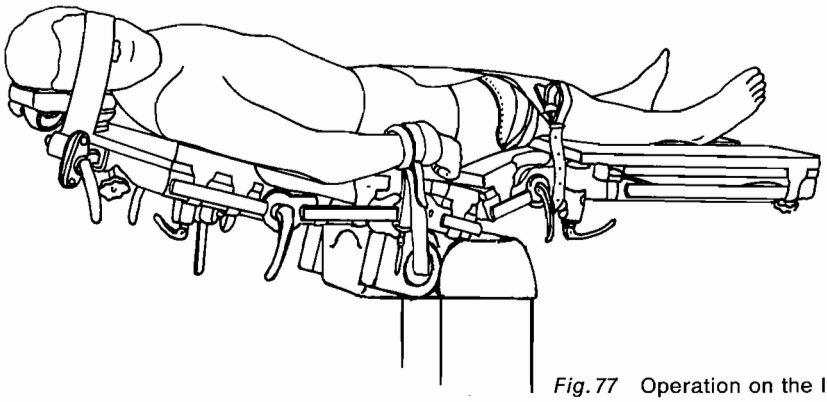

Fig. 77 Operation on the lateral head region.

field and fixed to it so that it is in good contact with its entire surface without, however, causing pressure sores (cf. figure 2 and pp. 34 to 35). The patient's arm intended for the infusion must lie flat with its full length on the well-padded armrest. Even the pressure caused by the edges of the armrest and of the operating table can be harmful, e.g., causing a paralysis of the nervus radialis or nervus ulnaris, particularly when muscle relaxants are administered. Should the armrest be too short, a padded Cramer's splint may be used to bridge the gap. It is equally dangerous to overstretch the arm (paralysis of the plexus), which applies to an abduction of more than 90° as well as to the lowering of the arm. The risk of overstretching the bend of the elbow is less likely. It is best to keep the arm in a supine position (palm upward), slightly bent and raised into a position just slightly higher than the horizontal level. The patient's legs are to be fastened about 6 inches above the patella with wide padded straps, which must not be tied too tightly. The foldable leg plates or, in the case of anatomically different legs, pads serve as a support for the knee joints. These pads are also to be laid between the patient's legs and under the heels in order to avoid burns or pressure sores.

Positioning in Lateral Head Injuries

Figure 77 shows the patient in the position described on p. 86 (Fig. 76).

The patient's head is turned sideways on the headrest and, if necessary, is secured after shaving with adhesive tape.

Positioning in Injuries to the Back of the Head

As shown in Figure 78, the patient is in prone position, and the separately adjustable padded segments are anatomically adapted to the patient's shape so that pressure sores are avoided. If the patient is corpulent, the table top can be adjusted in the abdominal region to form a hollow. The head is supported and held by a padded headrest in the region of the forehead. The arms are placed laterally to the body and held with hand straps. Flat cushions prevent the arms from developing pressure sores caused by the edges of pads or the supporting surface. If the arm is on an armrest following the anesthesiologist's instruction, pressure sores and overstretching should be avoided here, too. The neutral electrode is applied on the

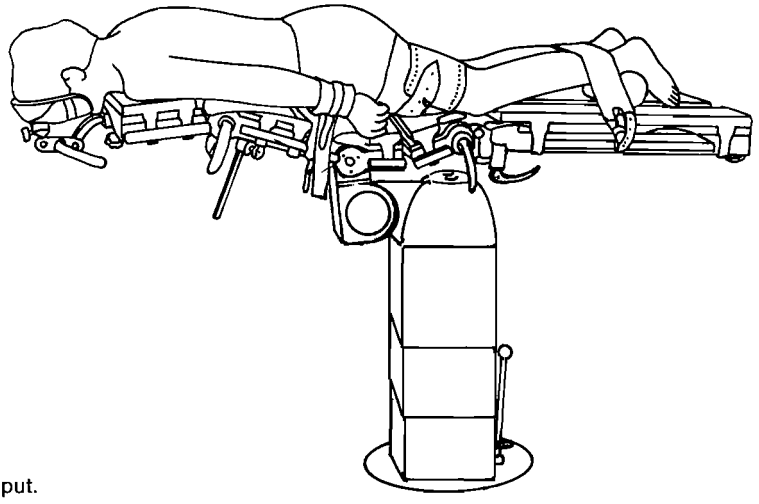

Fig. 78 Operation on the occiput.

outer side of the extremity near the operative field and fixed to it so that it is in good contact with its entire surface without, however, causing pressure sores (cf. Fig. 2 and pp. 34 to 35). The legs are positioned with the knees in the flex points of the leg plates; the lower legs are secured with wide belts and the feet are supported in the instep by a crescent-shaped pad. Before the operation is begun, the head is shaved and, if necessary, fixed with adhesive tape.

7 Neurosurgery

Neurosurgical operations are carried out with the patient in supine and prone positions, in sitting position, or in lateral, almost lying position. During such procedures, the patient is to be positioned particularly carefully to prevent pressure sores. The operative field must be easily and comfortably accessible to the surgeon. The same applies to the anesthesiologist, e.g., when working with measuring devices and monitors. Due to the fact that the patient's position must always be completely secure during this procedure, neurosurgery and especially microsurgery make great demands on the stability of the operating table and the special neurosurgical equipment. The positioning techniques to be described are of standard type. They can be modified, depending on the type of operation and on the surgeon's instruction.

