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69. Operating Tables – the Surgeon's Workplace

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The central element of any operating theater is without a doubt the operating table. Wherever surgical interventions are carried out, operating tables are essential. Accordingly, the variety of tables available is very wide, ranging from simple, mobile operating room (OR) tables, right up to OR table systems with various, special OR table tops.

The type, design and functional properties of the OR table depend on the surgical discipline, the ergonomic requirements of the surgical team and, last but not least, on the financial resources available.

Simple OR table designs are usually deployed in hospitals with smaller surgical departments as well as in larger hospitals with decentralized operating theaters like, for example, those with emergency department operating rooms (Fig. 69.1).

They are also often used for out-patient surgery, in so-called day clinics, or out-patient operating cen-

Fig. 69.1 Operating table for outpatient surgery

Fig. 69.2 Mobile operating table with electrical autodrive function

ters. These OR tables can be upgraded and modified by adding various accessories and, depending on the model, can be adjusted manually or electrically. An electrical autodrive function may also be implemented, assuming patient logistics calls for it (Fig. 69.2).

Modern OR table systems are characterized by the fact that the intervention-centric table tops mean they are optimized, on the one hand, to meet the special requirements of the individual surgical disciplines regarding the best patient positioning and best access to the surgical field and, as such, are a significant factor contributing towards the success of the surgical intervention. On the other hand, however, they also meet technical requirements in terms of stability and hygiene and the use of x-ray equipment.

69.1 The History of the Operating Table

Some 150 years ago, when asepsis was not even on the agenda, operations were normally carried out in the patient's bed. However, because of low bed heights, surgeons started to place their patients on higher tables, in order to gain better access to the surgical field and to give themselves a more ergonomic working position (Fig. 69.3).

The development of OR tables has kept pace with the development of surgery itself. It has occurred more or less in parallel with the continually expanding knowledge and ability of the surgeons and, over time, has been significantly influenced by specialization in the individual surgical disciplines.

Medical developments have called for improved access to the surgical field and, therefore, brought about improved patient positioning. This resulted in the emergence of *OR furniture* with table tops divided up into head, back, seat, and leg plates (Fig. 69.4).

Improvements in operating techniques made it necessary to be able to raise certain parts of the body (at the point of incision), to provide better access to the interior of the body and then to return them again to the flat position, after closing up.

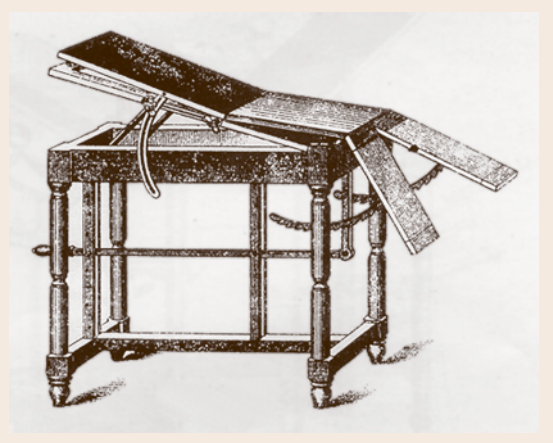

Fig. 69.3 Historic operating room furniture

Fig. 69.4 Segmented operating table top

Over the course of the last 70 years, general surgery has divided into individual surgical disciplines. The result of surgical specialization has been the development of special OR tables that differ in terms of the table top geometry and the layout of the various operating elements.

In the case of head operations, for example, no operating elements may be installed in this area of the OR table, as they may not be handled by nonsterile personnel during the operation, which could impact on overall sterility. As a result, special OR tables were developed for head operations.

The development of OR tables, with ever more complex table top adjustment options for other specialist surgical disciplines, followed at the same time.

A further significant factor that influenced the development of OR tables were the achievements of intraoperative imaging. It is impossible to imagine an OR these days without a mobile x-ray amplifier (Fig. 69.5).

