DESIGNING AN IDEAL OPERATING ROOM COMPLEX

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Summary

Designing of an operation theatre complex is a major exercise and is mainly intended to benefit the patient. The need for safety, convenience and economy will guide the planning of a modern operation theatre complex, whatever the size, number or the speciality. Guidelines based on current and widely accepted recommendations as also ones for possible expansion of the operation theatre complex are dealt with in this article.

Key words Operating room, Operating theatre complex; Designing, Planning and organisation; Induction room, Accreditation.

Introduction

An operation theatre complex is the “heart” of any major surgical hospital. An operating theatre, operating room, surgery suite or a surgery centre is a room within a hospital within which surgical and other operations are carried out. Operating theatres were so-called in the United Kingdom because they traditionally consisted of semi-circular amphitheatres to allow students to observe the medical procedures. The Old Operating Theatre in London is one of the oldest, dating back to 1822 (Oxford English Dictionary and Wikipedia.com).

The patient is the centre point of a functioning OT complex. He / she is in isolation for varying times, away from his near and dear ones and is physically sick. Efforts are directed to maintain vital functions, prevent infections / promote healing with safety, comfort and economy.

The establishment and working of the operation theatre (O.T.) needs specialised planning and execution and is not a simple civil engineering work. A “civil-mechanical-electrical-electronic- bio medical” combo effort driven and coordinated by the needs, preferences and safety of the medical/ surgical team forms the basis for starting and maintaining an operation theatre. Anaesthesiologists, by virtue of their knowledge of the intricacies of physiology, physics and biomedical aspects of medicine and constant proximity to the operation theatre should preferably be involved from the early stages of planning of operating theatres.

On an average, operation theatres cater to 50% of the needs of total healthcare seekers. Anaesthesia-controlled time typically represents a small fraction (10–20%) of the total case time, the remainder (> 80%) being surgeon and nurse-controlled.

In the following pages, we will discuss the various considerations while planning an operation theatre complex. Functioning of an OT complex including scheduling, administration, staffing, sterilization techniques and data / audit management are out of purview of this topic.

Purpose of operation theatre complex

OT complexes are designed and built to carry out investigative, diagnostic, therapeutic and palliative procedures of varying degrees of invasiveness. Many such set ups are customized to the requirements based on size of hospital, patient turnover and may be speciality specific. The aim is to provide the maximum benefit for maximum number of patients arriving to the operation theatre. Both the present as well as future needs should be kept in mind while planning.

Different zones of OT complex

The location and flow of the patients, the staff and the materials form the three broad groups to be considered during all stages of design.

Four zones can be described in an OT complex, based on varying degrees of cleanliness, in which the bacteriological count progressively diminishes from the outer to the inner zones (operating area) and is maintained by a differential decreasing positive pressure ventilation gradi-
ent from the inner zone to the outer zone.

(1) **Protective zone:** It includes
- Change rooms for all medical and paramedical staff with conveniences
- Transfer bay for patient, material & equipments
- Rooms for administrative staff
- Stores & records
- Pre & post-operative rooms
- I.C.U. and P.A.C.U.
- Sterile stores

(2) **Clean zone:** Connects protective zone to aseptic zone and has other areas also like
- Stores & cleaner room
- Equipment store room
- Maintenance workshop
- Kitchenette (pantry)
- Firefighting device room
- Emergency exits
- Service room for staff
- Close circuit TV control area

(3) **Aseptic zone:** Includes operation rooms (sterile)

(4) **Disposal zone:** Disposal areas from each OR & corridor lead to disposal zone

**Sub areas (excluding OT place)**

(1) **Pre-operative check in area (reception):** This is important with respect to maintaining privacy, for changing from street clothes to gown and to provide lockers and lavatories for staff.

(2) **Holding area:** This area is planned for IV line insertion, preparation, catheter / gastric tube insertion, connection of monitors, & shall have O₂ and suction lines. Facility for CPR should be available in this area.