Procedures with the Patient in Supine Position

As shown in Figure 79, the prepared, anesthetized patient is placed on the table top in the supine position with a shortened, one-piece dorsal plate instead of leg plates. The head is placed either on a horseshoe-shaped adjustable, padded headrest or immovably secured with a special neurosurgical head support (Mayfield skull clamp) whereby symmetrically arranged, adjustable metal pins are screwed into the skull bone. The latter case requires that the patient's body also remain absolutely fixed during the procedure. The adjustable and padded segments of the table top are anatomically adapted to the patient. As is shown in Figure 79, the divided pelvic plate is adjusted to form a hollow for the buttocks.

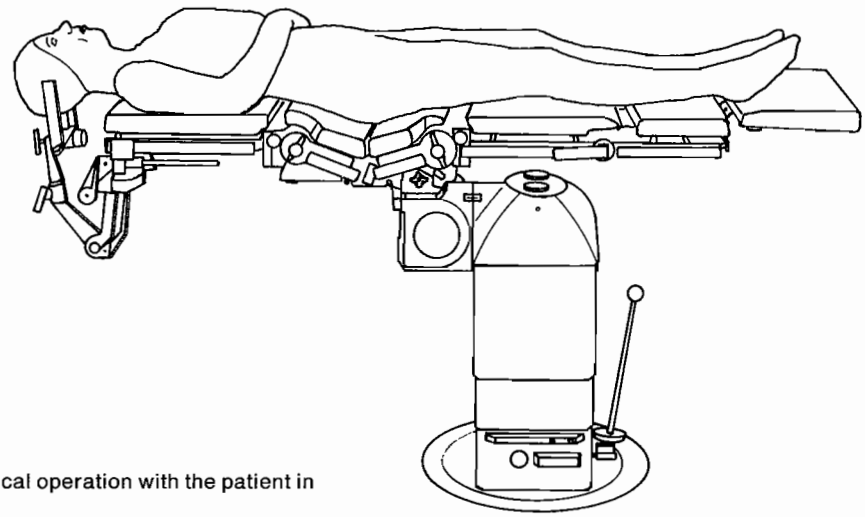

Fig. 79 Neurosurgical operation with the patient in supine position.

The patient's legs are to be secured about 6 inches above the patella, whereby the wide padded straps must not be tied too tightly. The foldable leg plates or, in the case of anatomically different legs, pads serve as a support for the knee joints. These pads are also to be laid between the patient's legs and under his heels in order to avoid burns or pressure sores. The neutral electrode is applied on the outer side of the extremity near the operative field and fixed to it so that it is in good contact with its entire surface without, however, causing any pressure sores (cf. Fig. 2 and pp. 34 to 35). The patient's arm intended for the infusion must lie flat with its full length on the well-padded armrest. Even the pressure caused by the edges of the armrest and of the operating table can be harmful, e.g., causing a paralysis of the nervus radialis or nervus ulnaris, particularly when muscle relaxants are administered. Should the armrest be too short, a padded Cramer's splint may be used to bridge the gap. It is equally dangerous to overstretch the arm (paralysis of the plexus), which applies to an abduction of more than 90° as well as to the lowering of the arm. The risk of overstretching the bend of the elbow is less likely. It is best to keep the arm in a supine position (palm upward), slightly bent and raised to a position just slightly higher than the horizontal level. The other arm is placed laterally to the body on a padded cushion of about 40 cm length and 20 cm width and secured with a padded hand strap in order to prevent blood congestion, pressure sores, or the hand's slipping.

Before the operation is begun, the patient's skull is shaved.

Procedures with the Patient in Prone Position

As shown in Figure 80, the prepared, anesthetized patient is positioned on the supporting surface in prone position with a shortened, one-piece dorsal plate instead of the leg plates. The head is placed with the forehead either on a horseshoe-shaped adjustable, padded headrest or immovably secured with a special neurosurgical head support (Mayfield skull clamp), whereby symmetrically arranged, adjustable metal pins are screwed into the skull bone, the latter requiring that the patient's body also remains absolutely fixed during the operation. Due to their adjustability, both head supports allow a maximum inclination of the head for procedures, e.g., for operations on the posterior cranial fossa or on the cervical part of the medulla. The adjustable, padded segments of the table top are anatomically adapted to fit the patient's shape.

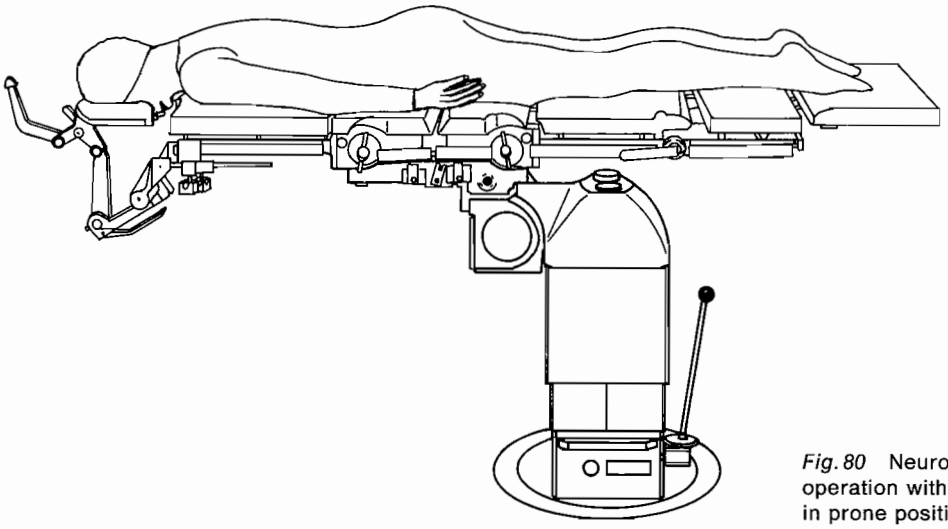

Fig. 80 Neurosurgical operation with the patient in prone position.