The call for the combining of further imaging processes such as CT and MR with OR tables, has led to an increase in the use of materials other than steel, such

Fig. 69.5 OR table for use with mobile x-ray amplifier

Fig. 69.6 Advanced workplace for image guided surgery (AWIGS)

as plastics reinforced with carbon fiber, as these ensure low-artifact radiolucence (Fig. 69.6).

69.2 The OR Table System

As surgeons required ever more specialized OR tables, tailored to particular operations, the development of mobile OR tables was extended to include, not just the division of the table tops but also to the table columns and/or their separation from the actual table tops, which brought with it further advantages and simplifications. The idea of an OR table system consisting of a column, a removable table top, as well as a transporter for the table top was born (Fig. 69.7a–c).

The predecessors of the current modern OR table systems had a mobile table column mounted on castors, so that the OR table could be moved and was not tied to one place, but the table top was fixed to the column. This had the disadvantage that the compact unit was very heavy for a single person to move, which had an adverse effect on mobility. As a result, the column and the table top were separated.

Modern OR table systems are available both as stationary, i. e. fixed versions, as well as mobile ones. With the stationary version, the table column is anchored to the floor and the electrics are fed through ducts in the flooring. The OR table top can be removed and is positioned over the table column using a transporter, (also known as a Lafette) and then transferred from the transporter so that it can then be wheeled away again.

Fig. 69.7a–c OR table system. **(a)** Column for stationary operating table. **(b)** Removable table top. **(c)** Transporter for the table top ▲►

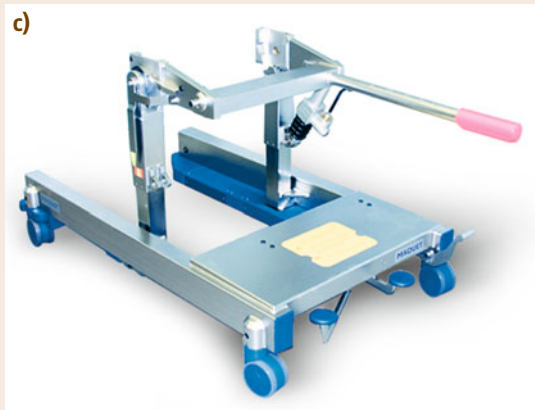

Fig. 69.7 (continued)

As the table column is bolted to the floor, there is no need for the deployment of a mobile OR table base. This gives the surgeons much more leg-room. A further advantage is that additional medical devices that are required, such as a mobile image amplifier or C-arms can be deployed and positioned at the surgical field without difficulties. The significant advantage of a mobile OR table system, on the other hand, is that this system can be moved freely within the operating theater or department. There is no need for electrical installations, as this OR system has rechargeable batteries to provide the required power, with sufficient capacity to be able to carry out some 100 operations under normal OR conditions.

Fig. 69.8 Modular assembly

OR tables or table systems are controlled using a hand-held device connected either wirelessly using infrared signals or via cable. In this way, the electrically adjustable functions can be activated from a distance, without impacting on the sterile OR environment. Individual segments of the table top, such as leg or head plates, can be removed (Fig. 69.8).

Technological advances in the area of medical technology have led to the development of high quality OR table systems with multifunctional system properties that fulfil today's high medical, hygiene and technical requirements.

69.3 Technology of Operating Room Table Systems

69.3.1 Construction of an OR Table System

The individual elements that make up the construction of an operating room table system can be described as follows:

Table Columns

An OR table system is available with a stationary column, i. e. one that is fixed to the floor, and therefore fixed to a particular location or with a mobile column, i. e. one that can be moved to different locations. Both types have their own, equally important advantages (Fig. 69.9a–c).