(3) **Induction room:** (anaesthetic room). It should have all facilities as in OT, but there is controversy as to its need. One for each OT is required, ideally each is a duplicate of the other in each floor. The anaesthetic room will provide a more tranquil atmosphere to the patient than the OT. It should provide space for anaesthetic trolleys and equipment and should be located with direct access to circulation corridors and ready access to the operating room. It will also allow cleaning, testing and storing of anaesthesia equipment. It should contain work benches, sink(s). It should have sufficient power outlets and medical gas panels for testing of equipment.

(4) **Post anaesthetic care units (PACU):** preferably adjacent to recovery room. These should contain a medication station, hand washing station, nurse station, storage space for stretchers, supplies and monitors / equipment and gas, suction outlets and ventilator. Additionally 80 sq ft (7.43 sq m) for each patient bed, clearance of 5 ft (1.5 m) between beds and 4 ft (1.22m) between patient bed sides and adjacent walls should be planned.

(5) **Staff room:** Men and women change dress from street cloth to OT attire; lockers and lavatory are essential; rest room TV, etc. are desirable.

(6) **Sanitary facility for staff:** One wash basin and one western closet (WC) should be provided for 8-10 persons. Showers and their number is a matter of local decision. Inclusion of toilet facilities in changing rooms is not acceptable; they should be located in an adjacent space.

(7) **The anaesthesia gas / cylinder manifold room / storage area:** A definite area to be designated. It should be in a cool, clean room that is constructed of fire resistant materials. Conductive flooring must be present but is not required if non inflammable gases are stored. Adequate ventilation to allow leaking gases to escape, safety labels and separate places for empty and full cylinders to be allocated.

(8) **Offices – for staff nurse and anaesthesia staff:** The office should allow access to both unrestricted and semi-restricted areas as frequent communication with public is needed.

(9) **Rest rooms:** Pleasant and quiet rest for staff should be arranged either as one large room for all grades of staff or as separate rooms; both have merits. Comfortable chairs, one writing table, a book case etc., may be arranged.

(10) **Laboratory:** Small lab. with refrigerator for pathologist to be arranged.

(11) **Seminar room:** Since staff can not leave an OT complex easily, it is better to have a seminar room
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within the OT complex. Intra-departmental discussions, teaching and training sessions for staff (with audio-visual aids) may be conducted here.

(12) **Store room**- This is designed to store large but less frequently used equipment in the OT. There should be storage space for special equipment after cleaning.

(13) **Theatre sterile supply unit (TSSU)**- Within this area, following are desirable:

   i. Temperature between 18\(^0\)-22\(^0\)C, humidity of 40%-50% is the aim.
   ii. Air conditioned with 10-12 air exchanges per hour
   iii. Storage of sterile drapes, sponges, gloves, gowns and other items ready to use.
   iv. Option to store in from one side and remove from other side.
   v. Proper inventory to prevent running out of stock.

(14) **Scrub room**- This is planned to be built within the restricted area. Elbow operated or infrared sensor operated taps / water source is ideal. It is essential to have non slippery flooring in this area.

**Types of OT complexes**

There are three main categories of operating theatres:

1. The single theatre suite with OT, scrub-up and gowning, anaesthesia room, trolley preparation, utility and exit bay plus staff change and limited ancillary accommodation.

2. The twin theatre suite with facilities similar to 1, but with duplicated ancillary accommodation immediate to each OT, sometimes sharing a small post anaesthesia recovery area.

3. OT complexes of three or more OTs with ancillary accommodation including post anaesthesia recovery, reception, porter’s desk, sterile store and staff change.

**Principles to be taken into consideration while planning an O.T. (physical / architecture):**

1. Location: Low rise buildings limited to two or three storeys high are preferred because of maximum advantage of natural light and ventilation as appropriate can be derived. The OT should be separate from general ‘traffic’ and air movement of rest of the hospital, OT, surgical wards, intensive care units (ICU), accident and emergency department (A&E), Radiological department (X-Ray) should be closely related and access is also required to Sterilizing and disinfecting unit (SDU) and laboratory facilities. The location of the operation complex in a multi-storey building is planned on the first floor, connecting to surgical and other wards on the same floor. Adequate electric lift is planned for vertical movement from casualty on the ground floor and ENT, Orthopaedics, Ophthalmology & other wards on the floors above.