The abdominal region of the surface, for instance, is adjusted to form a hollow. The arms are placed laterally to the body, secured with hand straps and protected by means of flat cushions against pressure sores caused by the edges of the pads or the table top. If, on the anesthesiologist's instruction, the arm is on an armrest, pressure sores caused by lying flat or being overstretched should also be avoided. The neutral electrode is applied on the outer side of the extremity near the operative field and fixed to it so that it is in good contact with its entire surface without, however, causing pressure sores (cf. Fig. 2 and pp. 34 to 35).

The legs are secured with wide belts and the feet supported in the instep with a crescent-shaped pad.

Before the operation is begun, the patient's skull is shaved.

Operations with the Patient in Sitting Position

The prepared, anesthetized patient is moved from the supine position into the sitting position, as is shown in Figure 81. The shortened, one-piece dorsal plate, which was mounted in place of the leg plates, is raised at an angle of about 90° to the table top, and the head plate, which was used in the first stage of the operation, is removed together with the fixation device. The head, which is inclined to the front, is immovably secured with a special neurosurgical device (Mayfield skull clamp), whereby symmetrically arranged, adjustable metal pins are screwed into the skull bone. The head-holding device is fixed to a frame that was previously mounted on the sliding rails of the operating table.

The operative field above the shoulder blades projects in the form of a bow, and a further inclination of the proximal end of the table top not only brings the patient into a well-balanced position with regard to his center of gravity, but also allows easier access for the surgeon. Before the patient is additionally supported and secured at the side of the thorax, which can be carried out using padded lateral supports, gauze, or wide adhesive tape, it should be checked that the patient is lying flat with his whole body on the surface and that no contusions due to skin folds are caused when the dorsal plate is

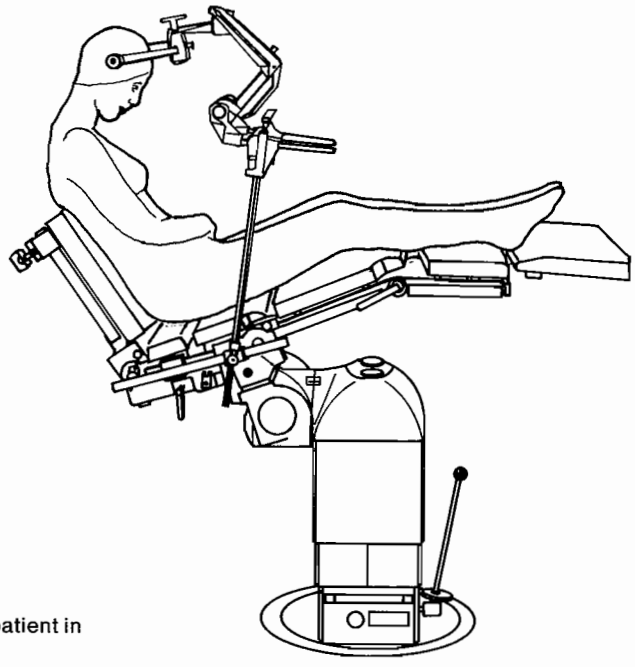

Fig. 81 Neurosurgical operation with the patient in sitting position.

raised. The padded segments of the supporting surface are to be anatomically adapted to the patient. The neutral electrode is applied on the outer side of the extremity near the operative field and fixed to it so that it is in good contact with its entire surface without, however, causing pressure sores (cf. Fig. 2 and pp. 34 to 35).

The patient's legs are to be secured about 6 inches above the patella, whereby the wide padded straps must not be tied too tightly. The foldable leg plates or, in the case of anatomically different legs, pads serve as a support for the knee joints. These pads are also to be laid between the patient's legs and under his heels in order to avoid burns or pressure sores. The patient's arm intended for the infusion must lie flat with its full length on the well-padded armrest. Even the pressure caused by the edges of the armrest and of the operating table can be harmful, e.g., causing a paralysis of the nervus radialis or nervus ulnaris, particularly when muscle relaxants are administered. Should the armrest be too short, a padded Cramer's splint may be used to bridge the gap.

It is equally dangerous to overstretch the arm (paralysis of the plexus), which applies to an abduction of more than 90° as well as to the lowering of the arm. The risk of overstretching the bend of the elbow is less likely. It is best to keep the arm in a supine position (palm upward), slightly bent and raised to a position just slightly higher than the horizontal level. The other arm, resting on a flat pad, is laid with the bent forearm on the patient's body and secured with gauze or wide adhesive tape. This positioning can also be used for both arms, with the hands lying one on top of the other. Before the operation is begun, the operative field is to be shaved.

In all cases, however, it must be possible to change the patient's sitting position immediately back to the original supine position, should the general constitution of the patient worsen during the procedure.

Operations with the Patient in Lateral Semi-lying Position

The prepared, anesthetized patient is moved from the supine position into the lateral position with his back near to the edge of the table top. The degree of lateral inclination of