OR Table Tops

OR table columns can be equipped with many different, exchangeable table tops that meet the special requirements of the individual surgical disciplines and whose

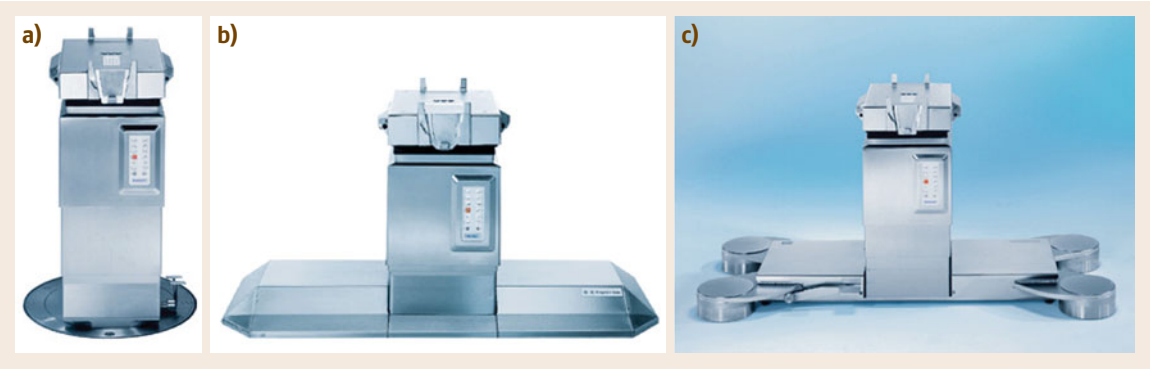

Fig. 69.9a–c Operating room table system columns. **(a)** Stationary column, **(b)** mobile column, **(c)** wheeled column

segments can be adjusted independently of each other, to achieve the required position. This means that the OR table top can be divided up in different ways, e.g. 4-, 5-, 6- or 8-way, in terms of:

- Head and foot sections, which can be swiveled up and down and removed if required.
- Middle or back sections that normally have multiple divisions and can be adjusted to achieve special slope angles.
- Leg sections that can consist of a pair of leg plates that are separated laterally or longitudinally and that can be adjusted automatically, with the option of moving or spreading both sections in a particular direction, either at the same time or independently of each other.

The OR table top is designed in such a way that adding or removing individual segments enables it to be lengthened or shortened as required. It should also have a longitudinal shift in order to facilitate whole body movement using the C-arms (Fig. 69.10a–c).

Operating Room Table Pads

The pads need to fulfill various functions. To start with, the patient must be positioned safely and carefully. The comfort of the patient is of less importance here, as the surgical procedure is done under anesthesia; it is more important to provide the greatest possible protection against nerve damage and pressure necrosis. Furthermore, the pads must be such that the surgical team has the best possible access to the area of the operation. As a result, the operation can be completed in the shortest possible time, which is particularly advantageous to the patient. Finally, the pads must comply with the strictest hygiene requirements, meaning that they must be easy to clean and disinfect.

Controllers

The table columns and the respective table tops are controlled wirelessly through an infrared or radio remote control. Alternatively, they can also be controlled using a cabled controller. In special application areas, control is also possible through a foot-operated switch, operated by the surgeon. Additional control options include the wall-mounted operating panel or an integrated OR control system, which controls the most important OR functions such as lights, OR table, endoscopy equipment, etc., either via a touchscreen monitor or though voice control (Fig. 69.11a,b).

Transporter

Using the transporter (Lafette), which is easy both to move and to manoeuvre, the OR table top is transported to the mobile or stationary table column, which then takes over the support of the table top for the duration of the operation. Lafettes are also used for transportation over longer distances and the exchange of table tops in the logistic workflow between bed transfer, preoperation, operation, post-operation, and the return to bed transfer (Fig. 69.7c).

Accessories. Standard accessories include arm positioning equipment, lateral supports, infusion stands, leg supports, head rings, back and pelvic supports, and hand and body straps, etc.