2. Zone wise distribution of the area, so as to avoid criss-cross movements of men & machines

3. Adequate & appropriate space allotted as per utility of the area

4. Provision for emergency exit

5. Provision for ventilation & temperature control, keeping in mind the need for laminar flow, HEPA filter air conditioner etc.

6. **Operation rooms:**

   The number & size can be as per the requirement but recommended size is 6.5 m x 6.5m x 3.5 m. Glass windows can be planned on one side only.

   Doors : Main door to the OT complex has to be of adequate width (1.2 to 1.5 m). The doors of each OT should be spring loaded flap type, but sliding doors are preferred as no air currents are generated. All fittings in OT should be flush type and made of steel.

   The surface / flooring must be slip resistant, strong & impervious with minimum joints (eg. mosaic with copper plates for antistatic effect) or jointless conductive tiles/ terrazzo, linoleum etc.. The recommended minimum conductivity is 1m ohm and maximum 10m Ohms.

   Presently the need for antistatic flooring has diminished as flammable anaesthetic agents are no longer in use.

   Walls- Laminated polyester or smooth paint provides seamless wall; tiles can break and epoxy paint can chip out. Collusion corners to be covered with steel or aluminium plates, colour of paint should allow reflection of light and yet soothing to eyes. Light colour (light blue or green) washable paint will be ideal. A semi-matt wall surface reflects less light than a highly gloss finish and is less tiring to the eyes of OT team.
Operation table: One operation table per OT
Electric point: Adequate electric points on the wall (at < 1.5 m height from the floor) (discussed later)
X-Ray illuminators: There should be X-ray film illuminators preferably recessed into the wall.
Scrub area: to be planned for at least for 2-3 persons in each OT.
7. There has to be a preparation room in clean zone
8. Corridors not less than 2.85 m width for easy movement of men, stretcher & machines
9. Separate corridors for uses other than going into OT.
10. Rooms for different persons working in OT & for different purpose (it should be as per zone & size)
11. Gas & suction (control, supply & emergency stock) for all OTs & areas where patients are retained. Oxygen, gas and suction pipe to be connected with central facility and standby local facility should also be available.
12. Provision for adequate & continuous water supply: Besides normal supply of available water at the rate of 400 litres per bed per day, a separate reserve emergency overhead tank should be provided for operation theatre. Elbow taps have to be 10 cm. above wash basins.
13. Proper drainage system.
14. Pre-operative area with reception with separate designated area for paediatric patients is desirable.
15. Adequate illumination with shadow less lamps of 70,000-120,000 Lumens intensity, for assessing patient colour and tissue visibility (discussed under “Lighting”).
16. The safety in working place is essential, and fire extinguishers have to be planned in appropriate zone.
17. Provision for expansion of the OT complex should be borne in mind during planning stages itself

Recommendations on the number of OTs required
It is observed that out of all surgical beds, of the hospital, 50% of patients are expected to undergo surgery. Thus for 100 beds, with average length of stay of 10 days for each patient, 10 operations per day can be performed.

In general, multiuse OTs, instead of multiple OTs offer advantages of efficient man power utilization, economical maintenance and better training of supporting staff.

Thus, in a 300 bedded hospital (with 150 surgical beds), one OT complex with 3 OTs for General Surgery, Gynaecology, Orthopaedics/ENT, one for Endoscopy and one for Septic.

OT will be required with 8 hours a day working duration.

Ventilation

Ventilation should be on the principle that the direction of air flow is from the operation theatre towards the main entrance. There should be no interchange air movement between one OT and another. Efficient ventilation will control temperature and humidity in OT, dilute the contamination by micro-organisms and anaesthetic agents.

There are two types of air conditioning systems: recirculating and non-recirculating.

Non-recirculating systems heat / cool the air as desired and convey it into the operating room with ideally 20 air exchange per hour. Air is then exhausted to outside. Anaesthetic agents in the OT air are also automatically removed. These are thus ideal but are expensive.