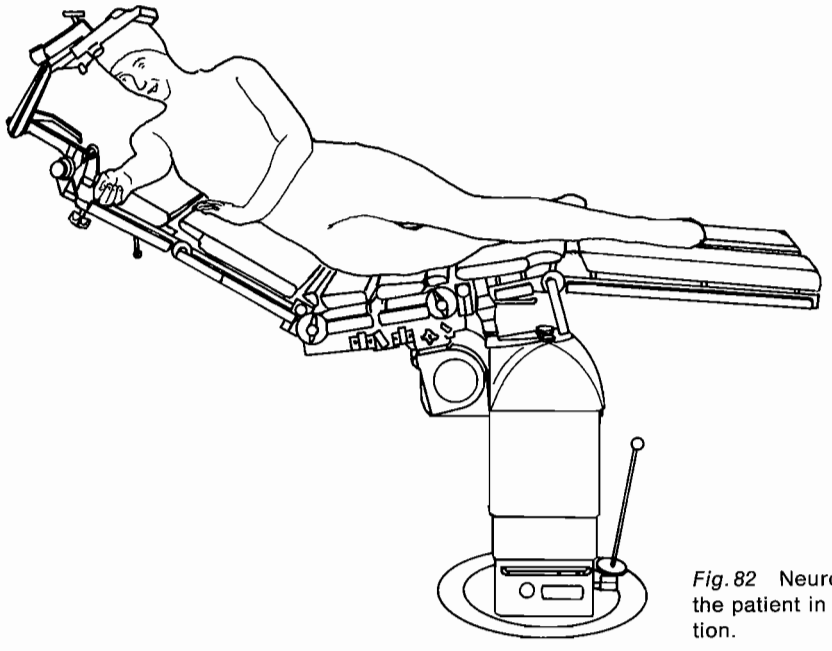

Fig. 82 Neurosurgical operation with the patient in lateral semi-lying position.

the patient's head and thorax depends on the type of operation or on the surgeon's decision. The head is immovably secured with a special neurosurgical device (Mayfield skull clamp), whereby symmetrically arranged, adjustable metal pins are screwed into the skull bone. The dorsal plate is elevated according to the surgeon's instructions and the entire table top slightly lowered toward the head end. The patient is secured with padded lateral supports in the thorax and pelvic regions. The neutral electrode is applied on the outer side of the extremity near the operative field and fixed to it so that it is in good contact with its entire surface without, however, causing pressure sores (cf. Fig. 2 and pp. 34 to 35). The patient's arm intended for the infusion must be easily accessible and lie flat and free of pressure on the padded armrest, since even the pressure caused by the edges of the armrest and of the operating table can be harmful, e. g., causing a paralysis of the nervus radialis or of the nervus ulnaris, particularly when muscle relaxants are administered. The other arm, resting on a flat pad, is laid with the bent forearm on the patient's body and secured with gauze or wide adhesive tape. The bottom leg is bent and drawn up toward the body on the table top. The top leg remains stretched. A pad is placed between the legs before they are secured with a wide strap. The flexible leg plates can be anatomically adapted to the patient. Before the operation is begun, the operative field is shaved (cf. Fig. 82).

Positioning of the Patient for Procedures on the Intervertebral Disks or for Laminectomies

Since the positions are the same as those described for vertebral operations, please refer to pp. 60 to 62, "Surgery on the Apparatus of Locomotion", and "Vertebral Operations."

8 E.N.T.

The prepared, anesthetized patient is positioned on the operating table in the supine position so that his shoulders are at the edges of the table top. The upper section of the dorsal plate is slightly elevated and the head reclined on the head plate or headrest. The position of the head and neck depends on the type of operation. The neutral electrode is applied on the outer side of the extremity near the operative field and fixed to it so that is is in good contact with its entire surface without, however, causing pressure sores (cf. Fig. 2 and pp. 34 to 35). The patient's arm intended for the infusion must lie flat with its full length on the well-padded armrest. Even the pressure caused by the edges of the armrest and of the operating table can be harmful, e.g., causing a paralysis of the nervus radialis or nervus ulnaris, particularly when muscle relaxants are administered. Should the armrest be too short, a padded Cramer's splint may be used to bridge the gap.

It is equally dangerous to overstretch the arm (paralysis of the plexus), which applies to an abduction of more than 90° as well as to the lowering of the arm. The risk of overstretching the bend of the elbow is less likely. It is best to keep the arm in a supine position (palm upward), slightly bent and raised into a position just slightly higher than the horizontal level.

The other arm is placed laterally to the body on a padded cushion of about 40 cm length and 20 cm width and fastened with a padded hand strap in order to prevent blood congestion, pressure sores, or the hand's slipping.

The patient's legs are to be secured about 6 inches above the patella using wide padded straps, which must not be tied too tightly. The foldable leg plates or, in the case of anatomically different legs, pads serve as a support for the knee joints. These pads are also to be laid between the patient's legs and under his heels in order to avoid burns or pressure sores. Figure 83 shows the standard position for the operation. Depending on the type of operation, the positions of the backrests and headrests can be modified.

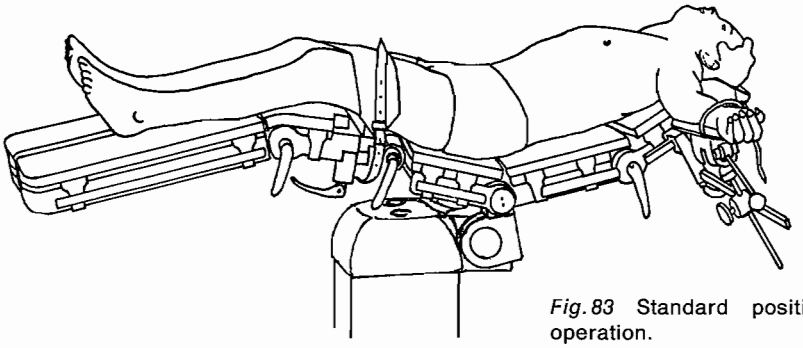

Fig. 83 Standard position for otolaryngologic operation.