69.3.2 Mobility and Flexibility of OR Table Systems

Modern OR table systems are characterized by their mobility, flexibility, and compatibility. It is not just the fact that a mobile OR table column allows you to select the location in the operating theater as required, it is also the fact that there is compatibility between the var-

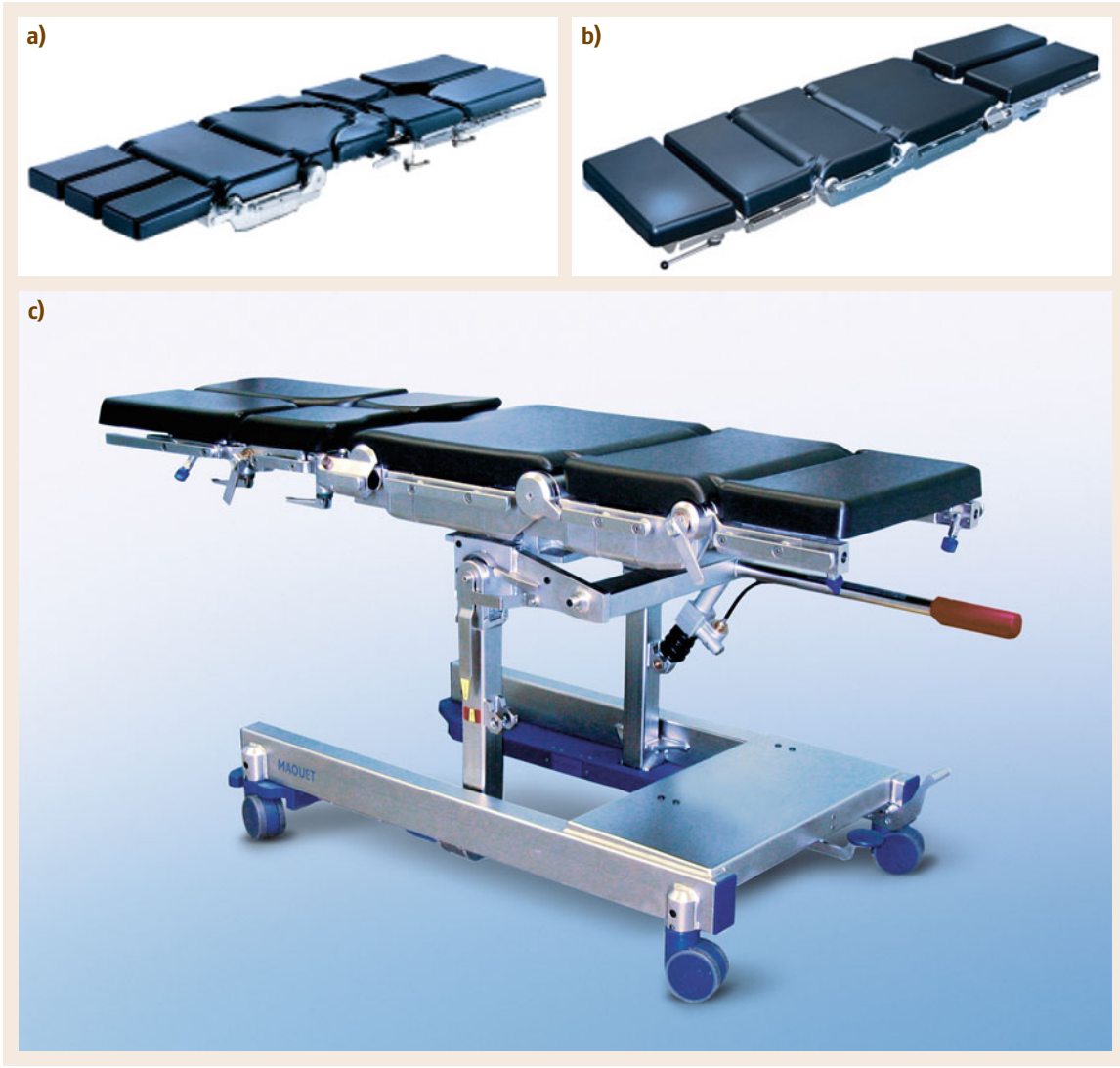

Fig. 69.10a–c Various operating room table tops. (**a**) Extensible, (**b**) universal, (**c**) on transporter

ious, differently-priced OR table systems, both mobile and stationary.