The circulating system takes some or all of the air, adjusts the temperature and circulates air back to the room.

The broad recommendations include:
- 20-30 air exchanges / hour for recirculated air
- Only up to 80% recirculation of air to prevent build up of anaesthetic and other gases
- Ultracean laminar air flow – the filtered air delivery must be 90% efficient in removing particles more than 0.5 m.
- Positive air pressure system in OT: It should ensure a positive pressure of 5 cm H2O from ceiling of OT downwards and outwards, to push out air from OT.
- Relative humidity of 40-60% to be maintained
- Temperature between 20°-24°C. Temperature should not be adjusted for the comfort of OT personnel but for the requirement of patient, especially in pediatric, geriatric, burns, neonatal cases etc.

Pendant services

Two ceiling pendants for pipeline services should be designed; one for surgical team and one for anaesthetist.
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Anaesthetic pendant should be retractable and have limited lateral movement and provide a shelf for monitoring equipment. It should have oxygen, nitrous oxide, four bar pressure medical compressed air, medical vacuum, scavenging terminal outlets and at least four electric sockets.

Piped gases in the OT
1. Automatic / semi-automatic fail safe manifold room to be designed.
2. Two outlets for \( O_2 \) and suction and one for \( N_2O \) are a minimum in each OT.
3. Pipeline supply system should be able to cut off from mainline if the problem occurs anywhere along the delivery hosing / tubing.

Scavenging
The method of scavenging should be decided during planning stage of OT. US and International standards are available for scavenging but it is ideal to plan the type of system (active / passive) and number and location of scavenging outlets beforehand.

Electrical
All electrical equipment in the OT need PROPER grounding

In the past, isolated power systems were preferred when explosive agents were being used. They have the advantage of a transformer using grounded electricity and there is no risk to the patient or machines if a machine gets faulty.

The grounded systems as used at homes offer protection from macro shock but devices may lose power without warning. Life support systems, if in use could be disturbed.

Following criteria are ideal with respect to electricity in OT complex:
1. Use of circuit breakers / interrupters is desirable if there is an overload or ground fault.
2. Power line of 220 Volts
3. Suspended ceiling outlets should have locking plugs to avoid accidental disconnection.
4. Insulation around ceiling electrical power sources should withstand frequent bendings and flexings. They should not develop cracks and should not damage wires. Wires inside rigid or retractable ceiling service column can help to some extent.
5. Wall outlets to be installed 1.5 m above ground (as already mentioned).
6. Use of explosion proof plugs.
7. Multiple outlets from different electrical line sources should be available.
8. Electrical load calculation should be based on, equipment likely to be used and appropriate current carrying capacity cords to be used.
9. Emergency power: OT electrical networks need to be connected to the emergency generators with automatic two way changeover facility.

Lighting
Some natural daylight is preferred by staff. Where possible, high level windows which give a visual appreciation of the ‘outside world’ can be considered in the OT.
1. General lighting: Colour corrected fluorescent lamps (recessed or surface ceiling mounted) to produce even illumination of at least 500 Lux at working height, with minimal glare are preferred. Means of dimming may be needed during endoscopies. To minimize eye fatigue, the ratio of intensity of general room lighting to that at the surgical site should not exceed 1:5, preferably 1:3. This contrast should be maintained in corridors and scrub areas, as well as in the room itself, so that the surgeon becomes accustomed to the light before entering the sterile field. Colour and hue of the lights also should be consistent.
2. About 2000 Lux light is needed to assess the patient's colour.
3. White and glistening / shiny body tissues need less light than dark and dull tissues.
4. Operating area: Overhead light should be shadowless and give 25000-125000 Lux of light (50000 to 100000 Lux at the centre and at least 15000 Lux at the periphery).
5. About 10-12 inch of focus of light gives adequate illumination both at depth as well as surface of body.
6. Lights should be freely movable both in horizontal and vertical ranges. Pendant systems are preferred. OT light should produce blue white colour of daylight.
at spectral energy range of 50000K (35000-67000-kelvin acceptable)

7. Halogen lights produce less heat and hence preferred. OT light should not produce more than 25000 mw/cm² of radiant energy. Elimination of heat by dichroic reflectors (cold mirrors) with heat absorbing reflectors or filters should be available along with the luminaire.