9 Pediatric Surgery

(F. Rehbein)

General

There are a few general fundamental distinctions between the positioning of children and adults for an operation. The child's body, which is smaller and weighs less than that of an adult, can be brought into every required position more easily and also be kept in this position with less complicated methods of fixation. Even during the operation, corrections can be made without great disturbances and without running the risk of a septic environment, although one should always endeavor to attain the ideal position from the start. Our experience has shown again and again that for a child, especially for a small child, neither a flexible table top nor an adjustable bench is needed. A device for lifting or lowering the head end of the operating table is also unnecessary. The elevation of the parts of the body for operation can be achieved by placing firm rolls, half rolls, sandbags or, in the case of newborn babies, just a small rolled up towel. It is, of course, necessary to have a number of rolls, half rolls, and sandbags of different sizes available. An operating table that is equipped with a continuous and, of course, radiotranslucent top is therefore sufficient for pediatric surgery. This top must be much narrower than that for adults, since this table must suffice for all pediatric surgical operations, including those for small premature babies. Since, for the positionings for pediatric surgery, a simple top is sufficient, complicated units are unnecessary.

The space under the table top can thus remain free so that the surgeon and his assistants are in a position to perform these frequently long operations on small patients from a sitting position, preventing their becoming tired too quickly.

Problems arise during positioning for pediatric surgery due to the different sizes. For premature infants weighing 1800 g, other aspects must obviously be taken into account than for 12-year-old children, especially since today children of that age are sometimes as large as adults.

Special care is to be taken before and during operations on babies and infants to prevent loss of heat. Children should never lie uncovered for longer than necessary. There are various methods of preventing decrease in body temperature (cf. p. 31). It has also proved worthwhile to position the child on rubber sheets that are filled with water at a suitable temperature. The sheets are connected to a hyperthermy device. The anesthesiologist can start the flow of water according to the body temperature. The size of the sheets is adapted to suit the table dimensions and the size of the child's body.

For operations on the thorax and abdomen and for renal surgery on newborn babies, it is often sufficient to elevate the thorax or the abdomen with a small rolled up towel. To secure the body during operations on the thorax, it is sufficient to fasten the pelvis to the table top using 2 cm wide adhesive tape (Fig. 84). During abdominal operations, both legs are secured to the table top with adhesive tape, which, as in the case of the leather belt for adults, is applied above the patellas over the thighs.

The cushion that was used to elevate the thorax or abdomen during the operation is removed from the head end of the table before wound closure. To make this easier, the operator can slightly raise the child's thorax, abdomen or pelvis.

In the case of children who are a few months old, the part of the body to be operated on must be elevated a little more.

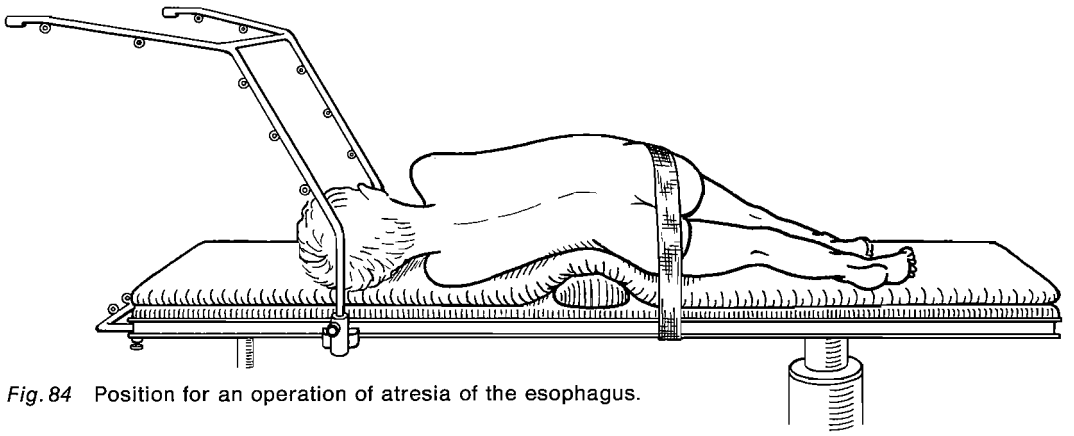

Fig. 84 Position for an operation of atresia of the esophagus.

A small roll, half roll, or a sandbag can be used for this purpose. The pelvis or legs are secured on the table. Up to the age of 3 or 4 years, this can be done using adhesive tape. The type of roll used depends on the child's size and the individual case. The surgeon himself should always make sure of the adequate position prior to pediatric operations.

In the case of a lateral position it is advisable to place a sandbag to the right or left side of the thorax or pelvis, to prevent the body from rolling forward or backward during the operation. This is a convenient method and ensures sufficient stability.

Whereas the arms of newborn babies, babies, and children up to 2 years may be raised, this is not allowed for children older than 2 years, in order to avoid the risk of a paralysis of the plexus, as is the case with adult patients. The wrist joint is fixed with a lined leather loop that is attached to a leather strap and is movable. Extreme elevation of the arms in the shoulder area should, of course, also be avoided in a child of more than 2 years of age.

The larger and older the child, the more the positioning techniques for each operation resemble those described for adults. Some operations can then hardly be carried out from a sitting position, and it is left to the surgeon to decide from what age it is better to perform the operation on an operating table for adults.

Special Positions

With suitable modifications to these general principles of positioning, it is possible to perform all special positionings. For operations on the face, the head is secured on the table with adhesive tape (Fig. 85). A wide cloth is wrapped around the patient's trunk. Wrapping the babies on a board for a cheiloschisis operation is thus unnecessary. For abdominal operations and operations on the diaphragm, for renal operations, pyloric stenoses, or biliary atresia, a cushion, a roll, or half roll of suitable size is laid beneath the operative field. Likewise a roll or half roll is always sufficient for renal operations, where the incision begins from

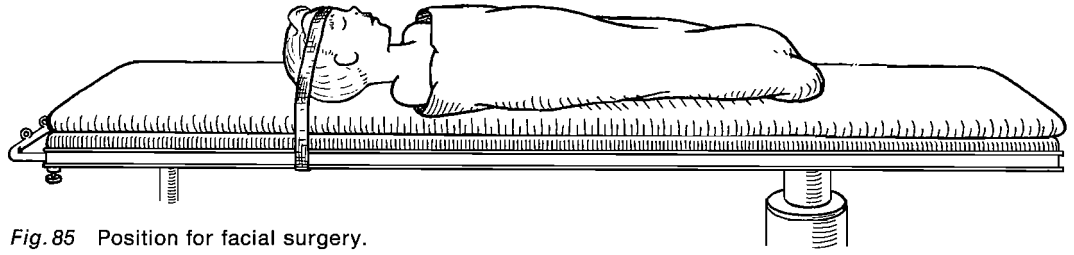

Fig. 85 Position for facial surgery.