In order to guarantee flexibility, today's OR table systems are designed in such a way, or can be modified, to ensure that they meet the positioning requirements of different surgical disciplines. If you have deployed an OR table system and, should operating and positioning techniques change in the future, you only need to order a suitably modified table top that is compatible with the basic OR table column element. In this case, in an OR department equipped with mobile operating tables, it would be necessary to order a completely new OR table, which would entail considerable investment.

Today, more than ever, time savings are a significant criterion for the efficient usage of operating theaters. The use of an OR table system, i. e. a table column, two transporters as well as two OR table tops, facilitates a so-called *roundabout system*. While one surgical procedure is being finished up in the operating theater, it is possible to bring the next patient from the bed transfer room to the pre-operation room on the second

Fig. 69.11a,b Control units for table tops. **(a)** Cable control unit, **(b)** wall-mounted control unit

table top, in order to administer the anaesthetic. Once the previous operation is complete, the patient has been taken out, and the operating theater has been cleaned, the already anaesthetized patient can be moved into the theater, where he/she can be transferred, while still lying on the table top and potentially already positioned, onto the OR table column. This *roundabout system* offers the advantage that operations can continue without any great time delay factor, whilst also taking the time periods required for the effects of local anaesthetics into account.

Of course, such overlapping working practices can also be achieved using two mobile OR tables. There are, however, both advantages and disadvantages. One disadvantage is that a mobile OR table weighs between 200 and 300 kg, which means that together with the weight of the patient, in a worst case scenario, around half a metric tonne would need to be moved. One advantage is that because all functions are *on board* with a mobile OR table, the patient can be positioned and prepared ahead of time almost 100%, for the surgical intervention. If well organized, this can represent time savings (Fig. 69.12).

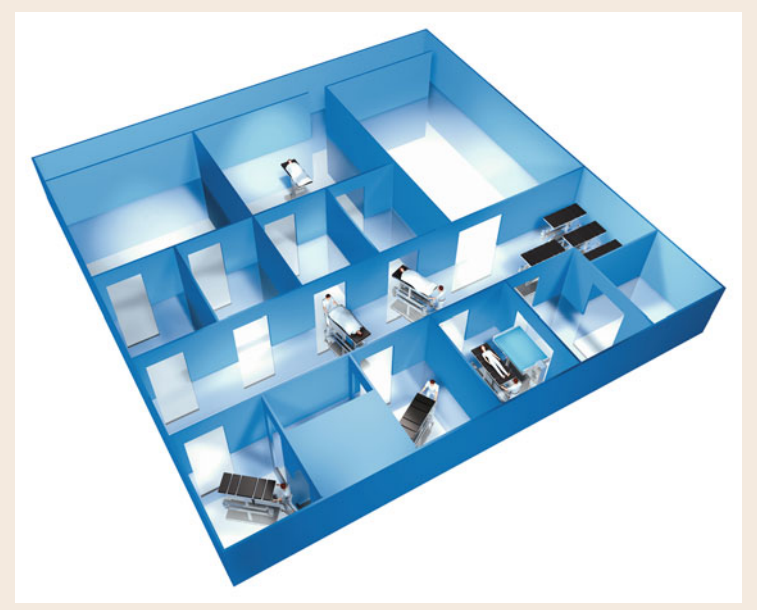

Fig. 69.12 Patient workflow

69.4 Safe Patient Positioning

Operation positioning designates the position that the patient's body is placed in, in order to guarantee the surgeon the best possible access to the operation area. Additionally, every effort is made to optimize the presentation of the anatomical structure of the operation field.