8. An auxiliary light for a second surgical site is often beneficial

9. UPS of adequate capacity to be installed after considering OT light, anaesthesia machine, monitors, cautery etc until the back up generator takes over

10. In endoscopic OTs, a reduced lighting is sometimes recommended. A grazing light over the floor can be helpful

**Anaesthesia equipment and monitoring needs**

At least one anaesthesiologist should be in the team involved in planning an OT. It is imperative that certain mandatory considerations with respect to the anaesthetic equipment and monitors be planned during the planning and design stage itself. Personal, practice and cost preferences may influence the plans.

**Communications**

Telephones, intercom and code warning signals are desirable inside the OT. One phone per OT and one exclusively for use of anaesthesia personnel is desirable. Intercom to connect to control desk, pathology and other OTs as well as use of paging receivers (bleeps) is also ideal. A code signal, when activated, signals an emergency state such as cardiac arrest or need for immediate assistance.

**Catering**

Basic services such as preparation of beverages and some snacks, use of vending machines may be planned, augmented by provision of hot and cold meals from main hospital kitchen.

**Cleaning**

The construction materials selected for the OT complex should aim to minimize maintenance and cleaning costs.

**Data management**

Customised network connections should be put in place or a conduit should be planned. A well designed system can provide automated records, materials management, quality improvement and assessment, laboratory tracking, etc. The Software for OT management are costly and hospitals are generally slow to adopt to changes. Customized OT software can be designed for individual needs.

**Operating theatre satellite pharmacy**

Access to the OT areas and outside should be possible. It should have a laminar flow hood, a refrigerator, space for drug storage locked containers for controlled substances computer, desk area for paper work and pharmaceutical literature. Special kits for specific surgeries may also be arranged. The pharmacy may open for 1 to 24 hours based on need but it is desirable that an after hour system is planned.

**Statutory regulations**

The design and planning of an OT complex will need compliance with mandatory regulations related to local administration such as Municipal Corporation, Government, Pollution Control Board, Fire Safety Department, Water supply and Drainage department, etc.

**Usual areas of deficiency in OTs (existing OTs)**

1) No reception area.

2) No separate rooms for - Surgeons

   - Anaesthesiologist

   - Jr. doctor

   - OT attendants

3) Not enough number of change rooms for different class of people.

4) Inappropriate size & type of doors etc.,

5) Lack of laminar flow & mandatory air exchange systems in OT.

6) Lack of standard OT protocol.

7) No separate Central Sterile Supply Department (CSSD)

8) Waiting Area – Recovery - Not well equipped

   - Lack of basic amenities
The authority for standardization

Recommendations are available in various surgical, anaesthesia and nursing manuals with regard to the planning and establishment of operation theatres/complexes. The hospital can get accredited by the Joint Commission on Accreditation of Healthcare Organizations (JCAHO)\(^7\), a professionally sponsored program that stimulates a high quality of patient care in health care facilities. There is also an accreditation option that is available for ambulatory surgery centers (Accreditation Association for Ambulatory Healthcare- AAAH). The department of health and social security (DHSS) in UK has publications containing information on planning for new health buildings and for upgrading existing buildings.

Conclusion

In the present era of evidence based medicine, it becomes imperative to give maximum importance to planning an Operation Theatre Complex. Within the limitations of finance and space, the best results can be obtained and anaesthesiologist with multiple roles inside the operation theatre complex, should be consulted in the process. Efforts should be made to conform to the standards laid down by local bodies and international agencies, as healthcare facilities in India are now catering to more and more international clientele. However, new OTs and hospitals that are being established can not be expected to fulfil all theoretical requirements as new ideas are constantly being developed. By the time they are incorporated into buildings, fresh ones take their place on the drawing board.

References

7. Joint Commission on Accreditation of Healthcare Organizations ("http://www.jointcommission.org/AccreditationPrograms/Hospitals/"

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