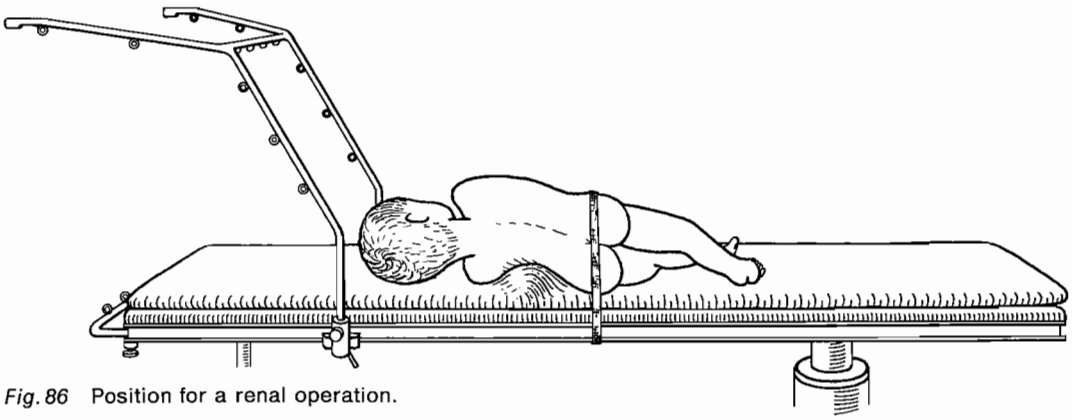

Fig. 86 Position for a renal operation.

the side. By strongly securing the pelvis on the table top using adhesive type the side is lifted and is thus sufficiently taut.

For the positioning of the patient for a thorax operation, a sandbag is laid to the right and left of the body in order to prevent the trunk's rolling forward and backward. Before wound closure, the roll is removed from beneath the cloths from the head end by slightly lifting the body.

Bladder Operations

For hernia operations, it is best to lay a sandbag of suitable size under the buttocks to make the groin region easily accessible for the operation.

The thighs are secured on the table top either with adhesive tape or with a strap. The same positioning can be considered for operations on male genitalia.

The same positioning is used for operations on the bladder, neck of the bladder, and for an abdominal colon resection due to Hirschsprung's disease (Fig. 87). Sometimes, e.g. in the case of congenital diaphragmatic hernia, it cannot be certain whether an abdominal operation will be sufficient, or whether it may be necessary to open the thorax, too, or vice versa. If this is to be expected, it is advisable to take this into consideration prior to the operation when the patient is being positioned and covered.

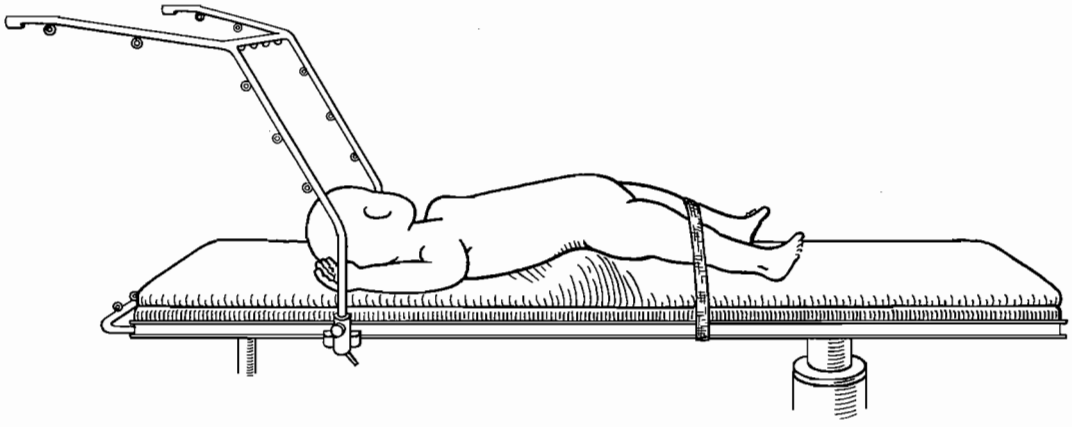

Fig. 87 Position for operations on the pelvis, e.g., for operations due to Hirschsprung's disease.

Anal Atresia and Colon Atresia

Special care is to be taken with regard to positioning for operations of anal atresia and colon atresia with vaginal or urethral fistulas. Since, in this case, an ileoanal passage with end-to-end anastomotic operation is often necessary (pull through operation), positioning and covering of the patient are carried out in such a way that it is easily possible to change from the abdominal operative field to the operative field of the perineum, and vice versa. The anesthetized child is raised and abdomen, back, buttocks, perineum, genital region and both thighs are disinfected. The table is covered and the child's buttocks positioned on the cushion lying under the covering cloth. Each leg is wrapped in a small sterile cloth that is fastened with gauze. Despite this, it is possible to apply the continuous intravenous drip to the right or left malleolar vein. In this position and using this covering it is possible to raise and spread the legs with the abdomen open in order to perform the anastomotic operation and to change over to the perineum region without endangering the aseptic environment. After completion of the perineal part of the operation, the legs are laid down again and the abdominal part of the operation can be continued.