The following *standard positions* have proved themselves (Fig. 69.13a–d):

- Supine position/special supine position
- Prone position/exposed stomach position
- Lateral position

Fig. 69.13a–d Standard positions operating room tables for various surgeries. **(a)** Supine position for knee arthroscopy, **(b)** thorax surgery, **(c)** sitting position for neurosurgery, **(d)** adiposity surgery

- Dorsosacral position
- Genucubital position
- Sitting position/half seated position.

The patient ought to be positioned or be placed in the optimum operating position by the anaesthetist and the surgeon in conjunction with the OR care team for administering the anaesthetic and for the operation. Before this, the responsible specialists must decide, based on the general condition of the patient, which stresses or strains the patient can be exposed to, as a result of the positioning on the OR table. The factors that need to be considered here are the patient's age, weight and constitution, as well as their general state of health in respect of heart, lungs, circulation, metabolism, nervous system, muscle tissue, and skin tissue damage that may have been caused by metabolic dysfunctions, obesity, rheumatoid arthritis, heart and vascular weakness, or circulatory disorders, etc. The factors listed here will significantly affect the strains that a patient can withstand and must be taken into account when deciding on the positioning, as every type of patient positioning represents an additional strain.

An additional factor is that the anaesthetic and muscle relaxants actually increase the strains as they affect breathing, blood supply, and nerves in particular. Pain sensitivity is deactivated while under anaesthesia so that the patient is not aware of pain caused by pressure or strain trauma and cannot react because of interrupted adverse effects reflexes and reduced muscle tone.

This means that the patient can suffer injury even before the actual surgical intervention has started. Extreme care must be taken when making even the simplest positional change during the operation.

Endotracheal anaesthesia is administered when patients are in the normal supine position. Only once the deep anaesthesia state with relaxed muscles has been reached, can the actual operation positioning be done, taking the patient-specific factors into account (see above).

It should be ensured that the patient's arm that is going to be used for the anaesthetic and the infusion is lying evenly and extended, on a well padded arm positioning device. If necessary, the arm positioning device must be lengthened with a padded Cramer rail. If the positioning is wrong this can lead, for example, to irritation or paralysis caused by damage to the *N. radialis* or *N. ulnaris*, in spite of soft OR table padding. Overstretching the arm past the 90° angle, both abduction and supination, can cause paralysis of the plexus.

When it comes to leg positioning, the foldable leg plates on modern OR tables can be adjusted to suit legs very well, so that pressure is distributed over a large enough area and the best possible operation position can be achieved. The use of leg holders on the other hand, e.g., during gynaecological or urological interventions, carries a certain risk of causing pressure injuries and strains through incorrect positioning or deployment, by, for instance, overstretching legs that have been relaxed by anaesthetic, by the pressure of wrongly adjusted knee crutches as well as by resting the lower extremities on the leg holder bars.

The same care must be exercised when positioning the trunk. Not changing the position of the patient of a longer period of time, can lead to a further problem: decubitus (bedsores or pressure sores).

69.4.1 Decubitus Injuries

As anaesthetics and muscle relaxants can relax the skin tissue such that the arterial pressure is weaker than the external pressure, which is influenced by body weight, the blood supply can be impaired and, as a result, the skin tissue receives insufficient nutrients. Thus, for patients who are kept in the same position for a longer period time, there is and increased risk of skin and skin tissue damage.

A decubitus caused in this way can develop into necrosis (localized death of skin tissue cells), in particular when there is only a thin layer of skin covering the bone. Locations particularly at risk are:

- In supine position: heels, sacrum, elbows, shoulder blades, back of the head
- In prone position: pelvis, hips, knees, points of the toes
- In sitting position: heels, crucial ligaments, elbows, head
- In lateral position: hips, toes, knees.

At the same time, care must be taken that there is no trapping of the skin, which can lead to necrosis as a result of reduced blood flow. This risk is particularly prevalent in longer operations.