We have often performed fistula operations in the region of the rectum and vagina in prone position with raised buttocks. Here, too, the simple position using a suitable cushion or roll has always proved sufficient with regard to easy access and good view. Special leg supports have proved unnecessary for babies, and such operations are in most cases carried out on children of this age.

Radiographic Diagnosis during Operation

Apart from radiographs during surgical procedures on the skeletal system or when searching for foreign bodies, radiographic examinations during operations are required in pediatric surgery for different reasons. During the Spitz-Holter operation for hydrocephalus, the position of the catheter inserted into the vena cava must be monitored. In the case of biliary atresia it is sometimes necessary to perform a cholangiography. In the case of portal hypertension, contrast radiographic studies are necessary and in many cases the additional contrast radiographic study of the upper urinary passages has proved worthwhile during the operation, especially in cases of complicated abnormalities of the kidneys and ureters. These examinations can be performed on radiotranslucent operating tables with the x-ray image intensifier and movable x-ray apparatus. It is true that the removal and repositioning of the sandbag or roll may be a nuisance, but due to the low weight of the children, this can usually be done without problems.

Conclusion

The principles of positioning in pediatric surgery described here are based on personal experience gathered over 12 years of work. The basic principle is simplicity. It has been seen that it is possible to achieve ideal positions and easy access for the various operations using the simplest techniques. The surgeon's sitting position, which is nearly always possible, increases the endurance and concentration of the surgeon, which is of benefit to the patient.

It is certainly a question of practice, how well one can handle such simple means to achieve a good, stable position. Skilled assistants are necessary, since this is a matter of subtleties, as in many other cases.

Of course, in a number of special positions it is decisive which operative technique the surgeon prefers to use. It is not necessary to go into detail concerning the varying circumstances that can and do give rise to considerable differences of approach in different hospitals.

10 Laparoscopy

This chapter was included due to the fact that the laparoscopy is one of the many endoscopic studies that is invasive, thus making high demands on the positioning of the patient and the flexibility of the operating table and the x-ray equipment.

Figure 88 illustrates the patient on the endoscopy table in one of the various positions for examination that are used for laparoscopy. The examining doctor is shown, too, in order to illustrate the relaxed working position.

The patient is positioned on the endoscopy table in normal supine position and supported by means of padded supports for the feet, shoulders, and the trunk in the pelvic area. These supports are mounted on the accessory rails of the table. The patient's arms are placed laterally to the body and secured with hand straps.

Since the laparoscopy does not only include hepatoscopy, but also the examination of other organs in the upper and lower abdomen (gallbladder, stomach, spleen,

Fig. 88 Position of the examining doctor and of the endoscopy table with the covered patient during a laparoscopy.

uterus), the table top of the endoscopy table is modified according to the instructions of the examining doctor:

- Inclination to the left or to the right by about 45°
- Simultaneous elevation of the head up to about 30°
- Electrically moved and adjusted in height so that the examining doctor can work in a relaxed position, and that unhindered studies with the x-ray image intensifier are possible at the same time

For the examination of organs of the lower abdomen a less extreme position of the table top is required:

- Lateral inclination
- Lowering of the head end (Trendelenburg's position)

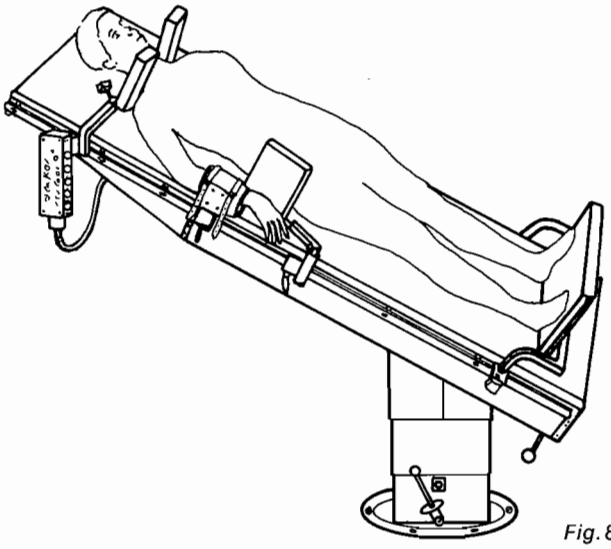

Fig. 89 Positioning for a laparoscopy.

Glossary

Abdominal — pertaining to the abdomen

Abduction — movement away from the axis of the body, i.e., raising of the arm to the outside or spreading of fingers

Adduction — opposite of abduction

Aerobe — microorganism that can live and grow in oxygen

Aerogenic infection — infection caused by a gas-producing microorganism

Anaerobe — in the absence of oxygen

Anaerobes — microorganism that can live and grow without oxygen

Analgesia — insensibility to painful stimuli without loss of consciousness

Anatomy — science of structure and relationship of the parts of the body

Anteroposterior — passing from front to back, said of the projection of x-rays, i.e., in relation to the anatomic part

Appendectomy — excision of the vermiform appendix

Asepsis — sterile, free of microorganisms and from infection

Atresia — absence of normal body opening, as of the mouth, anus

Axial — pertaining to the axis, a real or imaginary line that runs through the center of a body or about which a part revolves

Coagulate — to cause to change from a fluid to a semisolid state

Condylus — any rounded eminence on a bone, usually for articulation, especially the femur, humerus, and mandible

Conservative treatment — preservation rather than excision or physiologic alteration

Cramer's splint — flexible wire splint that can easily be cut to length, in the form of a ladder with two strong longitudinal wires and thinner transverse wires

Cross-infection — infection that a patient contracts from another patient

Dielectric — an insulating medium in which a moderate electric field once established may be maintained with minimum loss of energy

Diffusion — slow penetration and mixing of gases and liquids during direct contact

Drainage unit — semi-high washing and drainage sink (about 60 cm) in the surgical department, frequently made of chrome-nickel steel and equipped with lateral wall flush, dispenser for disinfectant, and splash guard

Electrocardiograph — instrument that receives electrical impulses as they vary during the cardiac cycle

Electromedical instruments — instruments for examination (diagnosis) and treatment of diseases using electric current

Electroresection — excision by means of electrocautery using an electrosurgical unit in which the active electrode serves as a scalpel (cf. p. 30)

Endemy — a disease present in a community at all times, i.e., not ending state of contamination

Endogenous — produced within the body

Endoprosthesis — prostheses to replace tissue or parts of organs by implanting foreign material (artery, knee, hip, elbow)

Endoscope — instrument consisting of a light and lenses used for the examination of the interior of body cavities

Ergonomics — science concerned with the relationship between human beings, the machines they use, and the working environment, but frequently used as a general term for anatomical, physiological, psychological, and mechanical principles of work

Exogenous — produced outside the body

Extension — straightening out of a limb

Extremity — the distal, or terminal, end of any part

Flexion — the bending of a limb

Fracture — break, as a bone

Functionalism — in architecture, period since 1920 emphasizing the elements of a building, giving all components a form according to their practical use and supporting "esthetics of machines"

Ganglion — a group of nerve cell bodies located outside the central nervous system

Ganglionic blocker — drugs that, by a paralysis of the ganglia, cause vasodilation and thus a reduction in blood pressure

Germ protection wall — additional dividing wall in the operating room between the operative field and the anesthesia field or traffic area with a cut out for operating table and patient; using the plastic apron, the patient's head in the working field of the anesthesiologist can be separated from the operative field

Gynecology — branch of medicine that deals with diseases and disorders of the genital tract of women

Herniotomy — an operation for the correction of irreducible hernia

Hiatus hernia — protrusion of the stomach or intestine through the esophageal hiatus of the diaphragm

High-frequency surgical instrument — cf. p. 30

Horizontal — in a plane parallel to the ground or a base line, at right angles to the vertical axis

Hospitalism — see p. 1

Hydrocephalus — increased cerebrospinal fluid within the ventricles of the brain, often with abnormal enlargement of the skull

Hydrophobic — insoluble in water, or not readily absorbing water

Induction — electrical current produced according to Faraday's law at the ends of a coil as long as the magnetic flux is varying in a field surrounded by a coil; induction is the result of a close interaction between electrical and magnetic fields (electricity)

Infusion — the introduction of solutions into the intestine or bladder or subcutaneous tissue or a vein

Insufflation anesthesia — anesthesia produced by the inhalation through a tube, which has at its lower end an inflatable cuff. The tube is introduced into the patient's respiratory system, the cuff is inflated so that it is in contact with the wall of the trachea, thus making it tight

Intraoperative — during the time of a surgical operation

Laparoscopy — method of examining the peritoneal cavity by means of an endoscope

Meniscus — crescent-shaped interarticular wedge of fibrocartilage in the knee and other joints

Microorganisms — microscopic organism, either animal or plant, especially a bacterium or protozoan

Muscle relaxants agent that lessens or reduces tension or produces relaxation of striped muscles

Necrosis pathologic death of a cell or group of cells in contact with living cells

Nosocomial pertaining to a hospital

Paralysis of the ulnar nerve paralysis of the ulnar nerve of the forearm

Paralysis of radialis nerve paralysis of the radial nerve of the arm

Paralysis of plexus paralysis of the network of spinal nerves

Parenteral outside the intestine

Patella a sesamoid bone in front of the knee

Perineum region between the anus and the genitals

Pneumonectomy excision of a complete or part of a lung

Portal vein the vessel that conducts blood from the gastrointestinal tract into the sinusoids of the liver

Proctoscopy inspection of the anus and rectum with a proctoscope

Pronation the turning of the palm of the hand downward or backward

Prostatectomy excision of part or all of the enlarged prostate

Pyloric stenosis obstruction of the pyloric orifice of the stomach, usually congenital

Pyrogen producing fever

Quenu (French surgeon) operation for rectal carcinoma

Radius the outer of the two bones of the forearm

Rectum the distal portion of the large intestine

Reposition return of an abnormally placed part to its proper position

Resection operation of cutting out, as the removal of a section or segment of an organ

Resectoscope tubular instrument by means of which small structures may be divided or removed from a body cavity without an opening or incision other than that made by the instrument itself

Rib resection also called costectomy; excision of all or part of a rib

Rotate to roll, to turn

Sacral pertaining to the sacrum

Secure to fasten, to fix

Supination the turning upward, e.g., of hand and forearm

Supracondylar above a condyle

Thoracoplasty the mobilization of the chest wall by the resection of any number of ribs, wholly or in part, in order to produce collapse of the lung and obliteration of the pleural cavity or reduction of the thoracic space

Thorax the chest

Transurethral through the urethra

Trendelenburg's position (Friedrich Trendelenburg, Berlin 1844–1924) the posture of a patient lying supine on a table that is tilted head downward 45° or less and flexed at the knees

Trochanter major a process situated on the outer side of the upper extremity of the femur

Ulna the bone on the inner side of the forearm

Vaginal operation operation on or through the vagina

Vertical perpendicular to the plane of the horizon, at right angles to the horizontal axis

Virulent infectious, noxious

Wire extension traction on a bone using a wire that is screwed through the bone and tensed by means of frames

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