Following heart operations during which the patient's body was cooled down and single-pole high frequency devices were used, large areas of tissue necrosis were identified, which principally were diagnosed as burns. Initial tests regarding for the causes of this necrosis points that were identified as burns, by the operation team, the hospital's technical staff, health and

safety and the manufacturer of the HF surgical equipment were unable come up with any explanation based on a physical cause. Only a differential diagnosis investigation of the suspicion of pressure necrosis, could definitively exclude the possibility of exogenic causes of burning.

A first indication of pressure damage is given by a reddening of the skin that does not recede immediately following a change of position.

Essentially the risk of decubitus is not greater for a person who is overweight than it is for one who is underweight. The difference is that with overweight patients, the area of damaged skin is larger, but in most cases the damage is less pronounced, while with underweight patients, the damaged area is smaller but the skin damage is more pronounced.

Reasons for the Development of Decubitus Caused by OR Positioning

The following list gives possible causes for the development of decubitus caused by OR positioning:

- OR table padding that is hard or worn out.
- Longer operations with increasingly older patients.
- Increased self-weight, particularly with obesity. On the other hand, however, also with cachectic patients where the skin is very close to the bones because of missing or reduced layers of fat under the skin. Areas of the body particularly affected here include the sacrum and the heels.
- Medicinal influences (anaesthetics), which reduce muscle and tissue tone.
- Punctiform loads resulting from positioning necessary during the operation.

Decubitus Prophylactics

Decubitus can be avoided by implementing the following countermeasures:

- Aiming for shorter operation times, as experience shows that skin tissue damage is likely to occur, at the latest, after 2 h.
- Regular and timely replacement of older or worn OR table pads with padding that is thick and soft enough.
- Careful attention to the individual segments of the OR table top and the body of the patient.
- Pressure relief brought about by the application of additional padding at the predisposed locations.
- Avoidance of skin trapping and the formation of folds or creases both in patients' skin and in the OR table padding during positioning and intra-operative patient positioning.
- Avoidance of the intra-operative distortion of patient positions.
- Carrying out positional changes during longer operations, whereby small adjustments of the motorized joints of the OR table can be used to relieve pressure on tissue and enable reperfusion.

69.4.2 Long-Term Position Injuries and Legal Responsibility

Optimized patient positioning is the best prophylactic against decubitus! As analyses of damage claims by authorized experts show operation position injuries are reported regularly in many damage claims, which represents a serious problem for the patients and increases the costs of the post-operative care.

Improper and incorrect patient positioning on the OR table may cause problems, ranging from temporary impairment up to serious and irreversible injuries. The areas most affected are:

- Nerves that are traumatized, in particular the plexus brachialis
- Eyes
- Skin
- Muscle tissue
- Tendons and ligaments.

There are comparable rules in force in different countries when it comes to clarifying the questions of legal responsibility for sustained position injuries. They indicate that while the task of positioning patients on the OR table before the operation is down to the anaesthetist, during the operation it is the job of the surgeon, taking any anaesthetic-related risks into account. However, essentially it is the joint responsibility of both the surgeon and the anaesthetist.

For the surgeon, this means that he bears the medical and legal responsibility and that any increase in risk in relation to anaesthesia, resulting from a necessary change in position, is justified. The legal responsibility rests with the anaesthetist, as part of his intra-operative duties, to make provisions for the specific risks that result from the positioning and/or to mitigate against them through the implementation of particular preventive measures. Special attention should be paid to the important issue of the risk of burning, in connection with patient positioning, during operations where single-pole high frequency devices are used.

69.4.3 Patient Positioning When Deploying Single-Pole HF Devices

High-frequency (HF) surgery equipment is used to separate specific areas of tissue using thermal energy and at the same time to cause coagulation. For this purpose, single-pole high frequency surgical devices with an active and a passive electrode are used. Because of its shape, a high current density occurs at the active electrode, the so-called cutting or coagulation electrode, as opposed to the large-surface, passive electrode (neutral electrode), which conducts the current away and, therefore, has a low current density.

Possible causes for complications when carrying out single-pole high frequency surgery are, on the one hand, that the patient has not been placed correctly in a position that will ensure that the body is not earthed and, on the other hand, the faulty application of the neutral electrode. In order to avoid localized burning caused by HF surgical equipment, the patient must be positioned in such a way that he/she is completely insulated from the OR table and its accessories, as well as being safeguarded, through a correct installation of the neutral electrode. This means:

- The patient must be positioned in such a way that he/she is not in contact with electrically conductive components such as metal parts of the OR table, holders, damp cloths, etc. with particular attention being paid to the extremities. There must be an electrically-insulating, dry, thick underlay between the patient and the OR table and holder, which must not become damp during the HF surgery, e.g. with blood or liquids used to rinse out the area of the operation.
  As dry and nonconductive fabric must be laid between patient and table padding, a minimum conductivity for the padding is laid down, in order to avoid electrostatic discharge. If this were not the case, discharge sparks caused by frictional electricity could be produced, which would represent a dangerous source of ignition energy for flammable anaesthetic gases or alcohol vapors.
- The whole surface of the neutral electrode must be applied well to the patient's body, such that it cannot become detached if the patient moves or is moved. Preferred application points are the upper and lower extremities. This prevents the occurrence of too high a transfer resistance, which interrupts the current backflow through the neutral electrode.

69.5 Preparation: Care, Maintenance, and Hygiene

69.5.1 Manual Cleaning and Disinfection

Following each operation, special attention must be paid to the preparation of the OR table tops and the OR table system transporters that were used for the operation, i. e. they must be carefully cleaned and disinfected. Particularly in smaller hospitals, cleaning and disinfection is often done manually by support staff in the operation area or by the nursing staff themselves. Because of the multiple divisions of the complete OR table system and the high hygiene demands, manual cleaning cannot always be seen to be the most reliable approach. It is also very time and staff-intensive.

Hygiene issues, maintenance work, and any repairs that may be necessary are already allowed for during design and construction. For instance, the upper part of the OR table, as well as the covers of the column and base, consist principally of smooth-surfaced, individual components made of chrome nickel steel that can be removed without any problem. Also, the electrically conductive roller bearings that are used to move and manoeuvre the mobile OR table are easily accessed from above for inspection and cleaning. Here, there are significant advantages with the OR table system since table tops and transporters can be moved effortlessly into the corresponding cleaning rooms. Any repairs can also be carried out well away from the operation area, without disturbing the OR procedures.

69.5.2 Automatic OR Table System Cleaning and Hygiene

A second option is offered by so-called decontamination machines, which automatically carry out the cleaning, disinfection and drying of suitable OR table tops, Lafettes, and OR accessories. This alternative is most frequently used in larger operating centers, as it is neither staff nor time-intensive, unlike manual cleaning and disinfection procedures. A further, not insignificant, advantage is that an automated procedure using a machine, assuming that operating instructions are correctly followed, offers maximum hygiene levels. With manual

Fig. 69.14 Operating room table cleaning and decontamination machine

cleaning, a lot rests on the care practiced by the staff as well as the time invested.

On average, the cycle time of a decontamination machine, including all the individual processes such as cleaning, disinfection, intermediate drying, rinsing, and final drying is 10 min. It should also be said here, that the cycle time is dependent on the level of contamination and is, therefore, variable. All data generated during this process is recorded, in order to ensure traceability.

From the standpoint of the care staff, this represents not only a simplification of and a significant improvement in working conditions, but it also contributes to the optimizing of safe working processes in the operating area (Fig. 69.14).

Maintenance

As well as the ongoing cleaning and disinfection of the OR table as a prerequisite for aseptic working, it is essential, because of the many electrical, hydraulic, and electro-hydraulic control elements, that the OR table system is regularly maintained, in order to prevent downtimes and to ensure the safety of both patients and OR staff.

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